

S T O M A T O L O G Y   E D U   J O U R N A L

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# stom<sup>o</sup>edu<sup>J</sup>

A WORLD OF EDUCATIONAL RESOURCES FOR EACH PRACTICE





## Hofident Q<sub>10</sub>

**Product presentation:** Solution for oral hygiene.

**Composition (INCI):** aqua/water, alcohol, *Capsella Bursa Pastoris* extract, *Plantago Lanceolata* extract, *Chamomilla Recutita* extract, *Achillea Millefolium* extract, *Aesculus Hippocastanum* extract, *Mentha Piperita* extract, Ubiquinone.

**Action:** The product has antiseptic, healing, hemostatic, anti-inflammatory action, it acts as an antioxidant, detoxifier, deodorant. It is strongly recommended in gingivitis, stomatitis, thrush, compression pain caused by dental prostheses, after tooth extraction, in case of nipple lesion, bleeding gums, mouth and gum ulcers.

**Recommendations:** It delays dental plaque formation, it prevents bad odour and provides daily mouth hygiene.



## HofImun<sup>®</sup> FORTE

**Product presentation:**

Chewable tablets to stimulate the immune system

**Composition:** Each chewable tablet contains raspberry fruit extract (*Rubii idaei fructus*), Echinacea extract (*Echinacea purpurea*), concentrated extract of licorice root (*Glycyrrhiza radix*), magnesium ascorbate and excipients.

**Action:** It stimulates the immune system, it is anti-inflammatory, antiviral, antiseptic, it fluidifies the bronchial and pharyngeal secretions, antioxidant, cardioprotective, vasoprotective, it has antineoplastic antileukemic action, (due to the ellagic acid), it contributes to wound healing, fortifies and remineralizes (it regulates the potassium balance), it has antiulcer effects and is an overall body tonic.

**Recommendations:** to supplement the diet with nutrients and bioactive substances in: acute and chronic infections of the upper airways (angina, pharyngitis, laryngitis, bronchitis), prophylactic during periods with increased risk of infection with influenza viruses, it has sweating effects in fever, in recurrent herpes episodes of mucocutaneous rash, frequent urinary tract infections, inflammatory urogenital processes; immunodepression after radiotherapy or chemotherapy, bacterial skin infections, psoriasis, neurodermitis, chronic cardiovascular diseases associated with hypercholesterolemia, adjuvant in the diet indicated in the treatment of gastroduodenal ulcers, tonic during periods of physical and mental strain, exhaustion.



## Bucoprotect gel

**Product presentation:** Gel for oral hygiene.

**Composition (INCI):** aqua, *capsella bursa pastoris*, *calendula officinalis*, *achillea millefolium*, *hippophae rhamnoides*, *olea europea*, *hypericum perforatum*, carbomer, triethanolamine, collagen, *foeniculum vulgare*, *mentha piperita*, *citrus amara*.

**Action:** Antiseptic, anti-inflammatory, healing, stimulates the inside lining of the mouth and gums trophicity, reduces pain caused by specific oral diseases (gingivitis, stomatitis, lesions of the prosthesis, thrush, periodontitis).

**Recommendations:** Fights against bad breath (halitosis).

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## Life long learning in a world of globalized knowledge

Jean-François Roulet  
DDS, PhD, Prof hc  
Professor

University of Florida, Gainesville, FL, USA



Dear Readers,

We live in a world that is dramatically different from the world I was born into more than 65 years ago. When I was a student, my main source of information was textbooks. As a young researcher I learned that journals are the source of the most recent advances in my profession. The library was the location where every project started: search the literature. For information on the daily life we usually relied on the local newspaper. Today everything is different. We not only produce much more information and renew knowledge on a much faster pace, but due to the internet, information becomes globally available usually a short time after it happened. If I want to go to the movies, I just consult a local website, where all the movie programs of the week are listed. I can even buy the tickets right away and select my favorite seats. At home in Gainesville, Florida I watch the Swiss TV news and I am informed about a flood that happened a few hours before in the area I used to live. If I want to know something, a scientific fact or something about a person, I just access the internet, log in to a known search engine and within seconds I have a multitude of information. So someone should think that life long learning has become very easy and that we are moving to a totally informed society. Unfortunately the contrary is happening. It has become much more difficult to be informed, not only because we are almost drowning in the sea of information, but also because there is a problem related to the validity/truthfulness of the information. You can see this, if you search a topic you are very familiar with. I just tested this again on May 3rd 2016 by looking up “amalgam” on a very well known search engine. The result: 8,700,000 hits in 0.41 seconds – impressive, but how to digest that huge amount of information – impossible. So, as everybody would probably do it, I start to look into the first hit: there I find quite a neutral description of what amalgam is, however with quite some inaccuracies. Furthermore the concerns of the group of people that believe that amalgam is toxic and dangerous for the patient and the dentist’s health are reported without validation. I personally know that, based on solid research, these concerns can clearly be reduced to a risk which is much smaller than taking an aspirin against a headache. Two entries down the road I find an link offered by a tooth paste producer “Dental Amalgam: A Health Risk”. There Amalgam and its toxicity is explained in lay terms quite reasonably, but not without errors. And finally amalgam entry # 9 is called “Dental Amalgam Mercury Solutions” which is the view of the hard core anti amalgam fraction, naming all the false arguments to make you believe that amalgam is a serious and deadly health risk....

I could tell exactly the same story about fluoride (20,000,000 hits with much more vigorous and contradictory argumentation; the internet offers automatically as search keywords “fluoride dangers, fluoride conspiracy, fluoride side effects and fluoride in water”) or any other topic I consider myself competent about. So how should a consumer know which source to trust? My answer as an editor is clear and loud: “read a peer reviewed scientific journal!”

Andreas Linde, the Editor of the Scandinavian Journal of Dental Research once said: “Nothing is scientifically “shown” or “proven” before it has been published in a scientific journal with a peer review system, so one can critically judge what was done, how it was done and evaluate how solid it is.” How is this accomplished? Every peer reviewed journal usually has a

substantial editorial board, which is a list of experts in the field (e.g. see page - 4 - 5). They consult the journal about the philosophy, the topics to be published, the marketing strategy, the format and more general things about the journal. They also conduct reviews of the manuscripts submitted. But this is not sufficient to accomplish the goal of publishing valid data. First a submitted manuscript is checked by the editorial office for the correct format (structure of manuscript, literature quote etc.), then usually the editor in chief checks if the topic of the manuscript is congruent with the topic of the journal and then usually the manuscript is sent to a section or associate editor, which then reads it and if he/she considers it worth being reviewed sends it to at least 2-3 reviewers for anonymous review. These reviewers are experts in the field and work according to a check list, to make sure that the introduction leads the reader comfortably to the "Objective of the study", that materials and methods are understandable and do not contain methodological errors (e.g. lack of control group, or statistical evaluation), that the results are reported in a readable format, that the discussion and conclusions are correct and limited to the facts reported. Then a manuscript is either accepted or rejected by the editor or most probably sent to the authors for revisions, where the authors must decidedly answer the comments of the reviewers. Then finally the manuscript lands on the desk of the editor in chief, who makes the final decision about to publish or not to publish. But, this is not the end of the story. Usually then a language editor checks the correctness of the text and then the layout of the manuscript is done. Before it goes to printing, with the Stoma Edu.] the Editor in Chief has a last look at the paper. If you counted correctly, the manuscript has been seen by at least 9 pairs of eyes (of course with a critical brain attached to) before it ends with the readers. Therefore, Dear Readers, if you want to be accurately informed with valid data, read a PEER RREVIEWED JOURNAL.

Sincerely yours,  
J-F Roulet  
Editor-in-Chief

## Unbroken continuum in European dentistry education for lifelong learning

Marian-Vladimir Constantinescu  
DDS, PhD, Professor  
Editor-in-Chief



Dear Readers,

We are pleased that due to the active contribution of our editors we are now able to print the fifth issue of the Stomatology Edu Journal (Stoma Edu.), a journal the aim of which is to overcome the informational and technological handicap imposed by history and geopolitics on Central and Eastern Europe.

Starting from Plato's statement that "education is the greatest gift that man can receive", quality improvement in our readers' education is a permanent concern of our journal.

We aim to permanently provide information to practitioners, educators, researchers and students as highlighted by the latest technologies, by the progress made in education and research in order to continuously develop and improve the quality of dental professionals in this part of the world and beyond.

In a dynamic world which is undeniably going global, we must work towards the rapid integration of our readers with the European and international practice standards, so as to familiarize them with the latest breakthroughs in the holistic approach to the multimodal Oral Pole (OP).

If we take a look at the early dentistry education and practice in Central and Eastern Europe, we find a number of remarkable educational influences from European dentistry.

There are a number of forerunners, creators and promoters of scientific accuracy in dental practice that we should honor and highlight their merits: Dimitrie Nedelcu (1812-1882), George Bilaşcu (1863-1926), Dimitrie D. Niculescu (1871-1928), George Bârlea (1885-1937) and Dan Theodorescu (1899-1948), whose work is the subject of a separate article.

These prestigious predecessors were educated at the Universities in Vienna, Paris, Budapest, Bucharest and Jassy. Each of them has played a role in shaping the modern scientific school of dentistry in Romania, competitive on the European level, in the strict enforcement of the sanitary law preventing the admission of amateurs in the dental field and a curative-preventive care for children and young people.

The new EU program on learning throughout one's life - Lifelong Learning Programme (LLP) aims to strengthen exchanges, cooperation and mobility between education and training systems in the European Union (EU). The objective of this EU program is to contribute by promoting lifelong learning, to the development of the EU as an advanced knowledge society with sustainable economic growth, with more jobs and greater social cohesion.

So, it is a challenge for the prestigious editors of our magazine to engage more decisively in the improvement of the quality of our readers and to continuously improve the quality of dental professionals in this part of the world and beyond.

Sincerely yours,  
M-V Constantinescu  
Editor-in-Chief

### **13th International Congress of Esthetic Dentistry**

Date: 12 - 14 May 2016

Location: Bucharest, Romania

Event types: Conference, Exhibition

Visit event website: <http://www.sser.ro/congres>

### **CDA Spring Scientific Session 2016 - California Dental Association**

Date: 12 - 14 May 2016

Location: Anaheim, CA, USA

Event types: Conference, Exhibition

Visit event website: [www.cda.org](http://www.cda.org)

### **56th International Congress and Exhibition of Iranian Dental Association in conjunction with 1st FDI Persian Regional Congress**

Date: 17 - 20 May 2016

Location: Tehran, Iran

Event types: Conference, Exhibition

Visit event website: [www.excida.ir](http://www.excida.ir)

### **RDS 2016 - Congress of Romanian Dental Society**

Date: 19 - 21 May 2016

Location: Bucharest, Romania

Event types: Conference, Exhibition

Visit event website: <http://sdr.info.ro/>

### **2016 International Congress of Quintessenza: "A" Dental Italian Culture in the World"**

Date: 26 - 28 May 2016

Location: Verona, Italy

Event types: Conference, Exhibition

Visit event website: [www.quintessenzaedizioni.com](http://www.quintessenzaedizioni.com)

### **British Dental Conference and Exhibition 2016**

Date: 26 - 28 May 2016

Location: Manchester, United Kingdom

Event types: Conference, Exhibition

Visit event website: [www.bda.org/conference](http://www.bda.org/conference)

### **InDent 2016 International Dental Exhibition and Conference**

Date: 26 - 28 May 2016

Location: Brno - Czech Republic

Event types: Conference, Exhibition

Visit event website: [www.bvv.cz/en/indent/](http://www.bvv.cz/en/indent/)

### **Stomatology St. Petersburg 2016**

Date: 31 May - 02 June 2016

Location: St. Petersburg, Russia

Event types: Conference, Exhibition

Visit event website: [www.stomatology.primexpo.ru/en/](http://www.stomatology.primexpo.ru/en/)

### **IFEA 2016 - 10th World Endodontic Congress**

Date: 03 - 06 June 2016

Location: Cape Town, South Africa

Event types: Conference, Exhibition

Visit event website: [www.ifeaendo.org](http://www.ifeaendo.org)

### **SINO-DENTAL 2016 The 21st China International Dental Exhibition and Scientific Conference**

Date: 09 - 11 June 2016

Location: Beijing, China

Event types: Conference, Exhibition

Visit event website: [www.sinodent.com.cn](http://www.sinodent.com.cn)

### **The 6th International Camlog Congress "Tackling everyday challenges"**

Date: 09 - 11 June 2016

Location: Krakow, Poland

Event types: Conference, Exhibition

Visit event website: [www.camlogcongress.com/site/front\\_content.php](http://www.camlogcongress.com/site/front_content.php)

### **Art of Modern Dentistry**

Date: 10 - 11 June 2016

Location: Budapest, Hungary

Event types: Conference, Exhibition

Visit event website: <http://www.styleitaliano.org/events/art-of-modern-dentistry>

### **3rd International Expert Symposium**

Date: 11 June 2016

Location: Madrid, Spain

Event types: Conference, Exhibition

Visit event website: <http://www.ivoclarvivadent.com/ies2016/en/program/>

### **1° European Forum on Ultra-Short Implants**

Date: 17 - 18 June 2016

Location: Ferrara, Italy

Event types: Conference, Exhibition

Visit event website: <http://www.idc-italy.com/en/Events/Subscriptions>

### **European Society of Dental Ergonomics**

Date: 17 - 18 June 2016

Location: Wroclaw, Poland

Event types: Conference, Exhibition

Visit event website: [http://esde.org/next\\_annual\\_meeting.html](http://esde.org/next_annual_meeting.html)

### **2016 APDC - The 38th Asia Pacific Dental Congress**

Date: 17 - 19 June 2016

Location: Hong Kong, Hong Kong, China

Event types: Conference, Exhibition

Visit event website: [www.kenes-group.com/events/](http://www.kenes-group.com/events/)

### **2016 IADR/APR (International Association for Dental Research) General Session & Exhibition**

Date: 22 - 25 June 2016

Location: Seoul, South Korea

Event types: Conference, Exhibition

Visit event website: [www.iadr.org/i4a/pages/index.cfm?pageid=4537#VXIZ6Pntmko](http://www.iadr.org/i4a/pages/index.cfm?pageid=4537#VXIZ6Pntmko)

### **2nd Annual Meeting of the International Academy for Digital Dental Medicine**

Date: 03 - 04 September 2016

Location: Busan, South Korea

Event types: Conference, Exhibition

Visit event website: <http://iaddm.com/meetings/second-annual-meeting-of-iaddm/>

### **2016 FDI Annual World Dental Congress**

Date: 07 - 10 September 2016

Location: Poznan, Poland

Event types: Conference, Course, Exhibition

Visit event website: [www.fdiworlddental.org/media/news/news/official-poznan-%28poland%29-to-host-the-2016-fdi-annual-world-dental-](http://www.fdiworlddental.org/media/news/news/official-poznan-%28poland%29-to-host-the-2016-fdi-annual-world-dental-)

## OPERATOR PREFERENCE OF RETRACTION METHOD DURING ANESTHESIA DELIVERY

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### ABSTRACT

**Introduction:** Dental Health Care Providers (DCPs) traditionally use finger retraction or mirror retraction when delivering local anesthesia. Needlestick injuries (NSIs) occur as hand retracting mucosa is likely to experience injury during dental anesthesia delivery. The aim of this paper is to examine a clinical split mouth study comparing two retraction methods and DCP's retraction preference during delivery of dental anesthesia. The clinical implications from this study impact the practitioner's risk of experiencing an NSI.

**Methodology:** The IRB approved study (clinical trials ID: NCT02414620) compared the comfort and ease of the retraction method used while delivering an anterior superior alveolar (ASA) injection bilaterally. Surveys given to participants asked about comfort and ease of use of retraction methods, as well as preferred method of retraction during anesthesia delivery. Chi-square tests of goodness-of-fit were conducted to investigate whether there was a significant difference in the proportion of respondents that chose the various categories within one criterion.

**Results:** 62 DCPs participated in the study and no reported NSIs. Data from the DCPs report significance ( $p$  value < 0.001) in comfort comparing retraction methods when providing anesthesia. Regarding preference of retraction, 22 prefer mirror, 29 preferred device, and 3 preferred their finger. Regarding ease of retraction used, 30 chose mirror, 18 device, and 10 chose finger.

**Conclusion:** Our hypothesis and clinical implication were confirmed. More studies need to be conducted regarding the benefits of using a fingerless retraction method and its effectiveness in dental anesthesia.

**Keywords:** dental anesthesia, dental injection technique, dental armamentarium.

### 1. Introduction

Dental Health Care Providers (DCPs) traditionally use finger retraction or mirror retraction when delivering local anesthesia.<sup>1-3</sup> Existing dental anesthesia curriculums and educational programs have not emphasized techniques other than using the finger for retraction of mucosa.<sup>4-7</sup> Literature presents cases of needlestick injuries (NSIs) when finger is used to retract mucosa to deliver anesthesia.<sup>8, 9</sup> Innovations towards dental anesthesia delivery have progressed throughout the years.<sup>1,4,10-13</sup> In addition, various instruments exist both in clinical practice and on the market to aid in retraction (cheek retractor, tongue depressor etc).<sup>1,14-16</sup>

In 2010, a device was approved for purchase in the United States for use during dental anesthesia

delivery (Fig. 1). This device is a cordless, rechargeable, handheld system that delivers pulsed micro-oscillations to the injection site. The disposable retraction tips consisting of two rubber prongs with an illuminating LED light appropriate for the generation 2 model can be assembled onto the device prior to use. If the DCP applies too much pressure, the device will automatically shut down the oscillating pulses until an appropriate handle and pressure is applied.<sup>17</sup>

The aim of this paper is to examine a clinical split mouth study comparing two retraction methods and DCP's preference during delivery of dental anesthesia. Our hypothesis is that introducing a new device will provide an alternative method to aid in retraction during delivery of dental anesthesia. The clinical implications from this study

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**Figure 1.** Generation 2 model of Dental Vibe System (device) provided by Bing Innovations, LLC



**Figure 2.** Extraoral palpation of Infraorbital foramen

may impact the practitioner's risk of experiencing an NSI. Unpublished university data have seen preliminary data that relate the reduction in intraoral NSI when a mirror retraction technique was introduced into the curriculum.<sup>18</sup> Although this paper focusses on the perception of DCPs and their preferred method of retraction, the authors are working on publishing a paper regarding the perception of patients involved in this study.

## 2. Materials and Methods

The IRB approved study (clinical trials ID: NCT02414620) was performed within a university clinical setting, informed consents were obtained from all participants, and occupational safety health administration (OSHA) guidelines were followed. The inclusion criteria for DCPs covered students enrolled in dental and international dental programs, who successfully completed the basic techniques course in their respective local anesthesia curriculum. These novice DCPs initially learned how to provide anesthesia using a dental mouth mirror during their training. Some DCPs also had prior exposure to using their finger as a retraction method to provide dental anesthesia, and none had previous experience using the device. Exclusions from the study covered DCP's who did not complete their basic training in the dental anesthesia curriculum.

The armamentarium used to compare the retraction methods consisted of the mirror and the device (Fig. 1). In addition, a standard dental syringe, 27 gauge short needle, and 1.8 ml 2% Lidocaine HCl 1:100,000 epinephrine were provided. The study protocol compared the comfort of the retraction method used while delivering an anterior superior alveolar (ASA) injection. The participants were required to watch a two minute video describing the proper use of the device. The DCP's were encouraged to ask questions prior to the clinical

segment of the study for clarification. The delivery of dental anesthesia was performed under the supervision of the principal investigators.

Prior to the injection, the DCPs palpated for the infraorbital foramen extraorally (Fig. 2). Once the injection sites were identified, a piece of gauze was used to dry a single injection site and then a small amount of topical was placed for about a minute at the insertion site. The insertion site for the ASA is the muccobuccal fold above the maxillary first premolar.<sup>1</sup> The range of insertion depth was from 5-10 millimeters for each individual patient. The DCPs were required to pull tissue taut with either retraction method applied.

The right side of the mouth used a mirror (control side), while the left side applied the device (device side) as retraction method. After initial penetration into tissue, the needle was slowly advanced apically towards the infraorbital foramen. Once at the deposition site, a supervising investigator verified the depth of insertion and delivery of ASA injection using 0.9 ml of the anesthetic (Fig. 3). Upon reaching the insertion depth, the DCP aspirated during the delivery of the anesthetic to confirm that they were not within a blood vessel, and was verified by the supervising investigator.

If aspiration tests were negative, the same syringe and remaining 0.9 ml of anesthetic were administered on the device side, but a new 27 gauge needle was assembled. If aspiration tests were positive, indicated by the entrance of blood into the anesthetic cartridge, then the cartridge and needle were replaced.

Per the manufacturer's training video, the DCPs were instructed to install the disposable tip onto the device in the view of the patient. The DCPs then placed the device over the back part of the patient's hand and communicated to the patient an initial perception of what the device would feel and sound like. The tissue on the device side was



**Figure 3.** Control side featuring mirror retraction



**Figure 4.** Device side featuring device retraction

prepared exactly as on the control side, including topical application after drying the insertion site with 2x2 gauze. Prior to the injection, the device was placed in the mouth over the area of the insertion site and kept on for five seconds. The needle was inserted in close proximity to one of the two tip prongs, and advanced to the deposition site where anesthetic (0.9 ml) was delivered through an ASA injection (Fig. 4). Verification of insertion depth, amount deposited, and aspiration tests were conducted by both the DCP and the supervising investigator. Upon completion of the delivery of the anesthetic, the needle was removed from the mucosa, and the device remained on for an additional five seconds as instructed by the manufacturer.

The DCPs were given a one page survey (appendix 1) and asked to circle their preferred answer. The questions from the survey inquired about the DCP's perception regarding the study. Question 1 asked if the DCP was compliant with watching the training video for the device. Question 2 asked about anxiousness and comfort when delivering the ASA injection on the control side. Question 3 asked about anxiousness and comfort when delivering the ASA injection on the device side. Question 4 asked the DCPs about their preferred retraction method. Question 5 asked the DCP's which retraction method is perceived as easier.

Chi-square tests of goodness-of-fit were conducted to investigate whether there was a significant

difference in the proportion of respondents that chose the various categories within one criterion. In a few surveys, the DCPs chose multiple preferences among the given answers making cross statistical studies meaningless. As a result, these respondents were not part of the analyses, leading to some missing data.

### 3. Results

62 DCPs participated and there were no reported NSIs. The DCP's were compliant with watching the recommended training video from the manufacturer. Regarding comfort and confidence, about the delivery of the anesthesia on the control side, 11 stated they felt "uncomfortable and anxious" while the remaining 51 responded favorably: "comfortable and confident" leading to a p-value of less than 0.001. The p-value confirms that the proportion of participants who felt comfortable and confident was significantly higher than the proportion that felt uncomfortable and anxious (Table 1).

When asked about comfort and confidence during the delivery of the anesthesia on the device side, 17 DCPs answered they felt "uncomfortable and anxious" while the remaining 45 stated they were "comfortable and confident" leading to a p-value of less than 0.001 (Table 2). As in the previous case, this p-value indicates that the proportion of participants who felt comfortable and confident was significantly higher than the proportion that felt uncomfortable and anxious.

**Table 1. During Delivery on Control Side**

Comfortable and Confident	Uncomfortable and anxious	p value
51	11	< 0.001

**Table 2. During Delivery on Device Side**

Comfortable and Confident	Uncomfortable and anxious	p value
45	17	< 0.001

The participants were then asked about their preference of the retraction method; 22 responded they preferred the mirror to be used for the delivery of the anesthesia, 29 preferred the device, and 3 preferred their finger as retraction (Table 3). Due to the small number in the last group, it was not possible to conduct a formal statistical analysis.

**Table 3. Preference of retraction method**

Mirror	Device	Finger
22	29	3

**Table 4. Retraction Method that was easier**

Mirror	Device	Finger	p value
30	18	10	< 0.005

However, when asked to choose the method that was easier, 30 chose the mirror, 18 the device, and 10 said using their finger for retraction was easier (Table 4). This resulted in a p-value of 0.005, which indicates that there is a significant difference in the proportions of participants choosing the three different methods.

**4. Discussion**

The results from this study relate with the conclusion from Haskell et. al, that novice practitioners can become comfortable with a learned technique using mirror retraction to deliver anesthesia<sup>19</sup>. From the results, the porportion of participants who felt comfortable and confident, was significantly greater than that of the other porportion feeling uncomfortable and anxious (p-value <0.001).

In some cases, as with learning how to use a new device, 27% of the DCP’s expressed anxiousness and discomfort. Limited evidence exists assessing anxiousness and discomfort of the DCP when “trying out” novel devices.<sup>20</sup> Our results coincide with studies stating possible nervousness or fear may exist in some people as there is an introduction of a new stiumuli.<sup>19,21-23</sup>

The results indicate 94% of the DCPs prefer to use a method of retraction other than their finger for delivery of dental anesthesia. The use of a finger for retraction during anesthesia guides the operator with palpating necessary landmarks prior to the injection,<sup>24</sup> in addition to the retraction of the mucosa. As mentioned earlier, leaving the finger intraorally during anesthesia delivery puts the retracting hand of the DCP at risk for an NSI.<sup>8,9</sup> Regarding which retraction was easier for the DCP, 83% of the DCPs stated that the alternative retraction (mirror or device) was easier than using the finger lending to a p value less than 0.005 among the three methods.

With the many advances and innovations created for the delivery of dental anesthesia, there is a necessity to consider alternative methods of retraction while providing dental anesthesia.<sup>9</sup> There are reports discouraging DCPs from using their finger for retraction and encouraging DCPs to use a safer method to deliver local anesthesia.<sup>13,25,26</sup> When changing technique, or working with a new device, DCPs need to review the clinical evaluations to gauge safety<sup>27</sup> and appropriateness of the innovative devices.

Our hypothesis and clinical implication were confirmed. Comfort and confidence with use of an

alternative retraction method (mirror and device) was found to be a constructive perception. The results reassure the profession, not just within a university clinical setting, but also in practice, that there are techniques and armamentarium available to the DCP to assist in retraction during dental anesthesia. Practitioners should consider the value of additional training to get comfortable with an easier and safer technique of delivering anesthesia,<sup>28,29</sup> especially if their learned technique was the use of a finger retraction. Clinicians may find other devices or armamentarium (tongue depressor, or alternative retractor) that may provide the same retraction method similar to the methods used in this study.

This study provides preliminary data to showcase benefits of using alternative retraction methods. The DCPs participating in this study are considered novice and show preferences and opinions different from DCPs practicing for over 10 years. More studies need to be conducted to further investigate the benefits of using a fingerless retraction method, its relation to NSIs, and its effectiveness in dental anesthesia.

**5. Conclusion**

As with providing any dental care, the dental practitioner should be comfortable and confident with the delivery of dental anesthesia. This study explored other techniques for retraction when delivering local anesthesia; an area that needs further exploration. Our results show that noninvasive techniques and armamentarium can be useful when delivering local anesthesia. Retraction techniques help in reducing the risk of NSIs, which is a benefit to the dental providers.

**Conflict of interest and financial disclosure**

The authors declare that they have no conflict of interest and there was no external source of funding for the present study.

We would like to acknowledge Bing Innovations, LLC for their support in providing supplies for use with device.

**Appendix 1:** Operator Survey for Device Study

1. Prior to using the device I watched the required training video
  - a) Yes
  - b) No
2. When delivering the anterior superior alveolar (ASA) injection using the mouth mirror for retraction, I felt
  - a) Uncomfortable and Anxious
  - b) Comfortable and Confident
3. When delivering the anterior superior alveolar (ASA) injection using the device for retraction, I felt
  - a) Uncomfortable and Anxious
  - b) Comfortable and Confident
4. The retraction method that I would prefer to use is
  - a) Mouth mirror
  - b) Dental Vibe system
  - c) Finger retraction
5. The retraction method that is easier for me to use is
  - a) Mouth mirror
  - b) Dental Vibe system
  - c) Finger retraction

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**Questions**

**Cases in literature present needlestick injury occurring**

- a. Only in Oral Surgery;
- b. When in general practice models;
- c. When finger is used to retract mucosa;
- d. Only to dentists and hygienists.

**The device used in the study features a**

- a. Disposable retraction tip;
- b. Automatic shut down if too much pressure is applied;
- c. Cordless unit;
- d. All of the above.

**Fingerless retraction during local anesthesia delivery**

- a. Is proven to be a superior retraction method;
- b. Is a difficult technique to learn;
- c. Helps to reduce risk of intraoral needlestick injury of dental provider;
- d. Is taught in all dental curriculums.

**Prior to delivery of the anterior superior alveolar (ASA) injection block, providers should**

- a. Identify the extraoral landmark
- b. Look for edentulous areas within the maxilla;
- c. Retract tissue while using finger;
- d. Confirm blood is not in cartridge container.

## REMINERALIZING POTENTIAL OF SALIVA ON PATIENTS HAVING DENTAL EROSIONS DUE TO WINE CONSUMPTION

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### ABSTRACT

**Introduction:** The aim of the study is to assess the action of a remineralizing product (calcium-phosphate-fluoride-based varnish) on the saliva remineralization capacity on patients having dental erosions caused by frequent wine consumption.

**Methodology:** The study group was made up of 15 patients who are frequent wine consumers. Unstimulated saliva was collected on the same day and at the same hour for each patient. A total amount of 0.5 ml of unstimulated saliva was placed on a glass plate, dried for 30 minutes in a thermostat at +37°C, and then studied using a Nikon Eclipse E 600. The images were saved and stored on a computer. The IMK index was determined using the formula:  $IMK = \frac{\text{number of the network areas filled with crystals}}{\text{number of the network areas projected on the entire saliva drop}}$ . The treatment plan for each patient included a five-week application of MI Varnish (GC Corporation) once a week. After 5 weeks IMK values were recorded again.

**Results:** The mean value of IMK increased from 0.33 before treatment to 0.83 after treatment. The distribution of micro-crystallization categories varied from 86% Type II before treatment to 93% Type I after treatment.

**Conclusions:** The fluor local treatment that uses varnishes containing casein phosphopeptide, tri-calcium phosphate, amorphous calcium phosphate and fluoride, increase the saliva remineralising potential and can be recommended both as preventive therapy and to counteract the erosive effect of acid oral environment on patients with dental erosions related to the frequent consumption of wine. Local treatment with GC Recaldent MI Varnish increased the remineralizing potential of saliva on patients with dental erosions due to wine consumption.

**Keywords:** erosion, wine, salivary micro-crystallization index, remineralization.

### 1. Introduction

Non-cariou lesions are chemical, mechanical and corosive complex processes. Despite the existance of numerous and various studies related to the topic, the issue is still considered a challenge for modern dentistry. Many questions remain unanswered regarding the definitions, factors and mechanisms of non-cariou lesions. Some researchers such as P. Fouchard<sup>1</sup> and others<sup>2-4</sup>

tried to explain the non-cariou dental loss as related especially to chemical exogenous and endogenous factors.

G.V. Black defined, in 1908, dental erosion as related to the effects of acid on dental tissues. He identified factors related to dental erosions as follows: defects of teeth formation, dental loss related to powder products, unknown acids, decreased saliva secretion, increased consumption of beverages, action of alkaline fluids on calcium

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salts, action of enzyme released by bacteria. Also other early studies focused on factors and processes related to dental erosions.<sup>5-7</sup>

The success of dental erosions therapy depends on the preventive and therapeutical strategy that must be focused on the risk assessment, oral hygiene practices, diet, lifestyle, medical factors. The long-term success is related to the possibilities to improve the saliva environment quality and regular application of remineralising protocols. Some studies<sup>8-15</sup> proved the effectiveness of products based on calcium and phosphate in the erosion lesion onset.

Initially, dental erosion is associated with enamel loss of a few micrometers, a process known as demineralization. Demineralization is associated to a decrease in the calcium and phosphate ions concentration. In time, the loss can affect the entire enamel layer. Factors like the remineralisation process and acquired pellicle formation can reduce the rate of dental erosion. De- and remineralisation processes alternate on long time intervals.

Remineralization is influenced by the concentration of calcium and phosphate ions in saliva. Previous studies<sup>16-19</sup> showed a direct correlation between the remineralizing capacity of saliva and the aspect of saliva crystals on microscopy analysis. Patients having high remineralizing capacity of saliva presented, in 93.5% of the cases, an aspect of fern-shaped crystals, with the highest crystals concentration in the middle of saliva drop. Patients with low remineralising capacity of saliva presented no such this structure or it was difuse in 87% of the cases and saliva presented a few crystals in the visual field or some needle-shaped crystals, homogeneously distributed or grouped to the periphery of the saliva drop.<sup>16,17</sup>

Dental erosion is influenced by a lot of internal and external factors.<sup>20-25</sup> The most important factor is considered the frequent consumption of beverages, including cola-like drinks, high acid drinks and wine.<sup>26,27</sup>

The frequent consumption of wine (alcoholism) or professional exposure to wines represent major factors in the dental erosions onset.<sup>28-30</sup> The erosive potential of red wine, white wine, and champagne is related to the presence of lactic acid, citric acid, malic acid, and tartaric acid.

The treatment of dental erosions is based on the removal of etiological factors and the use of remineralizing products containing calcium, phosphate, fluoride, magnesium, and zinc.<sup>16,22</sup>

The aim of study was to assess the action of a remineralizing product (calcium-phosphate-fluoride based varnish) on the remineralizing capacity of saliva on patients having dental erosions related to frequent wine consumption.

## 2. Metodology

The study group was made up of 15 patients who are frequent wine consumers (minimum 5 times a day), age 30-50, having dental erosions. The

patients were selected from patients treated in the Dental Clinic of the Dental Medicine Faculty, "Gr. T. Popa" University of Medicine and Pharmacy, Jassy. After clinical examination the remineralizing capacity of saliva was evaluated using micro-crystallization index (IMK). For IMK evaluation, unstimulated saliva was collected in a test tube before 12 a.m. From this saliva, 0.5 ml were applied on a microscope slide; the saliva liquid was dried for 30 minutes in 37°C temperature. The microscopy analysis was performed using Nikon Eclipse E 600, and images were recorded and stored in a computer. The IMK micro-crystallization index was calculated using the following formula:

IMK =	number of points of numbering grill projected on crystals
	number of points of numbering grill projected on saliva drop

The IMK values were divided in three types, namely high, moderate and low level of crystallization. The basic criteria for the crystals evaluation were the diameter, shape and number. The mean values of IMK between 0.6 and 1 were included in type I of crystallization, values between 0.4 and 0.6 were included in type II and values between 0 and 0.4 were included in type III. The treatment plan for each patient included a weekly application of MI Varnish (GC Corporation, Tokyo, Japan) for 5 weeks. Saliva was evaluated at the baseline and after 5 weeks.

## 3. Results

The IMK values before and after treatment are presented in Tabel 1. The mean value of IMK increased from 0.33 before treatment to 0.83 after treatment after treatment.

The distribution of the micro-crystallization categories varied from 86% Type II before treatment to 93% Type I after treatment.

The types of micro-crystallization were represented by needle-shaped, fern-shaped, tree-shaped, flake-shaped, oval-shaped or cubic-shaped crystals, as well as their multiple points or combinations (Figs 1-6).

Before treatment 86% of the IMK values were included in type II category of micro-crystallization and 14% in type III. After treatment 93% of the IMK values were included in type I and 7% in type II. The IMK values before and after treatment were statistically analysed using the Wilcoxon test. Statistically significant results were obtained when comparing the IMK values before and after treatment ( $p < 0.05$ ).

## 4. Discussion

Saliva acts as a buffer agent for various beverages. However beverages like fruit juices or wine are resistant to the acid neutralizing action of saliva and have the capacity to prolong the time of

**Table 1. IMK values at baseline and after 5 weeks of treatment using MI Varnish**

IMK values																	
																Mean	STDEV
initial	0.3	0.4	0.2	0.4	0.3	0.3	0.4	0.5	0.3	0.3	0.2	0.5	0.2	0.3	0.4	0.333	0.097
after treat.	0.7	0.8	0.6	0.9	0.7	1	0.8	0.9	0.8	0.9	0.8	1	0.8	0.9	0.9	0.833	0.111



**Figure 1.** IMK = 0,2



**Figure 2.** IMK = 0,8



**Figure 3.** IMK = 0,4



**Figure 4.** IMK = 0,8



**Figure 5.** IMK = 0,3



**Figure 6.** IMK = 0,8

**Figures 1-6.** Examples of saliva micro-crystallization aspects

pH dropping. The development, evolution and prognostic of dental erosion depend on the frequency and duration of the acid exposure. The protective biological factors against erosive factors are saliva and acquired pellicle.<sup>31-33</sup> The remineralizing ability of saliva is influenced both by the minerals levels and the quality and levels of salivary mucins. Mucins are proteins that participate in the saliva bio-crystallization processes and influence directly the increase and development of salivary biocrystals. Salivary mucins also influence the diameter and shape of the anorganic deposits and the type of crystallization in IMK test.

Lennon AM et al.<sup>34</sup> assessed in vitro the protective ability of a casein-calcium phosphate tooth against dental erosions. The researchers concluded that 12500 ppm AMF gels supply the most effective protection against dental erosion.

The mechanism by which the products containing casein-calcium phosphate reduce erosion is not clearly established yet. Except for the prevention of dental hard tissues demineralization, it was suggested that the product also remineralizes (repairs) eroded enamel and dentine crystals. Ramalingam observed a superficial granular structure formed on the enamel surface. It is highly possible for these structures to represent remineralized enamel crystals.<sup>11</sup>

Our study proved that local treatment with RECALDENT™ (CPP-ACP) MI Varnish™ influences the remineralizing potential of saliva for patients with dental erosions by increasing the mean IMK value after treatment. The crystallization types also improved significantly. In our study, prior to treatment, most of the patients presented the highest crystals concentration in the middle of saliva droplet. Other studies showed that patients having dental erosions presented separated crystals in the form of a branch or stem, placed relatively evenly over the whole surface of the dried droplet or a large amount of separated stellate crystals of an oval and irregular shape located isometrically.<sup>35</sup>

The major components of the varnish that we tested were casein phosphopeptide, calcium phosphate, amorphous calcium phosphate and fluoride. They can contribute to increase the remineralising potential of saliva and to arrest the erosive effect. Previous studies showed that other products having similar components (Tooth Mousse, GC Corporation, Tokyo, Japan) have good control on tooth erosion, possibly due to anticariogenic remineralizing agent represented by casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) nanocomplex.<sup>36</sup>

The reduction in tooth erosion induced by white wine consumption was clearly demonstrated by Manton (2010) and Piekarz C (2008).<sup>9,10</sup>

In the absence of a device focused on the early detection of dental erosions, the clinical aspect and the practitioner's experience contribute to the accurate detection in the early stages.<sup>6,9-13,34</sup>

IMK evaluation is an affordable test to monitor the effectiveness of the non-operative, preventive methods. The methodology is simple, accessible and inexpensive. The principal components of this varnish, casein phosphopeptide (CPP-ACP) calcium phosphate, amorphous calcium phosphate and fluoride, can contribute to the increase of saliva remineralising potential and to arresting the erosive effect. GC Recaldent MI Varnish can be recommended to counteract the erosive effect of wine and acid beverages.

## 5. Conclusions

The use of varnishes containing casein phosphopeptide, calcium phosphate, amorphous calcium phosphate and fluoride increases the remineralizing potential of saliva for patients having dental erosions related to frequent wine consumption.

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Dr. Nicoleta Tofan has published 2 articles in Chemistry Magazine (December 2015) and in Romanian Journal of Oral Rehabilitation.

## Questions

### **Researches of Leus showed that the patients with low remineralizing capacity of saliva presented in microscopy**

- a. A „fern” aspect of saliva crystals;
- b. A few crystals in visual field or needle-shaped crystals;
- c. The highest crystals concentration in the middle of saliva drop;
- d. A „corncob” aspect of saliva crystals.

### **The erosive potential of red wine, white wine, and champagne is related to the presence of:**

- a. Lactic acid, phosphoric acid, tartaric acid;
- b. Citric acid, phosphoric acid, malic acid;
- c. Lactic acid, citric acid, malic acid, tartaric acid;
- d. Stearic acid, linoleic acid, malic acid.

### **The use of MI Varnish containing casein phosphopeptide, calcium phosphate, amorphous calcium phosphate and fluoride:**

- a. Increased only the mean IMK values;
- b. Had no effect on IMK values;
- c. Decreased the type of saliva crystallization;
- d. Increased the mean IMK values and type of saliva crystallization.

### **The types of saliva micro-crystallization were represented by:**

- a. Needle-shaped crystals;
- b. Tree-shaped crystals;
- c. Cubic-shaped crystals;
- d. All the previous answers are correct.

## APICOECTOMY TREATMENT OF AN IMPACTED MAXILLARY CANINE THAT RESISTED ORTHODONTICALLY FORCED ERUPTION

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### ABSTRACT

**Aim:** This case study describes a palatally impacted maxillary canine that was successfully brought into occlusion after initial resistance to orthodontically-induced forces.

**Summary:** Clinical and radiographic examinations of the impacted canine revealed a dilaceration of the apical portion of the root, which was bent, and hooked into the dense cortical bone of the nasal cavity floor. Ankylosis was excluded as the main cause of immobility. Finally, the canine was endodontically treated and an apicoectomy was performed to remove the bent tip.

**Results:** During the follow-up period, orthodontic force was applied to encourage canine movement. Fourteen months after the operation, the canine had descended to a functional occluding position. Twenty-six months after the operation, no signs of apical lesion or root resorption were observed. The dentition and occlusion remained stable.

**Key learning point:** Apical dilaceration through the cortical bone may cause immobility of an impacted canine. Apicoectomy of the bent tip following endodontic treatment of the tooth led to successful exposure and eruption of the canine, with a favorable prognosis.

**Keywords:** apicoectomy, impacted tooth, canine guidance.

### 1. Introduction

Maxillary canine impaction occurs with a reported prevalence of 0.8-3.3%, as opposed to impacted mandibular canines, which occur less frequently.<sup>1-4</sup> Specifically, impacted canines with palatal displacements occur at a ratio of 1:3 compared to those with labial displacements.<sup>5</sup> Several etiologies have been identified that may potentially lead to impaction of a canine. For example, canine impaction may be due to failed resorption of the deciduous tooth root; early loss of the deciduous teeth, followed by lack of space in the arch; dislocation of the impacted canine and an abnormal eruption path; blockage of the eruption, due to the presence of a pathological entity in close proximity to the tooth (e.g., cysts, odontomas or supernumerary teeth); dental

crowding; root dilacerations; or even failure of the eruption mechanism. Also, an eruption may be obstructed by mucosa thickening after trauma or extraction.<sup>5</sup> It is important to identify the cause of impaction before treatment, to ensure the proper counteractive measure is included in a suitable treatment plan. Although lack of sufficient space is the most frequent etiologic factor for impaction of a maxillary canine, it has been found that palatally impacted canines are most often associated with sufficient space in the arch.<sup>6</sup>

Therefore, another cause or combination of causes should also be considered, when determining the etiology. The present report presents a case of a maxillary impacted canine that resisted an orthodontically forced eruption. Here, the treatment sequence is described, with a 1-year postoperative follow-up.

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**Figure 1.** Panoramic radiograph of the impacted right upper canine at its initial location

## 2. Case Report

A 26-year-old male was referred to the polyclinic for dental treatment. The clinical investigation revealed agenesis of the lower second premolars with residual space at location 45 and a retained tooth 75. Additionally, impactions were present at positions 15 and 13, with residual space at position 15 and a retained tooth 53, respectively (Fig. 1). The dental arches were not crowded; spaces between the teeth were observed in both the upper and lower jaws.

The suggested starting orthodontic treatment was to place a fixed appliance in the upper jaw to open the pathways for normal eruptions of teeth 15 and 13. We decided to treat the edentulous space at position 45 with an implant at a later date. The patient's consent was received, and the treatment plan commenced.

After 6 months, tooth 38 was extracted, due to recurrent pericoronitis, and tooth 53 was removed in the same session. The lingually-located, impacted canine (tooth 13) was exposed with a high degree of complexity, due to its deep impaction behind the root of tooth 12. A bracket was placed on the disto-palatal surface of tooth 13. Twelve months after the canine was exposed surgically, its downward movement had halted, despite the well-prepared exposure, the firm attachment of the bracket, the sufficient space, and the favorable eruption orientation.

The canine was tested for ankylosis with the PerioTest Classic (MedizinTechnik Gulden e.K, Modautal, Germany). The test result indicated normal mobility, with no suspicion of ankylosis. A radiographic examination with panoramic radiography (Orthophos XG Plus, Sirona, Germany) revealed that the canine was bent in the apical region. The apex was curved towards the cortical bone that forms the floor of the nasal cavity, and it anchored the canine in an impacted position. Further examination with cone beam computed tomography CBCT (Galileos, Sirona, Germany) and visualization of planar reconstructions

confirmed that the bent apical region was hooked into the cortical border of the nasal floor (Fig. 2). This morphologic characteristic of the canine apex was suspected to be the primary reason that the effort to force the tooth to its functional position was unsuccessful. Next, the recipient site of tooth eruption was examined both clinically and with CBCT reconstructions. The results revealed bone incompetence at the alveolar ridge and a palatal mucosal defect.

Therefore, autotransplantation of the canine was not considered feasible. The last alternative treatment option suggested for this case was the endodontic treatment of the exposed canine, followed by apicoectomy of the bent apical portion, which was anchored to the cortex.

The decision was based on the assumption that the downward movement of the canine along its normal eruption path was hindered by the anchoring of the bent apical portion in the dense bone. This anchor would not allow tooth advancement, regardless of the amount of force applied.

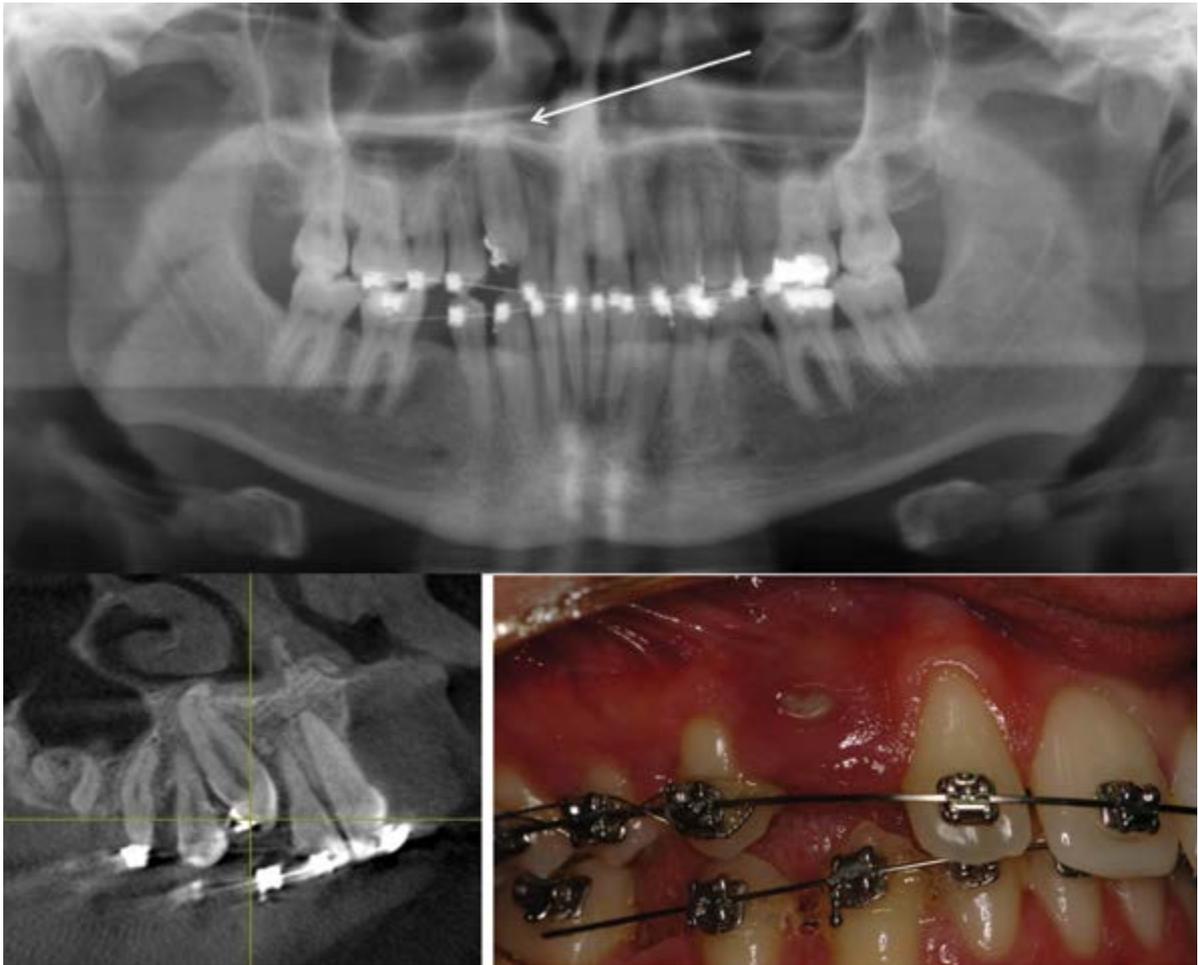
The patient was informed and agreed to the treatment plan, and the operation was scheduled. The endodontic treatment was performed 18 months after exposure of the impacted canine.

The root canal was prepared and filled to the apical bend.

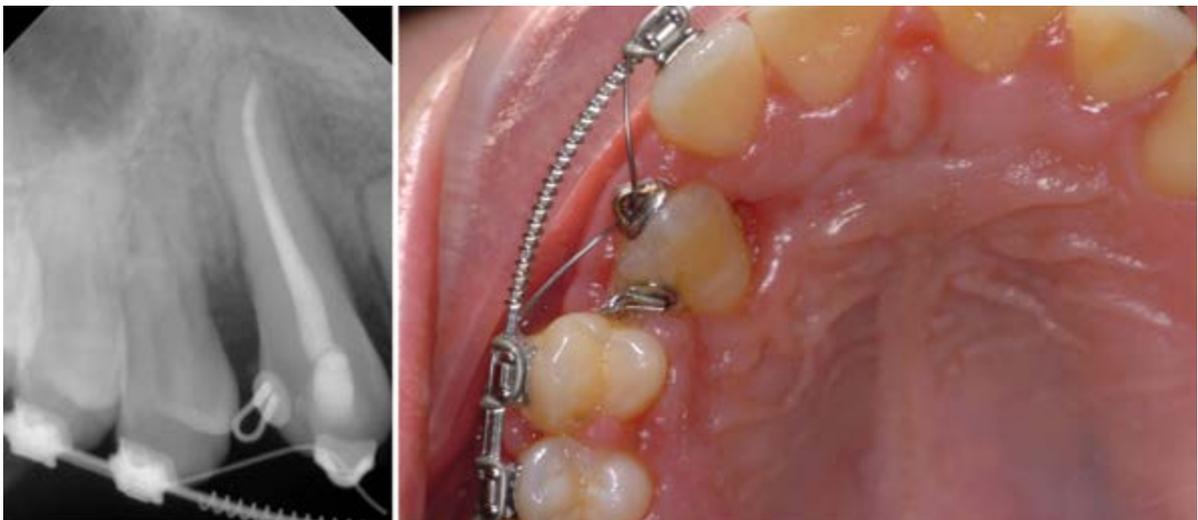
An apicoectomy followed, under local anesthesia, essentially to remove the hooked apical portion of the tooth from the compact floor of the nasal cavity (Fig. 3). An initial post-operative control follow-up was performed a week after the operation.

Normal healing was observed, and the patient was asked to return for another follow-up appointment after the orthodontic treatment. The first recall took place 14 months after the operation. The canine had positively reacted to the treatment. During the post-operative period, force was applied on the bracket, and the canine had descended to its functional occlusion position.

At the next recall, 20 months postoperatively, no



**Figure 2.** Panoramic radiograph and a CBCT reconstruction show the apical bend in the canine, which anchored it to the cortical bone of the nasal cavity floor. The canine could not descend to eruption, despite sufficient space and orthodontically-induced forces



**Figure 3.** One week after apicoectomy of the apical bend, and after endodontic treatment

evidence of lesion or resorption was observed, and a third (last) follow-up appointment was scheduled (Fig. 4). At the last follow-up, 26 months postoperatively, a complete clinical and radiographic examination was performed. It included a panoramic radiograph and a CBCT scan, with lateral and cross-sectional reconstructions. The patient was symptom-free, and the right

maxillary canine had maintained its functional position. There were no radiographic signs of periapical lesion or root resorption. The lamina dura was visible and the periodontal ligament space was normal. The radiographic examination showed a reduction of the alveolar bone height around the canine; this reduction was attributed to generalized periodontitis (Fig. 5).



**Figure 4.** Postoperative follow-ups show successful results. The panoramic radiograph taken 20 months postoperatively shows no further signs of a periapical lesion or root resorption



**Figure 5.** Two-year postoperative follow-up. Panoramic radiograph, CBCT lateral and cross-sectional reconstructions, and clinical photographs show the right maxillary canine in functional occlusion with no sign of periapical lesion or root resorption. The lamina dura is visible, and the periodontal ligament space is normal

### 3. Discussion

Maxillary canine impaction is a well-documented dental condition. Many etiologic factors have been described in the literature.<sup>7,8,9</sup> Impacted maxillary canines typically require a multidisciplinary approach. A correct diagnosis of the predisposing factors that cause tooth immobility is important for setting up a successful treatment plan<sup>10</sup>. Lack of space is a frequently reported cause of impaction, but palatally impacted maxillary canines have been associated with sufficient space in the dental arch.<sup>5,6</sup>

This association was consistent with the clinical situation in the present case study; no crowding was observed at the recipient site, and the remaining space was favorable. With the first orthodontic treatment, the canine was exposed and a bracket was placed to force its eruption. Nevertheless, the impacted canine resisted the orthodontically-induced forces, which raised the suspicion of an ankylosis. However, ankylosis could be ruled out, based on results from mobility tests on the exposed canine crown and radiography (CBCT scan) of the periodontal ligament space around the root.

We next investigated a probable cause for the lack of mobility by examining reconstructions of the CBCT data in all planes. Finally, we found a morphological discrepancy of the canine that could explain the clinical situation; that is, we found an apical bend at the canine tip, which passed through the cortex of the nasal floor.

Autotransplantation was the first treatment alternative suggested, based on sufficient reports in the literature about successful rates in treating maxillary impacted canines;<sup>11, 12</sup> moreover, the recipient site had been opened orthodontically. However, an important factor in the prognosis of an autotransplanted tooth is the competence of the alveolar bone and the surrounding soft tissues in the recipient zone.

It is generally assumed that the periodontal ligament will not initiate osteogenesis in the absence of adjacent bone. Furthermore, wound closure with a gingival flap is a key factor in successful healing.<sup>13,14</sup> In our case, the canine had

previously been exposed and had commenced descent towards the alveolar ridge before halting. However, we detected defects in the supporting bone tissue and the mucosa. Due to the lingual localization of these defects, we suspected that the condition of these tissues would deteriorate after the surgical removal of the canine.

Moreover, because these types of bony defects do not close optimally,<sup>15</sup> they may potentially persist as periodontal defects after transplantation. Thus, the prognosis of an autotransplanted tooth was considered unfavorable.

The key to successful treatment for this patient was a careful assessment of the clinical situation, combined with early identification of the true cause of immobility (i.e., the dilaceration of the canine root apex, which anchored the canine to the cortical bone of the nasal floor).

The only alternative treatment option would have been an extraction of the immobile canine. Instead, we hypothesized that the hooked apical root tip had provided resistance to guided eruption. Therefore, we performed an apicoectomy of the anchored portion, after endodontically treating the exposed canine.

The follow-up examination performed 14 months postoperatively supported our hypothesis, because removal of the hindering factor allowed the canine to react positively, by promptly descending to its functional position with guided eruption.

A second follow-up examination was performed 26 months postoperatively. The treatment outcome was stable, as shown by the absence of mobility, resorption, periapical lesion, or recurrence of impaction.

In conclusion, an apical dilaceration through the cortical bone may immobilize an impacted canine. After treating the tooth endodontically, an apicoectomy of the bent tip can facilitate canine exposure and eruption, with a favorable prognosis.

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## CV

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His professional field of interest is in orthognathic and orthodontic surgery and trigeminal nerve dysfunction. Clinical research projects include prevention and repair of iatrogenic trigeminal nerve injury; transplantation of teeth and orthognathic surgery.

## Questions

### Impacted canines are most frequently found:

- a. In the palate;
- b. Buccally in the maxilla;
- c. Midcrestal in the maxilla;
- d. In the mandible.

### Buccal displacement of maxillary canines is mostly caused by:

- a. An insufficient dental arch length;
- b. An odontoma;
- c. Compact bone;
- d. A PTHR1 gene mutation.

### Following syndrome is not associated with eruption disorders of teeth:

- a. GAPO-syndrome;
- b. Gardner syndrome;
- c. Dysostosis cleidocranialis;
- d. Gorlin-Gotz syndrome.

### Following sign is not a landmark sign of ankylosis after a heterotopic transplantation of an impacted canine:

- a. Pulp obliteration;
- b. Loss of lamina dura;
- c. Failure to respond to orthodontic forces;
- d. Replacement resorption.

## CHRONIC APICAL PERIODONTITIS IN CHRONIC KIDNEY DISEASE PATIENTS

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### ABSTRACT

**Introduction:** The involvement of oral-dental infectious pathology in triggering or worsening kidney diseases has been known for a long time. The purpose of this study was to evaluate the prevalence of chronic apical periodontitis in a group of chronic kidney disease patients and their relationship with the parameters related to renal function.

**Methodology:** Medical parameters of 51 predialysed adults were extracted from the observation charts of the hospital using a registration form. Chronic apical periodontitis has been diagnosed on periapical radiographs by the presence of any radiolucent areas detected in the apical third of teeth.

**Results:** 29.41% of patients had no periapical lesion, 33.33% had one periapical lesion, 17.64% had 2 periapical lesions and the remaining 19.62% had at least three periapical lesions. Chronic apical periodontitis was not statistically significantly associated with any of the demographic variables. Lower serum albumin levels were significantly associated with a greater number of periapical lesions. In addition, the large number of chronic apical periodontitis was significantly associated with high values of cholesterol.

**Conclusion:** The detection of some abnormal cholesterol and albumin levels during regular investigations of patients with chronic renal failure, require a mandatory dental visits that will be associated with a radiological examination to detect chronic apical periodontitis. The results obtained in our study emphasize the importance of radiological examinations for all patients, prior to kidney transplantation, since they may have teeth with inflammatory lesions, which cannot be clinically detected.

**Keywords:** chronic apical periodontitis, predialysed patients, cholesterol, albumin.

### 1. Introduction

The oral health of patients with chronic kidney disease (CKD) has become a subject of intense investigation in recent years, not only due to the oral and systemic manifestations of the disease but also due to treatment-related complications. Moreover, the chronic kidney disease is a disease whose incidence is steadily increasing and as a result, a large number of patients are seeking dental care. The possibility that events in the oral cavity may influence systemic diseases has been highlighted by numerous studies on associations and interactions between oral diseases and cardiovascular diseases, myocardial infarction, manifestations during pregnancy, diabetes, and bacterial pneumonia. Research conducted has

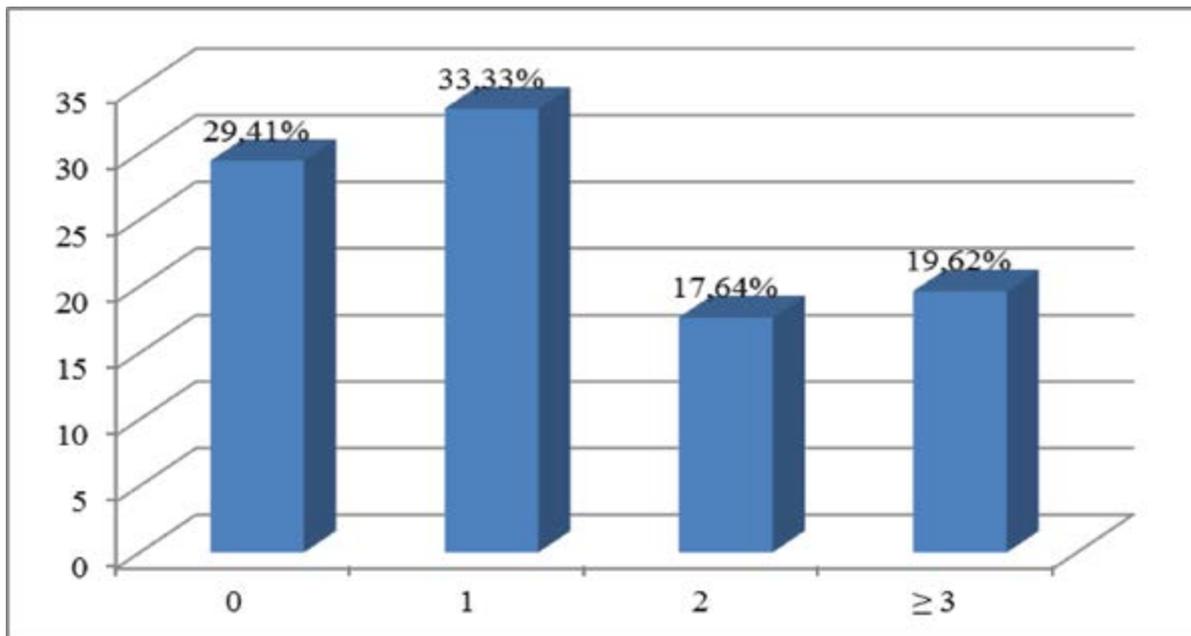
included epidemiological studies, intervention studies and studies that have attempted to elucidate the mechanisms of action. The results were occasionally contradictory, which is not surprising, given the variations in study designs, populations studied and the statistical analysis used for the studies.<sup>1</sup> The involvement of oral-dental infectious pathology in triggering or worsening kidney diseases has been known for a long time.<sup>2</sup> Most evidence gathered involve infectious outbreak, located in the oral cavity, ingravescence of chronic glomerulonephritis with mesangial deposits of IgA, but also in updating and increasing the rate of other renal diseases progression. In this context, the identification of sources of inflammation in patients with CKD and their removal is a matter of great interest in nephrology but also in cardiology

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**Figure 1.** Prevalence of chronic apical periodontitis in the group of patients

and in other specialties.

Apical periodontitis are oral inflammatory disorders associated with systemic inflammatory changes. Endodontic infections are characterized by the presence of some soluble bacterial products with a strong pro-inflammatory potential. Lipopolysaccharides, present and released from the gram-negative cell walls, are components of endodontic bacteria best described to induce cytokines and other inflammatory components as  $IFN\gamma$ ,  $IL-1\alpha$  and  $\beta$ ,  $IL6$ ,  $IL8$ ,  $TNF\alpha$ .<sup>3</sup>

The purpose of this study was to evaluate the prevalence of chronic apical periodontitis in a group of chronic kidney disease patients and their relationship with the parameters related to the renal function.

## 2. Materials and methods

51 predialysed adults were included in this study that was approved by the Ethical Committee of the "Carol Davila" University of Medicine and Pharmacy, number 31 on August 9, 2014. They were known for at least one year to have CKD ( $GFR < 60\text{ ml / min / }1.73\text{ m}^2$ ), had the ability to understand the protocol and signed the informed consent form. Bimaxillary edentulous patients under immunosuppressive treatment, those with mental retardation, mental illness or malignancy, pregnant or lactating women were excluded.

The medical parameters were extracted from the observation charts of the hospital using a registration form that included: age, gender, residence, education level, smoker/non-smoker status, the diagnosis of basic kidney disease, current level eGFRs, the stage of CKD, association or not with diabetes or not, acid-base balance parameters of bone mineral metabolism, anthropometric and biochemical parameters of nutritional status, hematological changes and state of systemic inflammation. Panoramic radiographs

were performed to diagnose chronic periapical dental infections or other pathology existing in the bone tissue. Retroalveolar X-rays were indicated by the contributor specialist radiologist after seeing the orthopantomograms, for those cases where he considered them to correctly diagnose chronic apical periodontitis. Chronic apical periodontitis has been diagnosed by the presence of any radiolucent areas detected in the apical third of teeth. The diagrams were made using Microsoft Excel 2007, and the statistical analysis was performed using SPSS statistical analysis software version 19. Statistical correlations between variables were tested by using the tool **Analyze→Correlate→Bivariate**.

## 3. Results

Chronic apical periodontitis was diagnosed radiographically and confirmed by the presence of any radiolucent areas detected in the apical third of teeth. Thus, 29.41% of patients had no periapical lesion, 33.33% had one periapical lesion, 17.64% had 2 periapical lesions and the remaining 19.62% had at least three periapical lesions (Fig. 1). Chronic apical periodontitis were not statistically significantly associated with any of the demographic variables (Table 1).

In exchange, lower serum albumin levels were significantly associated with a greater number of periapical lesions. In addition, the large number of chronic apical periodontitis was significantly associated with high values of cholesterol. There was evidenced no significant relationship between chronic apical periodontitis on the one hand, and smoking, diabetes or body mass index (BMI), on the other hand (Table 2). The presence of apical lesions was not associated with any estimated glomerular filtration rate, or the chronic kidney disease stage (Table 3).

**Table 1. Relations between apical lesions and demographic variables**

	Gender	Age	Environment	Education	CKD Etiology
<b>Apical Lesions</b>					
Pearson Correlation	.199	-.038	.083	-.141	-.095
Sig.(2-tailed)	.162	.791	.562	.322	.509
N	51	51	51	51	51

**Table 2. Relationship between chronic apical periodontitis on the one hand, and smoking, diabetes, BMI, cholesterol, serinemia, on the other hand**

	Smoking	Diabetes	BMI	Cholesterol	Albumin
<b>Apical lesions</b>					
Pearson Correlation	.119	-.199	-.010	.411**	-.440**
Sig.(2-tailed)	.404	.162	.948	.004	.002
N	51	51	48	48	48

\*\* The association is significant at  $p < 0.01$

**Table 3. Relations between apical lesions on the one hand, and eRFG, CKD stage, on the other hand**

	eRFG	CKD Stage
<b>Apical lesions</b>		
Pearson Correlation	.034	.005
Sig.(2-tailed)	.813	.972
N	50	50

**4. Discussion**

The study was performed on a group of 51 patients, the same number used by Buhlin et al,<sup>4</sup> who investigated the oro-facial health of patients with end-stage renal disease, focusing on their periodontal conditions. They showed that a substantial number of patients who suffer from chronic kidney disease have dental problems that required attention.

The investigation of infection sources in this study was complemented by panoramic radiographs, which enabled visualization of teeth together with the bone support structures. Studies using radiological analysis for patients with chronic kidney disease are limited in the literature.

In the present study, the most common radiological changes observed were deposits of calculus, dental caries and the presence of chronic apical periodontitis. For the latter, periapical radiographs were the only means of identification, approximately 70% of patients from the group investigated having at least one periapical lesion, characteristic for chronic apical periodontitis. In a similar study, Thorman et al.<sup>5</sup> compared the panoramic radiographs of 93 pre-dialytic and dialytic patients with chronic kidney disease with a control group and found an increased prevalence of periapical infections in patients from the study group.

Epidemiological studies have shown that apical periodontitis is a chronic common disease in the general population.<sup>6,7,8</sup> However, data on the

prevalence of chronic apical periodontitis vary between populations and countries, and depend on differences in the prevalence of dental caries, access to dental services and the methodology used.

Thus, a study conducted in Portugal on a group of 322 individuals resulted in a 27% prevalence of chronic apical periodontitis<sup>6</sup> and another study in Norway a 16%.<sup>7</sup> Higher values were reported in research conducted by Jiménez-Pinzón et al. in Spain (61.1%),<sup>8</sup> Loftus et. al in Ireland (33.1%),<sup>9</sup> Tsuneishi et al.<sup>10</sup> in Japan (69.8%), Demo et al.<sup>11</sup> in Belgium (63.1%).

The results of this study showed that elevated serum cholesterol levels (> 190 mg / dL) are associated with an increased number of chronic apical periodontitis.

The explanation could be given by the presence of cholesterol crystals, commonly found in biopsies of periapical lesions. It seems these crystals come from disintegrated erythrocytes present in the blood vessels stagnant inside a lesion, lymphocytes, plasma cells and macrophages (which decay into periapical lesions) and circulating plasma lipids. Once they have been deposited, cholesterol crystals act as irritants and cause foreign body reactions. Macrophages and giant cells trying to devour cholesterol crystals, but are unable to degrade crystalline cholesterol. Furthermore, macrophages exposed to cholesterol crystals apparently act like a bone lysis and thus a chronic inflammation in the periapical area is supported.<sup>12</sup>

Cholesterol is also related to another common

condition in the chronic kidney disease, the cardiovascular disease. Atherosclerosis is a multifactorial disease, which occurs at young ages and evolves with age. The presence of cholesterol crystals is also recognized in atherosclerotic plaques in humans.

Slutzki-Goldberg et al.<sup>13</sup> conducted a study in which they evaluated the possible link between age and cholesterol deposits in periapical lesions. They have examined the biopsies of lesions identified in a group of teenagers and one of elderly and found that there is a significantly increased incidence of cholesterol deposits in periapical biopsies performed in elderly individuals, where serum cholesterol levels were elevated. The cholesterol crystal formation mechanism is probably similar to the genesis of atherosclerosis.

Chronic apical periodontitis is an acute or chronic inflammatory lesion, present around the apex of a tooth and caused by a bacterial infection of the endodontic system.

Histologically, it is represented by a periapical inflammatory response that occurs after the resorption of the adjacent support bone and local infiltration of inflammatory cells.<sup>14</sup>

Thus, the significant associations, between lower serum albumin values and the high number of periapical lesions, from this study were not statistically surprising given that hypoalbuminemia (<3.5 mg / dL) can be caused by acute or chronic inflammatory responses.

## 5. Conclusions

This descriptive study showed that chronic apical periodontitis is highly prevalent in patients with chronic kidney disease, but future research is required to determine whether endodontic diseases are worsened by the chronic kidney disease or vice versa.

The detection of some abnormal cholesterol and albumin levels during the regular investigations of patients with chronic renal failure, require a mandatory dental visits that will be associated with a radiological examination to detect chronic apical periodontitis. Most often silent from a clinical point of view, chronic apical periodontitis is diagnosed accidentally or following an acute exacerbation. These are powerful outbreaks of infection with diverse microbial flora camped at this level, able to cause amplification of the inflammatory response in the chronic kidney disease. The results obtained in our study emphasize the importance of radiological examinations for all patients, prior to kidney transplantation, since they may have teeth with inflammatory lesions, which cannot be clinically detected.

According to the World Health Organization, health is an essential part of the social, economic and personal development of the individual and an important component of the quality of life. Especially in patients with CKD, the health of the oral cavity must be permanently assisted and improved in order to maintain a good overall body condition.

## Acknowledgments

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**Questions**

**How many patients were included in the study?**

- a. 24;
- b. 30;
- c. 51;
- d. 78.

**What percentage of the group had more than 3 apical lesions?**

- a. 22%;
- b. 19.62%;
- c. 29,41%;
- d. 50%.

**How was chronic apical periodontitis diagnosed?**

- a. Cone beam computed tomography;
- b. Bitewing radiographs;
- c. Panoramic radiographs;
- d. Periapical radiographs.

**Which of the following is false?**

- a. Chronic apical periodontitis was not statistically significantly associated with any of the demographic variables;
- b. Lower serum albumin levels were significantly associated with a greater number of periapical lesions;
- c. The large number of chronic apical periodontitis was not significantly associated with high values of cholesterol;
- d. The presence of apical lesions was not associated with any estimated glomerular filtration rate, or the chronic kidney disease stage.

## DIRECT VENEERS - FROM DESIGN TO IMPLEMENTATION

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### ABSTRACT

**Aim:** In a 58-year old female patient, the frontal teeth damaged by attrition were reconstructed by direct veneer technology. Frontal tooth configuration and esthetical appearance were restored. Using this case as an example, we describe the key steps of producing a direct veneer and study the scope of application of this technique and the expected lifetime of reconstructed structures.

**Summary:** The adhesive technique makes it possible to esthetically optimize such teeth which show no decay lesions without doing any damage. This way, we can also satisfy patients, who refrain from any more invasive treatment, e.g. crowning. Based on the literature data shown, it can be stated that – with appropriate indications – direct veneer restorations can be equivalent alternatives to conventional “golden standard” restorations.

**Key learning points:** 1. With the development of the adhesive technique, minimally invasive and non-invasive procedures play a bigger and bigger role in esthetic dentistry beside conventional interventions. 2. Our goal was to restore a harmonious smile, taking into account the principles of Visagismo. 3. Sufficient bonding power can only be obtained on the enamel surface, so it is reasonable to consider the indications of direct veneer if a large surface of dentin is exposed.

**Keywords:** direct veneers, smile design, composite layering, diagnostic wax-up, composite polishing.

### 1. Introduction

Beauty is a term used more and more often in our everyday life. There is nothing new about it: humans have shown great concern about their own appearance since ancient times. “Ideal beauty” is admired because it features characteristics that, in that particular culture, are associated with perfection. According to the Ancient Greek saying beauty is in the eye of the beholder, therefore there are differences in what the individual people find beautiful. Plato considered beauty to be the idea (shape) that lies above all ideas. Smile plays a key role in the beauty and esthetics of the human face. It is an accord of the mimic facial muscles, which extends even to the area of the eyes. Humans generally consider smile a sign of dearness, happiness and joyfulness, and it also radiates self-confidence and trustworthiness. Teeth are the most important elements of the overall picture of a smile. Therefore, it is not difficult to understand that there can be a correlation between the esthetic problems of one’s teeth and his/her mental and social issues. It is the duty of the dentist

with an interdisciplinary approach to identify the problem, to get to know the patient to such an extent sufficient for the treatment and to provide the complex treatment itself, with appropriate communication an important part of the latter. It can be clearly stated that the procedures used in dentistry have undergone significant development for the last years. With the development of the adhesive technique, minimally invasive and non-invasive procedures play a bigger and bigger role in esthetic dentistry beside conventional interventions.

Indications for direct veneers can be different abnormalities in terms of color, shape or position. Below is an incomplete list of cases that might call for such restorations:

#### **Color differences:**

- Hypocalcification
- Hypoplasia
- Fluorosis
- Tetracycline damage
- Discoloration (not removable by scaling and tooth whitening)
- Discoloring effects of earlier amalgam fillings
- Age-related physiological discoloration

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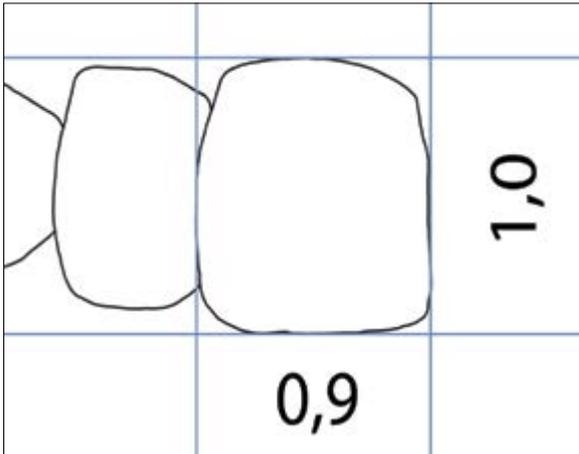
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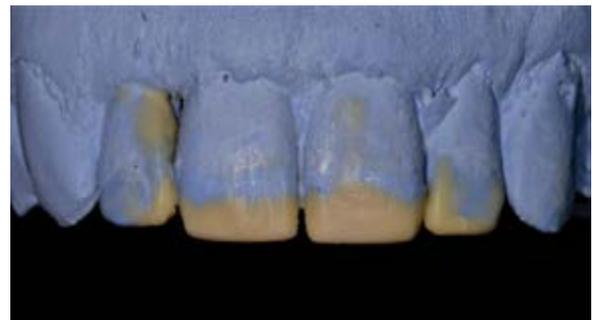
**Figure 1.** 58 - y.o. woman visiting the clinic with frontal teeth damaged by attrition



**Figure 2.** We selected a square tooth shape that matches "phlegmatic" temperament as a basis of further design



**Figure 3.** In young patients, tooth width is generally 65% of crown length. In older age, this ratio becomes generally 90% - this is what we considered in the design phase



**Figure 4.** Diagnostic wax-up

**Shape differences:**

- Asymmetry between the two sides
- Fractured teeth due to trauma
- Abrasion
- Attrition
- Erosion
- Peg lateral incisors
- Restoration of teeth replacing missing teeth by means of orthodontics

**Positional abnormalities:**

- Ectopic teeth
- Disharmony in the incisal curvature
- Diastema closure
- Anomalies in the inclination of teeth
- Torsion
- Infraocclusion
- Centerline shift

Nowadays it is obvious that we might design the patients' smiles with different characters. According to Rosenstiel et al. gender, ethnic, age group etc. determines people's thinking about the aesthetic smile character. Yet, there are people who cannot distinguish two different smile characters.<sup>1</sup> This points out the dentist's responsibility to carefully design and provide the patient with different alternatives. Paolucci et al. worked out the theory of Visagismo, which is a new approach to direct veneer design.<sup>2</sup> In their

opinion, the dissatisfaction of patients - which occurs so often in the clinical practice - is caused by the disharmony between the new smile created and the personality of the patient. Visagismo is a Portuguese word that means face shaping by means of makeup. Visagismo is a guideline for dentists and dental technologists, which helps create restorations which combine esthetical appearance with psycho-social characteristics. A personalized treatment using these guidelines may result in changes in the patient's behavior, posture and speech, too.<sup>2</sup> What does all this mean in the dentists' practice? To answer this question, it is inevitable to define Hippocrates' four temperaments (personality types). The first is **choleric/strong**: assertive, objective, vigorous and passionate. The second is **sanguine/dynamic**: hearty, open-minded, talkative, joyful, brimming and enthusiastic. The third is **melancholic/emotion-oriented**: organized, perfectionist, restrained, shy. The fourth is **phlegmatic/peaceful**: tactful, non-violent, mysterious, idealistic, and prone to apathy and conformity. Paolucci et al. defined the characteristics of the teeth matching each temperament as follows<sup>2</sup>:

**Choleric/strong:** Rectangular incisors, dominant central incisors, flat incisal edges, sharp cusps, vertical longitudinal axes;

**Sanguine/dynamic:** Triangular incisors, upward-arching smile line, converging tooth angles, inclined cusps;

**Melancholic/emotion-oriented:** Oval incisors, dominant central incisors, rounded cusps, delicate lateral incisors, round frontal tooth arch;

**Phlegmatic/peaceful:** Square incisors, lack of dominance, divergent tooth axes, horizontal



**Figure 5.** After creating the mock-up, it is possible to do corrections intraorally upon the patient's request



**Figure 6.** Enamel prepared off to 45 degrees and the silicon key



**Figure 7.** The completed palatal enamel



**Figure 8.** Upon the patient's request, we wanted to give the frontal teeth a youthful characters and that's how we applied the dentin color shade, too.



**Figure 9.** Restoration after applying the enamel layer



**Figure 10.** The character of the teeth matches the requirements of the original plan

configuration.<sup>2,3</sup> The above-mentioned features show that it may be necessary to learn the patient's personality in order to set up a complex esthetical treatment plan.

## 2. Case report

In our example case, the patient was a 58-year old female, who visited the clinic with frontal teeth damaged by attrition. She had a good and stable periodontal situation, did not smoke and had no other illnesses. In terms of functional pathology, no abnormalities were found, therefore no other treatment was necessary. We assume that abrasion had been caused by a previous (already removed) bridge in the lateral region and bruxism induced by it (Fig. 1). Our goal was to restore a harmonious smile, taking into account the principles of Visagismo. Based on intensive communication with the patient, we managed to find a balance between her requirements and what was feasible.

After long talks with her, we chose the square tooth shape, being characteristic of a primarily "phlegmatic" temperament, as the basis of the further stages of the design process (Fig. 2).

It was inevitable to take the patient's age into account. Younger patients' smiles are generally characterized by longer, rectangle-shaped central incisors, more marked edges, mamelons, HALO effects, visible perikymata and surface grooves, brighter colors, etc. (Fig. 3) These characteristics are different in older patients. Incisors tend to be shorter, and individual features (edge transparency, mamelons, HALO effect, perikymata, etc.) are significantly less or not at all visible on the teeth.<sup>4</sup> The diagnostic wax-up was produced by the dental technician with these in mind and computer-aided design. The visualization plan created was discussed with the patient in detail and we outlined the options to her. After the diagnostic wax-up, the



**Figure 11.** The completed restoration



**Figure 13.** Six-month checkup. Teeth 21, 22 showed that the closure line at the edge had become minimally visible

silicone impression key was created in order to manufacture the intraoral mock-up (Fig. 4).<sup>5</sup> During the next session, the mock-up was created, which we used to demonstrate to the patient her later treatment options. By re-shaping the mock-up, it was possible to finalize the planned shape. (Fig. 5)

### 2.1. Preparing the teeth

After obtaining the desired shape, we prepared a silicon key intraorally for the final restoration. Thereafter, we carefully removed the composite material used for the mock-up. We chose the A3 tooth shade by using Vita Classic shade guide. We put - whitout adhesive technique - a minimal amount of the appropriate dentin and enamel on the tooth, which were removed after reviewing the shade. After that we prepared the enamel edges off to 45 degrees (Fig. 6). An important step is to select the appropriate tooth color shade before isolating, before the tooth material dehydrates. Thereafter, the dental rubber dam, which is essential in such restoration works, is put into place. We conditioned the surface by means of total etch technology - 37% orthophosphoric acid for 40 seconds, Adper Single Bond 2 Adhesive (3M ESPE, St. Paul, MN 55144-1000, USA).<sup>6</sup>

### 2.2. The composite layering technique

The first step was to put the palatal enamel to teeth upper right and upper left central and lateral incisor (Filtek Ultimate A3 Enamel, 3M ESPE, USA). We used a vertically cut silicon block in the process (Fig. 7). Upon to the patient's request, we intended to give a youthful character to the frontal teeth - we



**Figure 12.** The relative widths of the teeth can be evaluated. It is visible that the ratio of the large and small incisors complies with the "golden standard" and the relative width of the two canines is larger than the "golden standard"

applied the dentin color shade accordingly (Filtek Ultimate A3 Dentine, 3M ESPE, USA).<sup>7</sup> We believed that any more marked edge transparency or HALO effect was not necessary, so we could proceed to the application of buccal enamel (Fig. 8).<sup>8</sup> During the application of enamel layers, we used Teflon tape to isolate the individual teeth from each other (Fig. 9). Using a silicon brush (Micerium S.p.A, Avegno (Ge), Italy) was a great help for us in working out the surface. The sticking of the brush can further be reduced using Composite Primer (GC, Tokyo, Japan).<sup>9</sup> Special care must be taken not to break the morphologic elements of existing tooth material in the restored part but to "continue" them carefully (Fig. 10).<sup>10</sup>

### 2.3. Lifelike shaping of the characters and polishing

The characters were created in a lifelike way during finishing/polishing. As a first step, we used FG mounted Arkansas stone at 40,000 RPM with water cooling to create the above-mentioned morphologic elements, correct the routing of marginal ridges and create the final shape of the surfaces. To polish approximal area, we used Super-Snap (Shofu Dental Corporation, Kyoto, Japan) disks.<sup>11</sup> Then, we reworked the surface using FG mounted Arkansas stone at low RPM and 3-micron polishing paste - SuperPolish (Kerr SA, Bioggio, Switzerland). The final polishing was carried out with the appropriate steps of the ENA Shiny polishing system (Micerium S.p.A (Ge), Avegno, Italy).<sup>12</sup> Studying the complete restoration, the relative widths of the teeth can be evaluated. It can be seen that the ratio of the large and small incisors meets the „golden standard" (Fig. 11).<sup>13</sup> The relative width of the two canines is larger than the "golden standard" value, but the dominant canines do not have any disconcerting effect on the patient's smile (Fig. 12).<sup>14</sup> At the six-month checkup, the clinical situation was as follows (Fig. 13). The patient was completely satisfied with the restoration (Fig. 14). At the examination, we found the restoration to be intact; the closure line at the edge had become minimally visible at teeth upper left central and lateral incisor. We removed this by polishing (Super-Snap, Shofu Dental Corporation,



**Figure 14.** The content smile of the patient



**Figure 15.** Smile of the patient



**Figure 16.** Smile of the patient

Kyoto, Japan) by replacing the upper lateral bridges on both sides, we created an esthetic smile that met the requirements of our patient, too (Fig. 15).

### 3. Discussion

Many studies prove the usability of direct veneers in the everyday dental practice. Frese et al.<sup>15</sup> conducted a five-year follow-up study on 176 direct veneers. All veneers were made without preparatory works in order to provide color and shape correction at the Conservative Dental Clinic of Heidelberg University, Germany. After the follow-up period, the restorations were grouped into three categories: „failure“, „survival“ and „success“. Damage occurred in 30 cases, but all of them could be repaired, so they belonged to the “surviving” group. In the end, no restoration was classified as “failure”. This made the five-year survival rate to be 100% in this group, whose size can be considered as statistically significant. With the faults taken into account, the success rate was 84.6%.<sup>15</sup> Garcia-Godoy et al. conducted a 6-year follow-up study on in vitro and in vivo restorations.<sup>14</sup> In vitro, they fitted MO restoration to 32 extracted human teeth, then exposed them to various influences for 6 years in a randomized way (immersion in water, thermo-mechanical load, both). In the in vivo group, direct restorations were fitted into 68 teeth of 30 individuals in total. After 6 years, the closure at the edges was evaluated. The in vitro experiments showed an 85 to 100-percent success for the enamel, while a 42 to 52-percent

one for the dentin. In the in vivo group, the edge closure was intact in 75 to 90 percent for the enamel.

It was shown that there were significant differences between the enamel and the dentin.<sup>16</sup> In a third case, Gresnigt et al. monitored 96 direct veneer restorations for more than 40 months. Survival rate was 87.5%.<sup>17</sup> The adhesive technique makes it possible to esthetically optimize such teeth which show no decay lesions without doing any damage. This way, we can also satisfy patients who refrain from any more invasive treatment, e.g. crowning. Based on the literature data shown, it can be stated that - with appropriate indications - direct veneer restorations can be equivalent alternatives to conventional “golden standard” restorations. As Garcia-Godoy et al. showed, the “appropriate indications” are a very important factor, because a sufficient bonding power can only be obtained on the enamel surface, i.e. it is reasonable to consider the indications of direct veneer if a large surface of dentin is exposed.<sup>17</sup>

Our experience justifies the facts presented above. In case there is a sufficient amount of enamel surface we can decide on direct veneer restoration after measuring the possibility of preparing, elaborating and polishing the restoration.

### 4. Conclusions

To conclude, in the first place we can say that this adhesive technique makes it possible to esthetically optimize such teeth which show no decay lesions without doing any damage. We are also in a position to say that the facts presented in this paper are justified and supported by our experience.

Secondly, another conclusion would be that, if there is a sufficient amount of enamel surface, a decision that could be taken would be to resort to direct veneer restoration. This can only be done after measuring the possibility of preparing, elaborating and polishing the restoration.

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**Questions**

**In which case can you choose direct veneers?**

- a. Hypocalcification;
- b. Abrasion;
- c. Missing teeth;
- d. Disathema closure.

**It's typical of a young frontal teeth:**

- a. HALO effect;
- b. Visible perikymata;
- c. Surface grooves;
- d. Mamelons.

**A direct restoration is needed to**

- a. Diagnostic waxwork;
- b. Porcelain layering;
- c. Intraoral mock-up;
- d. Composite layering.

**The step of direct veneer implementation:**

- a. Teeth preparation;
- b. Precision Impression;
- c. Conditioned the surface by means of total etch technology (37% orthophosphoric acid);
- d. Composite layering.

## IN VITRO WEAR OF 4 DIFFERENT UNIVERSAL COMPOSITES

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### ABSTRACT

**Objectives:** To test the hypotheses: (1) there is no difference in the volumetric wear among composites tested, and (2) there is no difference in the wear rates calculated from the linear relationship of wear increase over cycling.

**Methods:** Two composites comprising pre-polymerized particles (Herculite-Précis [H], Tetric-N-Ceram [T]), one composite with very fine glass fillers (Charisma Opal [C]), and one composite with a mixture of agglomerated and nonagglomerated silica, and zirconia fillers (Filtek Z 350 XT [F]) were tested in a chewing simulator (CS 4.8, SD Mechatronik) with spherical Steatite antagonists (Ø 6 mm). Eight specimens of each composite were made by applying two increments in aluminum specimen-holders with a cylindrical cavity (Ø 8 mm, depth 1.5 mm), light cured (Bluephase G2; 1383 mW/cm<sup>2</sup>) for 20 s, polished to high gloss, and subjected to mastication cycles (59 N, 1.2 Hz, lateral movement 0.7 mm) and thermocycles (5/55°C; 116 s per cycle) simultaneously. After each 100, 500, 1,000, 2,000, 5,000, 10,000, 20,000, 30,000, 40,000, 50,000, 60,000, 70,000, 80,000, 90,000, 100,000, 110,000, and 120,000 mastication cycles, 3D images of worn surfaces were captured with Laserscanner LAS-20 (SD Mechatronik), and volumetric wear in mm<sup>3</sup> was calculated by Geomagic software.

**Results:** Five samples were lost due to separation at interface between increments. The means of total volumetric wear (mean±SD) after 120,000 cycles are 0.78±0.26 mm<sup>3</sup>, 0.91±0.15 mm<sup>3</sup>, 0.99±0.29 mm<sup>3</sup>, and 1.15±0.36mm<sup>3</sup> for F, H, T and C. Wear rate of each surviving sample between 2,000 and 120,000 cycles was calculated by linear regression (R<sup>2</sup>>0.99 for all specimens). The wear rates (mean±SD ; µm<sup>3</sup>/cycle) are, 5.97±2.29x10<sup>3</sup>, 6.85±1.06x10<sup>3</sup>, 8.91±2.81x10<sup>3</sup> and 6.43±0.58x10<sup>3</sup> for F, H, T and C. GLM shows statistically significant differences in the wear rate among the four materials (p=0.0488). Looking at the total volumetric wear of the four composites and wear of antagonists no differences were found (p=0.1183 (p=0.3027) respectively).

**Conclusions:** The first hypothesis was accepted and the second hypothesis was rejected. To prevent separation between increments, future specimen preparation should consider bulk fill.

**Keywords:** composite, in vitro wear, chewing simulator.

### 1. Introduction

When composite resins were introduced to the market, depending on the filler content, some of them were recommended for anterior and posterior use. Adaptic (Johnson & Johnson, New Brunswick NJ, USA) composite material was chosen for a clinical study primarily based on mechanical and physical data.<sup>1</sup> Furthermore the authors reported wear results obtained with a tooth brushing machine. Adaptic showed similar wear as compared to amalgam, when abraded with a slurry of heavy CaCO<sub>3</sub>, though 4x less wear when abraded

with pumice. This was not clinically confirmed. In a 3-year report, the same authors<sup>2</sup> using the USPHS criteria for evaluating restorations described a dramatic decrease in the quality of the occlusal anatomy from 44 "Alpha" at baseline to 6 "Alpha" and 36 "Bravo" ratings, which was interpreted as wear. This result was confirmed by Roulet et al.<sup>3</sup> However, the wear in that study was measured using a 3 coordinate measuring machine. Using a 100 µm grid the x, y, and z coordinates, wear was determined at approximately 60 points per occlusal surface. The average vertical wear after 3

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**Table 1. Products manufacturers, filler composition, and batch numbers**

Code	Name	Manufacturer	Filler	Lot
C	Charisma Opal. A2	Heraeus Kulzer 63540 Hanau Germany	Ba-Al glass, 0.02 - 2 $\mu\text{m}$ , 20-70 nm $\text{SiO}_2$	010025
F	Filtek Z350XT A2 body	3M ESPE 82229 Seefeld Germany	Agglomerated/non-aggregated 20 nm silica filler, non-agglomerated/non-aggregated 4 to 11 nm zirconia filler, and aggregated zirconia/silica cluster filler (comprised of 20 nm silica and 4 to 11 nm zirconia particles).	N321220
H	Herculite Precis A2	Kavo Kerr Charlotte NC 28273 USA	Ba glass 0.4 $\mu\text{m}$ , PPF, 20-50 nm $\text{SiO}_2$	3649560
T	Tetric N-Ceram A2	Ivoclar Vivadent 9494-Schaan Liechtenstein	Ba-Al glass, 0.5 and 0.7 $\mu\text{m}$ , PPF, mixed oxide spheres 160 nm, Ytterbium trifluoride 180 nm, $\text{SiO}_2$ 40 nm	P72199

years for Adaptic was  $224 \pm 151 \mu\text{m}$ . Using better equipment, it became possible to distinguish between wear in the occlusal contact area (OCA) and the contact free area (CFA). It was found that the OCA:CFA ratio equals an average of 2.5.<sup>4</sup> Different equipment was used to accomplish this: Profilometer,<sup>5,6</sup> 3 coordinated table using a long lens to determine the vertical dimension,<sup>7</sup> and a computer controlled 3-coordinated table with a mechanical switch for the vertical dimension.<sup>8</sup> Today, laser scanners measure fast and efficient occlusal anatomy and wear.<sup>9</sup>

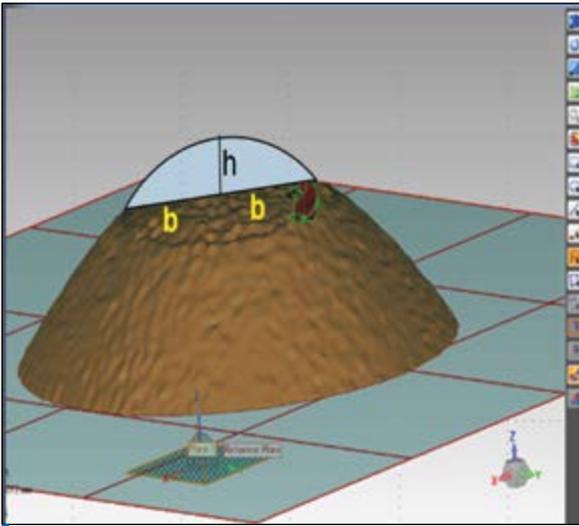
Current composite wear resistance has vastly improved mainly due to refinement of filler technology.<sup>10</sup> Clinical studies document the excellent longevity of posterior composite restorations if applied correctly;<sup>11-15</sup> therefore, it seems that wear is no longer the primary concern. Wear behavior of restorative materials will remain important and in focus, since today more and more occlusal bearing restorations are placed clinically due to the recent expansion of the indication for composites, including cusp replacements. Palaniappan et al.<sup>16</sup> reported that hybrid composites had a vertical substance loss within the same magnitude as enamel. However, comparing the volumetric wear, enamel was worn significantly less than the 3 tested composites. Frankenberger et al.<sup>17</sup> observed significant wear of nanohybrid and fine hybrid composite restorations in extended class II cavities after 8 years of service. With more nanoparticle-based composite materials being introduced, there is a need of investigating wear resistance of those materials. Therefore, the objective of this investigation was to measure in vitro wear of 4 nano particle based, commercial universal composites.

The null hypotheses are (1) there is no difference in volumetric wear among composites tested, and (2) there is no difference in wear rates calculated from the linear relationship of wear increase over cycling.

## 2. Materials and Methods

The four universal composites were received and the samples prepared according to standard procedures being equal for each brand. The manufacturer, filler composition and lot numbers are displayed in Table 1. Eight samples were prepared for each brand (n=8), which resulted in total 32 samples.

Thirty-two aluminum sample holders (inner  $\varnothing$  7.9 mm depth 1.5 mm) were grit blasted with 27  $\mu\text{m}$  aluminum oxide (EtchMaster Tips Small, Groman, USA) then one coat of universal bond (Monobond Plus, Ivoclar Vivadent, Liechtenstein) was added and left for 60 seconds, followed by air blasting to evaporate the solvent. Then one coat of adhesive (Optibond FL 2, Kerr, USA) was applied and light cured for 10 s using the BluephaseG2 (Ivoclar Vivadent, Liechtenstein) at "HIGH Power" mode delivering 1383  $\text{mW}/\text{cm}^2$  at a distance of 1.5 mm (verified with MARC Resin calibrator, BlueLight Analytics Inc., Halifax, NS, USA). The composites were filled into the sample holders in two increments, and each was light cured for a total of 40 s that delivered 55  $\text{J}/\text{cm}^2$  (1383  $\text{mW}/\text{cm}^2 \times 40$ ). The composite surfaces were finished and polished by using (Sof-Lex Discs, 3M, USA), light orange disc for finishing and yellow disc for polishing for 10-15 s. All samples were stored in distilled water for 3 weeks at 37°C. Steatite balls ( $\varnothing$  6 mm) mounted into aluminum holders with composite were used as antagonists. One antagonist per sample (n=32) was used and discarded after finishing all cycles. The samples were randomly distributed to the chewing simulator chambers (CS-4, Mechatronik, Germany) using random numbers. The chewing simulator was run according to the parameters listed in Table 2. The composite samples were scanned after 100, 500, 1,000, 2,000, 5,000, 10,000, 20,000, 30,000, 40,000, 50,000, 60,000, 70,000, 80,000, 90,000, 100,000, 110,000, and 120,000 mastication cycles.



**Figure 1a.** Wear facets were mostly symmetrical and round. By tracing the perimeter in the Keyence Microscope, the radius of the circle determining the “wear dome” could be determined

By using geometric software (Geomagic Control 2014, Geomagic, Cary, NC, USA), the scanned data was used to measure the wear of the samples after each round.

The flat surface of the sample was used as a reference plain. All wear facets at 120,000 cycles were examined with a digital microscope and digital images recorded (Keyence VHX 1000, Keyence Corporation of America, Elmwood Park, NJ, USA).

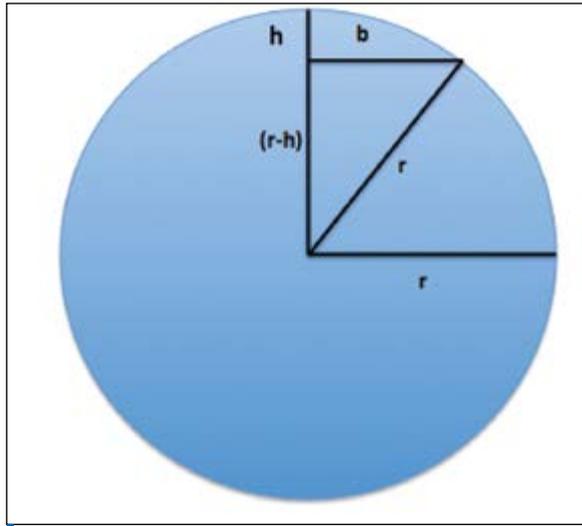
The wear of the Steatite antagonists was not measured with the laser scanner due to difficulty of establishing reference plane. They were determined indirectly by the geometric relationship (Fig. 1a). The radius (b) of the wear facet was measured using the Keyence digital microscope. Knowing the radius (r) of the sphere, we calculated the height of the abraded dome (h) using the following formula (Fig 1 b),

$$h = r - \sqrt{(r^2 - b^2)}$$

The volume of the wear dome (V) was calculated using the following spherical cap formula from standard mathematical tables,

$$V = \frac{1}{3} \pi h^2 (3r - h)$$

Samples C1, C3, C4, F2 and F7, experienced delamination at the interface between increments before conclusion of the experiment. Therefore they were excluded from the analyses. Due to imbalanced numbers of specimen per group of composites, GLM (SAS, 9.4; SAS Institute Inc., Cary, NC, USA) was used to analyze the variance of wear volume of the composites and antagonists. After the initial wear-in period, linear relationship between the wear volume and number of cycles from 2,000 to 120,000 cycles was apparent for all samples investigated. Linear regression was performed using SAS to determine the slope



**Figure 1b.** With the known radius (r) of the sphere and the radius of the wear facet (b), the volume of the “wear dome can be calculated

of the curve. The values represent the wear in  $\mu\text{m}^3/\text{cycle}$  of the samples and were called wear rate in this paper. GLM was used to determine statistical differences of wear rates among the four composite groups. The correlation coefficients ( $r^2$ ) between wear of antagonists and volumetric wear of composites, and between wear of antagonist and wear rate of composites were calculated by linear regressions.

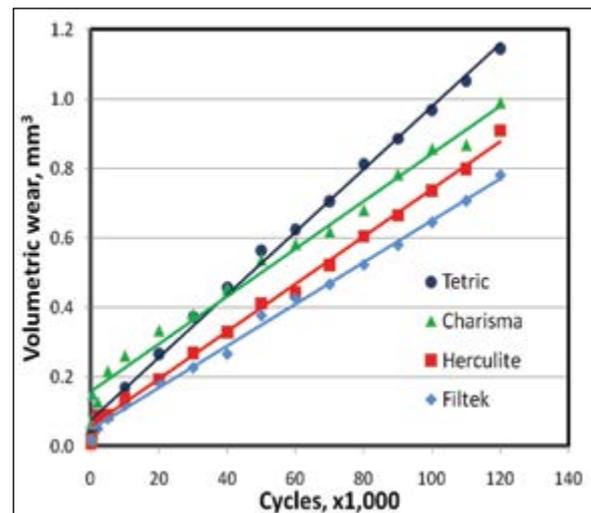
### 3. Results

GLM analyses showed that after 120,000 chewing cycles there were no statistical differences in total volumetric wear among the four composites ( $p=0.1183$ ) and wear of antagonist ( $p=0.3027$ ) with its respective composite. Linear regressions of the composite wear volume vs. number of cycles showed that the degree of fit ( $r^2$ ) was  $>0.99$  for each of the specimen investigated. GLM analysis of the values of wear rate determined for each specimen shows there was statistically significant difference among composites groups ( $p=0.0488$ ). It is important to note that the p-value was almost at the point of no significant difference ( $p=0.05$ ). The mean values and standard deviation of the total wear volume at 120,000 chewing cycle, wear of respective antagonist and the wear rates are shown in Table 3. The mean cumulative wear volumes as a function of the number of cycles, along with the best fit straight line of the mean values for each group of composite are displayed in Fig. 2. Analysis of the correlation showed that both wear volume and wear rate increased slightly as the wear of antagonist increased but with low correlation coefficient ( $r^2= 0.0027$  and  $r^2= 0.2081$ , respectively).

Some illustrative pictures of wear facets of the composites are shown in Fig. 3.

**Table 2. Settings of Chewing Simulator**

Load	6 Kg
Upstroke	2 mm
Downstroke	1 mm
Horizontal movement	0.7 mm
Upward speed	60 mm/s
Downward speed	60 mm/s
Horizontal speed	40 mm/s
Frequency	1.2HZ
Thermocycling	5°C-55°C; 116 s/cycle; total 860 cycles
Direction	Back and Forth



**Figure 2.** Mean wear of the four groups of composites up to 120,000 cycles. The respect straight for each material group represents the results of linear regression of wear between 2,000 and 120,000 cycles ( $R^2 > 0.99$ ).

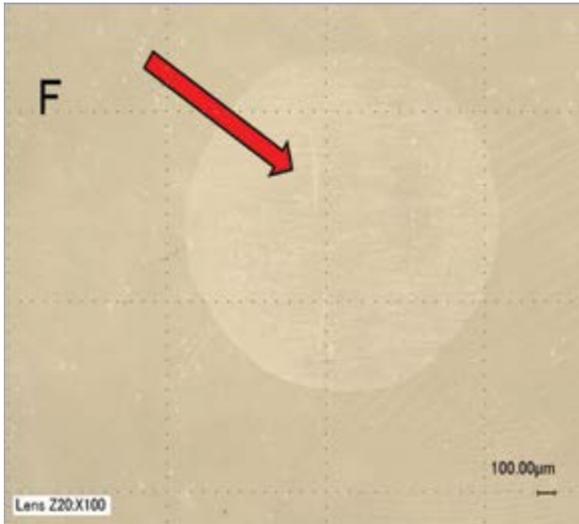
**Table 3. Wear of composite and respective Steatie antagonists at 120 K cycles**

Materials	Wear of composite, mm <sup>3</sup>		Wear of Steatie antagonist, mm <sup>3</sup>		Composite wear rate, μm <sup>3</sup> /cycle	
	Mean	SD	Mean	SD	Mean	SD
Filtek Z350XT	0.78	0.26	0.46	0.30	5.97x10 <sup>3</sup>	2.29x10 <sup>3</sup>
Herculite Precis	0.91	0.15	0.52	0.13	6.85x10 <sup>3</sup>	1.06x10 <sup>3</sup>
Charisma	0.99	0.29	0.32	0.23	6.43x10 <sup>3</sup>	0.58x10 <sup>3</sup>
Tetric N-Ceram	1.15	0.36	0.51	0.23	8.91x10 <sup>3</sup>	2.81x10 <sup>3</sup>

**4. Discussion**

The wear of all composites investigated were in a linear relationship with respect to the number of chewing cycles after wear-in period and the statistical analyses showed that there is significant difference among the composites in wear rate at  $p=0.0448$  and no significant difference ( $p=0.1183$ ) in final volumetric wear. Therefore, the first hypothesis was accepted and the second hypothesis was rejected. Various wear testers have been used to investigate the wear behavior of composites since their introduction. Wear simulation is a very complex process and over the last 40 years scientists have tried to build devices capable of simulating the wear of dental restorative materials. The outcome is heavily influenced by a multitude of factors, such as wear type reflected by the wear testing equipment, the load used, the antagonist material and shape, the use of thermocycling and finally of the material that is worn. One family of wear devices uses 3-body wear. This means that a third body, mimicking food, is forced between the two bodies which stress the

material with wear. Such devices are the ACTA wear machine,<sup>18</sup> the Oregon Health Science University (OHSU) machine,<sup>19</sup> the Alabama wear simulator,<sup>20</sup> and the CW3 of Peking University<sup>21</sup> and multiple toothbrushing machines.<sup>22,23</sup> Common to these devices is the introduction of a third body in suspension that affects the results heavily and it is not known which quality of the third body would be clinically relevant for wear of the occlusal surface. The ACTA machine can be run as a two body wear tester as well, having the two wheels run in contact. Osiewicz et al.<sup>24</sup> have reported differences in wear between 1 and 62.5 fold more wear for moving from 2-body wear to 3-body wear using the same abrasive, but different material combinations (4 composites for antagonist wheel and 6 composites for other wheel). Another approach is to use a two body wear. A simple and widely used device is the Taber abraser,<sup>25</sup> which comprises two abrasive wheels engaging on a rotating disk under constant pressure. Two body wear can be induced as a pin on block principle where a pin (antagonist) is



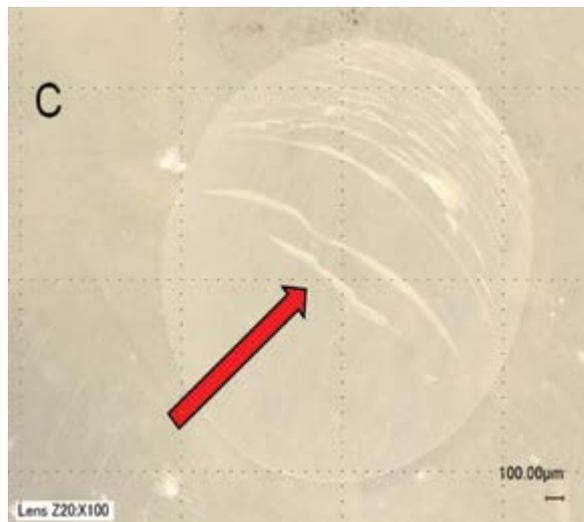
**Figure 3a.** Wear facette of Filtek Z 350 after 120.000 cycles. Note the white line perpendicular to the direction of the wear



**Figure 3b.** Wear facet of Tetric N-Ceram after 120,000 cycles



**Figure 3c.** Wear facet of Herculite Precis after 120,000 cycles



**Figure 3d.** Wear facet of Charisma Opal after 120,000 cycles. Note the multiple white lines perpendicular to the direction of the wear scratches

pressed under constant force onto a rotating disk<sup>26</sup> or oscillated against a flat surface.<sup>27</sup> Using a pin on block approach, scientists have tried to simulate chewing movements by having an antagonist lowered on a surface, then slid sideways under load, disengaged from the load and being moved to starting point to begin the next cycle.<sup>28</sup> Such devices are the Willitec Chewing simulator,<sup>29</sup> the Minnesota artificial mouth,<sup>30</sup> the CoCom Chewing simulator,<sup>31</sup> the TE88,<sup>32</sup> the Tokyo Medical Dental University Chewing simulator<sup>33</sup> or the Mechatronik Chewing simulator used in the present study. We decided to use a Pin on block chewing simulator, because the load and movements are well controlled and there is no third body to deal with, which makes interpretation of the results less problematic. Chewing forces are reported in the literature to vary from 20 - 120N.<sup>34</sup> Most researchers use 5 Kg (49N),

which has been reported by Gibbs et al.<sup>35</sup> to be the average chewing force under normal function. For the present study, 6 kg (58.9N) was chosen, with the idea to be able to better discriminate between the materials having a slightly higher load. However, the higher load apparently was incapable of discriminating the wear rate among the four material groups. Therefore, 5 kg load should be adopted as a standard for future study for ease of comparison. All wear facets exhibited typical grooves resulting from abrasive wear by harder antagonists with unique feature for each material. For Charisma (Fig. 3d), the white lines common for that group of material are not cracks on the surface but wear debris being folded perpendicular to the direction of horizontal movement. Some worn surfaces of Tetric-N-Ceram samples appear to have a round tab to the oval wear spot (Fig. 3b). The likely cause is that samples had shifted in the

initial stage of testing.

There is no agreement in the literature about the material and the shape of the antagonists to be used in in vitro wear studies. The following materials have been reported<sup>34</sup>: stainless steel, natural teeth, tooth cusps shaped to a specific shape and highly polished, leucite reinforced ceramic (Empress), Steatite (magnesium silicate ceramic), Degusit (aluminum oxide) and Zirconium oxide.<sup>36</sup> Average radius of natural cusps is 1.04 and 1.79 mm.<sup>34</sup> Artificial materials are used with diameters of 3mm,<sup>36</sup> 4mm,<sup>20,33</sup> 6mm<sup>37,38</sup> or 12mm.<sup>27,32</sup> In the present study 6mm Steatite antagonists were chosen. For horizontal movement, both 0.3 and 0.7 mm have been used, we used 0.7 mm as it is more commonly used. As a measurement tool a laser scanner was used. Heintze et al.<sup>39</sup> have shown that laser scanners give the same results as the ones obtained with optical or mechanical profilometers.

Due to the notable differences in in vitro wear testing methods described above it is almost impossible to directly compare the present results to other studies. Therefore, comparisons only to studies done with Willitec/Mechatronik wear testing machines are reported. As in the studies of Heintze et al.<sup>34,39</sup> and Wang et al.<sup>27</sup> the wear development over the number of cycles was linear. We can confirm Heintze's data<sup>34,39</sup> that the Antagonist wear is about half the wear of the composite materials. In contrast, the wear reported for a multitude of materials by Ivoclar Vivadent R&D is slightly lower than the wear found in this study. This may be due to the higher load used in the present study and the use of different antagonists (Empress vs Steatite). Lazaridou<sup>38</sup> found for Tetric Evoceram 0.3297 mm<sup>3</sup>, while Tetric N Ceram in the present study showed 1.15 mm<sup>3</sup>, which is substantially higher. Again, there are differences in the method which may explain the different findings. The load used in the present study was 20% higher, and we used thermocycling in contrast to Lazaridou et al.<sup>38</sup>

Most in vitro wear test methods demonstrate a steep increase in wear initially, also called wear-in or run-in phase, and then a flattening of the curve that appears increasing in a linear fashion, thereafter. The wear profile of individual sample tested and the profile of mean of the material groups all exhibited

the wear-in pattern (Fig. 2). The duration of wear-in varies among material groups. In the literature, this linear relationship is often recognized<sup>27,34,39,40</sup> but not used for calculating wear rates. Often for comparison, the final volumes of wear were used for comparison. Since the total volume of wear also depends on the number of cycles and the extent of vertical movement, it becomes necessary have both information available for comparison. Wear-in phase does not truly reflect the wear of the material but include the wear generated during the initial stage when the composite and the antagonist are adjusting to accommodate each other in forming a sliding interface. The linear portion of the curve can be used to calculate the wear rate without the influence of the wear-in phase. When the load and the horizontal movement remains the same, the effect of testing duration by cycles disappears when wear rates are used. A straightforward comparison of in vitro wear will become possible. Lastly, the unit for the wear rate should also be standardized. The unit of mm<sup>3</sup> is commonly used in discussing of volumetric wear and  $\mu\text{m}$  is used in presenting wear in depth. We used the unit  $\mu\text{m}^3/\text{cycle}$  for wear rate in this study. However, the quantity of  $\mu\text{m}^3/\text{cycle}$  is very small, a factor of  $10^3$  is needed (Table 3). The unit of mm<sup>3</sup>/cycle, on the other hand is so big that a factor of  $10^{-6}$  is needed. As a compromise, we suggest that mm<sup>3</sup>/megacycle be used in expressing volumetric wear for comparison. As such the values of wear rates shown in Table 3 would be presented without the factor of  $10^3$ .

## 5. Conclusions

The four tested composites showed a linear development of wear over the number of cycles and showed a wear which was comparable to wear in other studies.

It can be expected that in the clinical reality they will behave similarly to other composites of their class.

## Acknowledgments

The authors declare no conflict of interest related to this study. There are no conflicts of interest and no financial interests to be disclosed.

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**CV**

Patricia Matias is a DDS student of the University of Brasília (UnB). She had a scholarship for PET-Saúde Extension Program (2010/2012). Since 2010, she has been participating in the Integral Health and Education Extension Project. She also had a scholarship (2013/2014) from CAPES/IIE/Science without Borders to study at the University of Florida (UF). During this period, she studied English, participated in research activities and took courses at the Division of Operative Dentistry and Dental Biomaterials at UF. Therefore, she has benefited from training in dental technology, CAD/CAM, microtensile, thermocycling, chewing simulation, MARC resin calibration (analysis of fotopolimerization light), ceramic and composites. In 2015 she treated children and adults at J.J Mesquita Hospital Ship in Amazonas River-Brazil. Currently, she is a Scientific Initiation Scholar (PIBIC) mentored by Prof Dr. Leandro Augusto Hilgert at UnB and has a scholarship from CNPQ. Her interest lies with Dental Materials and Operative Dentistry.

**Questions****In the literature the chewing forces are reported to vary from:**

- a. 30 to 50 N;
- b. 100 to 800 N;
- c. 20 to 120 N;
- d. 5 to 25 N.

**All the following devices are two body wear devices, with one exception:**

- a. TE88;
- b. Willitec Chewing simulator;
- c. CoCom Chewing simulator;
- d. Alabama wear simulator.

**In in vitro wear studies, one of the following materials is used to create the antagonists:**

- a. Leucite reinforced ceramic;
- b. Dental amalgam;
- c. Composite resins;
- d. Acrylic resin.

**We can appreciate that the wear-in phase:**

- a. Does not include the wear generated during the initial stage;
- b. Does not truly reflect the wear of the material;
- c. Appears as a flattening of the wear curve;
- d. Has the same duration for all tested materials.

## PREDICTING THE PSYCHOLOGICAL WELL-BEING OF DENTAL STUDENTS DURING THE SEMESTER EVALUATION PERIOD: A PROSPECTIVE STUDY

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### ABSTRACT

**Aim:** The study aimed at monitoring the psychological well-being of dental students over the first semester of the academic year, in order to acknowledge if psychological well-being during the semester evaluation period is predicted by well-being during teaching period.

**Methodology:** Second year dental students from the Faculty of Dental Medicine, "Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania were evaluated across the first academic semester, on three consecutive times during the teaching period, and one time during the semester evaluation period. Well-being was evaluated in terms of subjective positive psychological well-being, assessed by WHO-Five Well-being Index (WHO-5), and as the severity of depression symptoms, assessed by Major Depression Inventory (MDI).

**Results:** As expected, the students' psychological well-being was highest at the beginning of the semester and lowest during the semester evaluation period. By regression analysis it was observed that well-being during the semester evaluation period is poorly predicted by their well-being at the beginning of the semester, and it is better predicted when assessed in similar periods with regard to the quality of stressors (i.e., written examinations) or at the end of the teaching period. Also, their psychological well-being in terms of severity of depression symptoms seems to be a more predictable state than subjective positive psychological well-being.

**Conclusion:** Early identification of students at high risk to exhibit lowering levels of psychological well-being should be implemented in order to plan the necessary interventions to help students cope with the examination distress and prevent its unwanted consequences.

**Keywords:** education, stress, risk, mental health, prevention.

### 1. Introduction

Subjective psychological well-being is seen as a component of the general construct of well-being with great impact on everyday life, on the ability to identify and fulfil goals, to adapt and cope with the environment.<sup>1,2</sup>

Evidence suggests that the educational process in the medical and dental schools associates a somehow inherent distress, which might have an inadvertent negative effect on the students' well-being, with probable short and long-term consequences, e.g. may affect the academic performance, is a risk factor for anxiety, depression and burnout, is linked to behavioural patterns and health of the future doctors.<sup>3,4</sup> Keeping in mind that

the basic aim of education is to train knowledge, efforts need to be made in order to identify the most adequate ways to implement it.<sup>5,6</sup> Since a negative side effect of the educational process on the student's psychological health is suspected, further high quality research is needed in order to understand the problem's magnitude, aetiology, prognosis, and if necessary to identify the best diagnostic and interventional approaches.

The aim of this study was to monitor the psychological well-being of second year dental students during the first semester of the academic year, in order to acknowledge if the psychological well-being during the semester evaluation period is predicted by well-being during the teaching period.

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**Table 1. Student's positive well-being, assessed by WHO-5 scores, over the first semester of the academic year**

Time	Students	WHO-5 score (mean)	p
T1	All	66	All (T1:T2): 0.038* All (T2:T3): 0.136 All (T3:T4): 0.009* All (T1:T4): 0.014* Male: Female (T1): 0.523 Male: Female (T2): 0.103 Male: Female (T3): 0.805 Male: Female (T4): 0.084 From Bucharest: Other (T1): 0.203 From Bucharest: Other (T2): 0.667 From Bucharest: Other (T3): 0.249 From Bucharest: Other (T4): 0.529
	Male: Female	65: 66	
	From Bucharest: Other	70: 65	
T2	All	62	
	Male: Female	66: 60	
	From Bucharest: Other	63: 61	
T3	All	65	
	Male: Female	64: 65	
	From Bucharest: Other	69: 64	
T4	All	58	
	Male: Female	65: 55	
	From Bucharest: Other	60: 57	

## 2. Materials and Methods

This study was approved by the Ethics Committee for Scientific Research at the "Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania (PO-35-F-03, No. 55).

### 2.1 Study design and settings

A prospective study was designed and implemented on a cohort of second year dental students from the Faculty of Dental Medicine, "Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania. Data were collected during the first semester of the 2014-2015 academic year (from October 1<sup>st</sup> 2014 to February 15<sup>th</sup> 2015), three consecutive times during the teaching period and one time during the semester exam period.

### 2.2 Subjects

One series of second year dental students who attended the above-mentioned university was enrolled in this study. Enrolment was done considering all eligible subjects, who voluntarily agree to participate in this study. Repeaters and transferred students were excluded, because their courses are partially different from those of regular students, having usually less or more subjects to attend. All participants were informed upon the main characteristics of this study and a written informed consent was granted, in the beginning, and also in the follow-up appointments.

### 2.3 Variables

The main study outcome was the subjective psychological well-being, assessed using the WHO-Five Well-being Index (WHO-5) and the Major Depression Inventory (MDI). The Romanian language version of both questionnaires was used. The Romanian language version of WHO-5 that was used was the one available on the website dedicate to this index, that of the Psychiatric Research Unit (Mental Health Centre North Zealand, Hillerod, Denmark). The index has been previously tested and demonstrated to have good

psychometric properties as a well-being scale and as a screening instrument for depression.<sup>7</sup> The Romanian language version of MDI that was used was the one available in the Romanian guide for adult depression for general practitioners. Other study variables were demographics (age, sex) and origin (from Bucharest or other). The latter was chosen on the idea that students from Bucharest experience less life changes, usually preserving their living accommodation and the relations with their family and friends.

### 2.4 Data collection

Data were collected by administering a written questionnaire before or after classes, its timing being related to the academic activities, as favouring different levels of stress, as follows:

T1 - 2<sup>nd</sup> week of the teaching period, corresponding to the beginning of the first academic semester;

T2 - 7<sup>th</sup> week of the teaching period, corresponding to its middle, during which half-semester theoretical examinations are scheduled for some of the courses taken; the questionnaire was filled just after a written examination;

T3 - 13<sup>th</sup> week of the teaching period, that was just after the Christmas and New Year break, corresponding to the end of the teaching period, when students have practical examinations for the seminars activities of most of the courses taken; the questionnaire was filled just after a practical examination;

T4 - 4<sup>th</sup> week (last week) of the semester exam period; the questionnaire was administered just after a written examination.

### 2.5 Statistical methods

Missing data, caused by not fully filling the questionnaire all four times, were managed by excluding the subject from the analysis.

Data analysis included frequency distributions, Wilcoxon test, paired t-test, Mann-Whitney test and unpaired t-test. Change in well-being was assessed by change of WHO-5 score and MDI

**Table 2. Change of positive well-being over the first academic semester**

Well-being change	WHO-5 score change (mean)	Clinically significant change of well-being		
		Improvement	No change	Worsening
In T2 compared to T1	3.88	17 (24%)	24(24%)	29 (41%)
In T3 compared to T2	-2.91	22 (31%)	36(51%)	12 (17%)
In T4 compared to T3	6.74	11 (16%)	32 (46%)	27 (39%)
In T4 compared to T1	7.71	18 (26%)	19 (27%)	33 (47%)

**Table 3. Student's well-being, assessed by MDI scores, over the first semester of the academic year**

Time	Students	MDI score (mean)	p
T1	All	10	All (T1:T2): 0.004* All (T2:T3): 0.637 All (T3:T4): 0.261 All (T1:T4): <0.001* Male: Female (T1): 0.194 Male: Female (T2): 0.082 Male: Female (T3): 0.681 Male: Female (T4): 0.174 From Bucharest: Other (T1): 0.229 From Bucharest: Other (T2): 0.710 From Bucharest: Other (T3): 0.799 From Bucharest: Other (T4): 0.810
	Male: Female	9:11	
	From Bucharest: Other	9:11	
T2	All	13	
	Male: Female	11:14	
	From Bucharest: Other	13:13	
T3	All	13	
	Male: Female	13:13	
	From Bucharest: Other	12:13	
T4	All	15	
	Male: Female	13:15	
	From Bucharest: Other	14:14	

score. The difference of WHO-5 scores of at least 10, considered as a clinically significant change in well-being, was recorded on an ordinal scale (improvement; no change; worsening). Regression analysis was performed in order to assess if well-being during the teaching period (in T1, T2, T3) predicts well-being during examination period (in T4). SPSS Statistics was used to perform the statistical analysis. Significance was set at  $p < 0.05$  (significance level 95%) for all statistical tests.  $p$ -value less than 0.05 as marked by “\*”.

### 3. Results

The selected series included ninety-two dental students, out of which eighty-five met the eligibility criteria and all agreed to participate in this research. Seventy of them (response rate of 82%) filled the questionnaires all four times. Most of them were females ( $n=49$ ; 70%), twenty years old ( $n=57$ ; 81%). Fifteen (21%) students were from Bucharest. The students' well-being during the first academic semester. The students' well-being exhibited changes during the first academic semester, in terms of subjective positive psychological well-being, assessed by WHO-5 score, but also as the severity of depression symptoms, assessed by the MDI score. Observing the WHO-5 scores, a statistically significant reduction of well-being was noticed during the first half of the semester (at T2 compared to T1), followed by a not statistically significant increase of it after a two-week holiday (at T3 compared to T2). In the winter exam period (at T4), as expected, a statistically significant reduction in the students' well-being

was observed, which reached its lowest level. A subgroup analysis showed that male students and Bucharest natives registered higher WHO-5 scores during the written exam period (at T2 and T4), which means better well-being, at a level that was not statistically significant (Table 1). Considering the difference of WHO-5 score out of 10, assessed as a clinically significant change in positive well-being, at almost all moments in time frequent changes in the positive well-being were noticed, with either improvement or worsening. Only ten students did not show a clinically significant change in the positive well-being when assessed at two consecutive times, across the entire semester. About 40% of the students registered a clinically significant worsening of their positive well-being during the written exam period (at T2 compared to T1; at T4 compared to T3). Over the entire first semester (T4 compared to T1) almost half of the students registered a clinically significant worsening of their positive well-being (Table 2). With respect to the MDI scores, a statistically significant reduction of well-being was noticed during the first half of the semester teaching period (at T2 compared to T1), that continued afterwards, at a level that was not statistically significant. A subgroup analysis showed that during the written exam period female students (T2 and T4) had a tendency of registering higher MDI scores, meaning higher severity of depression symptoms (Table 3). Classifying students according to the MDI score obtained, there were 6 students in T1, 8 students in T2, 13 students in T3 and 17 students in T4 with MDI scores  $\geq 20$ , regarded

**Table 4. Bivariate regression results for students' well-being during teaching period predicting well-being during semester examination period**

Dependent variable	Independent variable	B	t(69)	R <sup>2</sup>	F(1,69)	p
WHO-5 in T4	WHO-5 in T1	0.13	1.05	0.02	1.10	0.298
	WHO-5 in T2	0.52	5.04	0.27	25.36	<0.001
	WHO-5 in T3	0.43	3.93	0.17	15.45	<0.001
MDI in T4	MDI in T1	0.38	3.35	0.14	11.20	0.001
	MDI in T2	0.72	8.51	0.51	72.37	<0.001
	MDI in T3	0.69	7.88	0.48	62.04	<0.001

as having depression. Consequently, the ratio between mild to moderate to severe depression was the following: 2:3:1 in T1; 3:3:2 in T2; 7:2:4 in T3; 7:5:5 in T4. Prediction of subjective well-being during the semester evaluation period by well-being during the teaching period. Regression analysis showed that psychological well-being during the semester evaluation period (T4) is poorly predicted by the psychological well-being at the beginning of the first academic semester (T1). Even so, psychological well-being (i.e. both the positive psychological well-being assessed by the WHO-5 scores and the severity of depression symptoms assessed by the MDI score) during the semester evaluation period (T4) seems to be more accurately predicted by their well-being during similar periods with respect to the quality of the stressors, i.e. written examination (T2), or at the end of the teaching period (T3). Also, the psychological well-being in terms of severity of depression symptoms seems an aspect that is more predictable than subjective the positive psychological well-being. (Table 4).

#### 4. Discussion

The level of psychological well-being in dental and medical students was previously reported by several studies to be reduced compared to the population norms, being most probably related to the identified high level of stress, reported as present in about one in three dental students.<sup>4,8</sup> This study results suggest reduced levels of positive psychological well-being in dental students, compared to the general population (i.e., of approximately 70, when measured by WHO-5),<sup>9,10</sup> especially during the semester evaluation period. Two cross-sectional studies evaluating well-being using WHO-5 on samples formed by dental students from Europe were identified, i.e. one from Munich, Germany, reporting WHO-5 scores of about 55,<sup>11</sup> and one from Budapest, Hungary, reporting scores of WHO-5 of 58.<sup>12</sup> Both found the WHO-5 scores for dental students below 70, but it is difficult to compare the results of those studies to those of the current study considering the exact moment for data collection, with regard to the academic year progress, as it was not clearly specified in the two prior studies. Regarding the variation in the students' MDI scores, it was noticed that at the beginning of the academic semester the frequency of depression was rather similar compared to the general population in

Europe, i.e. of approximately 8.56%.<sup>13</sup> Even so, over the academic semester the frequency of depression increased, reaching its highest level during the semester evaluation period (24%), to a level closer to the one reported by Ibrahim et al. for university students (30.6%).<sup>14</sup> According to current knowledge, the association between stress and examinations is predictable, as they are believed to act as an acute stressor, and to have a cumulative effect.<sup>15,16</sup> This aspect is supported by our study especially for the written examinations, which are associated to a higher decrease in the students' level of wellbeing. Other prospective research, on dental students, suggests that there can be an increase in the stress perceived over the academic year, that is suspected to have detrimental effects on performance and health.<sup>17-19</sup> Stressors perceived by students' and their effects most probably are different among dental schools, being related to a mix of factors, including individual and institutional parameters, but also geographic and socio-demographic patterns, Romanian dental students being previously identified as experiencing a high perceived stress level.<sup>20-23</sup> The decrease in the level of well-being should be counted considering several aspects: subjective well-being predicts objective mental health, may impact on the learning performance, may bias the student's evaluation and have negative long-term effects, e.g., emotional problems such as depression, may limit and impact the future professional practice.<sup>9,10,24</sup> As concerns were raised with respect to the decreased well-being of the dental students, the inherent distress that exists and its negative effect at a personal and learning level, recommendations were made to help students to cultivate their skills to sustain their well-being, through formal and informal offerings within medical school.<sup>25-27</sup> According to this study's results, students at high risk of reduced levels of well-being during the semester evaluation period may be initially identified during other periods over the semester with written examinations, and interventions for coping with examination stress at the most demanding times of the academic year may be planned accordingly. Also, positive and negative psychological states are generally seen as related, but independent constructs of well-being. Our results suggest that negative well-being is a more predictable state than positive well-being, therefore better knowledge of the impact of academic stressors and their long-term effect on each of them, separately, may be

necessary to be understood, in order to have a clearer idea on this phenomenon. Regarding the instruments used for data collection, for positive and negative psychological states, some details about them are given in this paragraph. WHO-5 is an instrument developed by the World Health Organization, which measures self-reported positive psychological well-being. WHO-5 consists of a 5-item questionnaire, positively worded, with a time frame of previous two weeks. Its interpretation is in accordance to the score obtained, that ranges from 0 to 100 percentage score, where higher score means better well-being.

To monitor change, a difference of WHO-5 percentage score out of 10 is considered clinically significant.<sup>9,10,28,29</sup> MDI is also an instrument developed by the World Health Organization, and in this study it is used as a self-rating depression scale. It consists of a 10-item questionnaire, two of them having two alternative questions. It has a similar time frame, of previous two weeks. Its interpretation is in accordance to the score obtained, that ranges from 0 to 50. MDI results were recorded as scale score (where high score means higher severity of depression symptoms), were dichotomized according to the cut-off value of  $\geq 20$  into likely depression or not, and were recorded on an ordinal scale (mild depression: 20 to 24; moderate depression: 25 to 29; severe depression:  $\geq 30$ ).<sup>30</sup>

Study limitations include the possibility that results are biased by specific factors of the population that the sample was drawn, thus results need to be confirmed by studies implemented in other dental schools. Also, a deeper analysis, considering all

years of study, effects on academic performance and health, through high quality prospective research is recommended.

## 5. Conclusions

The psychological well-being of the dental students decreases over the first semester of the academic year, reaching its lowest point during the semester evaluation period. The students' well-being during the semester evaluation period seems to be poorly predicted by well-being at the beginning of the academic year, and it is better to assess it in similar periods with regard to the quality of the stressors (i.e. written examinations) or at the end of the teaching period. Considering the fact that medical training in general requires an increased number of examinations taken over a large time-interval, that may associate a cumulative reduction of well-being, the early identification of students at high risk to exhibit lowering levels of psychological well-being should be implemented in order to plan the necessary interventions to help students cope with the examination distress and prevent its unwanted consequences.

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## Questions

### Which of the following statements about the WHO-5 Well-being Index is FALSE?

- a. Is an instrument which measures self-reported positive psychological well-being;
- b. Consists of a 5-item questionnaire, positively worded, with a time frame of previous two weeks;
- c. It's interpretation is in accordance to the score obtained, where higher score means better well-being;
- d. To monitor change, a difference of WHO-5 percentage score of 100 is considered clinically significant.

### During the academic semester, dental students register the lowest level of subjective psychological well-being:

- a. At the beginning of the semester;
- b. During written exam periods, other than final exams;
- c. During practical exam periods;
- d. During semester evaluation period, when final exams are taken.

### Dental students' subjective psychological well-being during the semester evaluation period is better predicted by:

- a. Dental students' well-being at the beginning of the semester;
- b. Dental students' well-being in similar periods with regard to the quality of stressors (i.e., written examinations);
- c. Dental students' well-being at the end of the teaching period;
- d. All the above are similar as predictors.

### Which of the following statements regarding the dental students' well-being is FALSE?

- a. The level of their psychological well-being is higher than general population norms;
- b. Their psychological well-being in terms of the severity of the depression symptoms is more predictable than the subjective positive psychological well-being;
- c. Dental students should cultivate their skills to sustain their well-being;
- d. A decrease in their level of well-being may have short-term negative effects, e.g. may impact on the learning performance.

## HIGH VISCOSITY BULK-FILL GIOMER AND ORMOCER-BASED RESIN COMPOSITES: AN IN-VITRO COMPARISON OF THEIR MECHANICAL BEHAVIOUR

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### ABSTRACT

**Introduction:** The paper aims to assess the mechanical properties of novel high-viscosity bulk-fill composites based on the giomer and ormocer technology, and to compare their performance with materials of the same category previously launched.

**Methodology:** One Giomer (*Beautiful Bulk restorative/Shofu*), one ormocer-based (*Admira Fusion x-tra/Voco*) and the first launched bulk-fill composite (*QuixFil/Dentsply*) were compared to three established materials of the same category. The last (*Tetric EvoCeram Bulk Fill/Ivoclar Vivadent; X-tra Fil/Voco; SonicFill/Kerr*) were analysed under identical conditions and were partially presented in a previous study. The mechanical properties were assessed at macroscopic (flexural strength  $\sigma$  and flexural modulus  $E_{\text{flexural}}$ ) and microscopic scale (Martens *HM* and Vickers Hardness *HV*, indentation modulus  $Y_{\text{HU}}$ , Creep).

**Results:** The effect of the parameter *filler amount* was significant on all measured properties ( $p < 0.001$ ; partial eta squared varied among  $\eta_p^2 = 0.212$  (Creep) and  $0.891$  ( $Y_{\text{HU}}$ )), while being higher on the modulus of elasticity  $Y_{\text{HU}}$  ( $\eta_p^2 = 0.891$ ) and  $E_{\text{flexural}}$  ( $\eta_p^2 = 0.805$ ). Lower  $\sigma$  values were determined for the ormocer ( $99.9 \pm 10.7$  MPa) and giomer-based composite ( $106.0 \pm 12.7$  MPa), while the highest values were recorded for *QuixFil*, *X-tra Fil* and *SonicFill*. Significant lowest  $E_{\text{flexural}}$  was measured for the group *Tetric EvoCeram Bulk Fill* ( $4.5 \pm 0.8$  GPa) and *Admira Fusion x-tra* ( $5.3 \pm 0.5$  GPa), while *QuixFil* ( $9.4 \pm 1.8$  GPa) and *X-tra Fil* ( $9.5 \pm 0.6$  GPa) showed statistical similar values and the highest values in the range of the analyzed materials.

**Conclusions:** Owing to a lower inorganic filler amount, innovative modifications such as gomers or ormocers were related to materials with moderate mechanical properties, yet comparable to values measured in regular composites.

**Keywords:** bulk-fill resin-based composites, strength, modulus of elasticity, hardness.

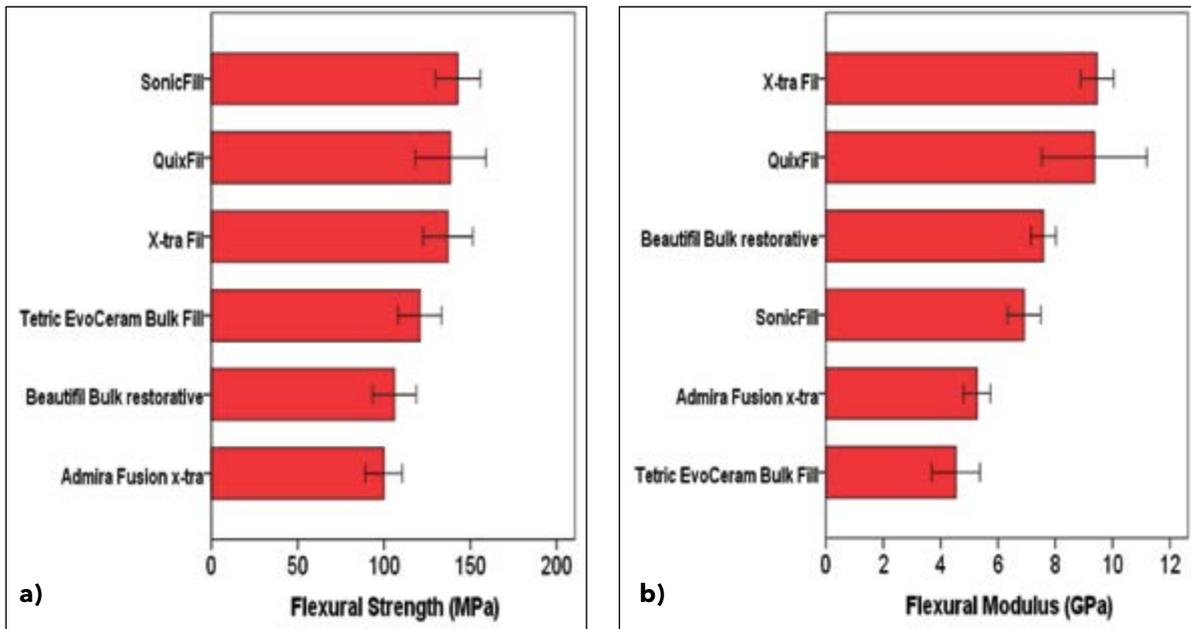
### 1. Introduction

In an effort to simplify and improve placement of direct resin-based composite (RBC) posterior restorations, manufacturers develop materials able to be cured in one 4 or even 5 mm thick increment. This allows to skip the time-consuming layering process and to reduce the risk of introducing failures or contaminants in-between increments. The material category is termed bulk-fill resin based composites and is classified on the basis of differences in viscosity and application technique, in low- and high-viscosity bulk-fill RBCs. The low mechanical properties of the former<sup>1</sup> require to finish a restoration by adding a capping layer made of regular RBCs, while high-viscosity bulk-fill RBCs

are intended to restore the entire preparation. Several in-vitro studies confirmed that bulk-fill RBCs may be applied in increments up to 4 mm thickness,<sup>2-5</sup> when adequately cured. Besides, an acceptable marginal adaptation is reported, which is similar to that of standard RBCs.<sup>6</sup> In a similar vein, Furness et al.<sup>7</sup> attested a comparable proportion of gap-free tooth-restoration interfaces in either bulk-fill or conventional RBCs restorations. Yet, the proportion of gap-free interfaces tended to decrease with increasing depth in the preparation, but was largely unaffected by RBC type (one low-viscosity and three high-viscosity bulk-fill RBCs versus one nano-hybrid RBC) or placement technique (4-mm bulk versus 2 x 2-mm increments). In contrast to these findings, Benetti et al.<sup>8</sup>

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**Figure 1.** Macro-mechanical properties - a) Flexural strength; b) Flexural modulus

identified some bulk-fill restoratives to produced larger gaps at the dentin margin of Class II cavities, when compared to regular RBCs restorations. Nevertheless, good in-vitro performance as reflected in improved self-leveling ability,<sup>9</sup> decreased polymerization shrinkage stress<sup>10-12</sup> and reduced cusp deflection<sup>13</sup> encourage a positive forecasting of the clinical performance of bulk-fill RBCs. Owing to the short time since the materials have been launched on the market, only few clinical studies are available. For the low-viscosity bulk-fill RBC, *SDR*, van Dijken et al.<sup>14,15</sup> attested in two different 3-year follow-up studies, a similar performance compared to restorations made by regular RBCs placed in a layering technique. As for high-viscosity bulk-fill RBCs, only one short 1-year clinical evaluation of class II restorations is reported so far, stating that the clinical performance of several high-viscosity bulk-fill RBCs was similar when compared to a conventional posterior RBC.<sup>16</sup> When considering the bulk-fill RBCs as a material category, their mechanical properties were identified to fall between those of regular and flowable composites, indicating a similar or possibly inferior clinical behavior relative to standard microhybrid or nanohybrid composites. Yet, the differences in mechanical properties within the bulk-fill category were identified to be very high, which is particularly due to the different filler content.<sup>1</sup> The performance of each material must therefore be assessed individually and cannot be transferred from the material category they belong to. Although the chemical composition of the organic matrix is largely similar to that described in regular RBCs, a particularity of bulk-fill RBCs is identified in the inorganic fillers. A lower filler content or enhanced filler size (>20

$\mu\text{m}$ ) was attested for several bulk-fill RBCs (x-tra fil and x-tra base, VOCO, Cuxhaven, Germany; SureFil SDR flow, DENTSPLY Caulk, Milford, DE, USA; SonicFill, Kerr, Orange, CA. USA, (1)), the result being enhanced material translucency. The changes in filler size involve a lower total filler-matrix interface compared to regular composites with lower filler size, resulting in reduced light scattering and increased light transmittance in depth.<sup>1</sup> The aforementioned changes in fillers, but also a reduced amount of pigments are made responsible for the enhanced depth of cure of bulk-fill restoratives.

Bulk-fill composite have rapidly achieved great popularity, therefore, progressively new material options have become recently available. Innovative material developments, like new and more competitive photo-initiators<sup>17</sup>, as well as new material categories such as giomers (**G**lass **i**onomer + **p**olymer)<sup>18</sup> and ormocers (**O**rganically **M**odified **C**eramics)<sup>19</sup> have recently been implemented also in high-viscosity bulk-fill RBCs. Therefore, the aim of this study was to comparatively assess the mechanical performance of novel high-viscosity bulk-fill restoratives materials such as giomers and ormocers and to compare them to three established materials of the same category measured under identical conditions and partly presented in a previous study,<sup>1</sup> by considering a battery of properties determined at both macro- and microscopic scale.

The null hypotheses assume no significant difference in macro (flexural strength ( $\sigma$ ) and flexural modulus ( $E_{\text{flexural}}$ )) and micro (Martens Hardness (HM), Vickers hardness (HV), indentation modulus ( $Y_{\text{HU}}$ ), and Creep) mechanical properties among the analysed high-viscosity bulk-fill RBCs.

**Table 1.** Materials, Manufacturer, chemical composition of matrix and filler as well as filler content by weight (wt.) and volume (vol.) %

Bulk Fill RBCs	Manufacturer, Color, Batch	Resin Matrix	Filler	Filler wt%/vol%
Tetric EvoCeram® Bulk Fill Nano-hybrid RBC	Ivoclar Vivadent IVA, P84129	Bis-GMA, UDMA	Ba-Al-Si-glass, prepolymer filler (monomer, glass filler and ytterbium fluoride), spherical mixed oxide	79-81 (including 17%prepolymers)/ 60-61
Admira Fusion x-tra Nano-hybrid RBC	Voco Universal, 1527519	Organically modified silicic acid	n.s.	84/-
X-tra Fil Hybrid RBC	Voco Universal, 1230323	Bis-GMA, UDMA, TEGDMA	n.s.	86/70.1
SonicFill™ Nano-hybrid RBC	Kerr A3, 3851737	Bis-GMA, TEGDMA, EBPDMA	SiO <sub>2</sub> , Glass, oxide	83.5/
Beautiful Bulk restorative GIOMER	Shofu Dental Corporation, Universal, 11402	Bis-GMA, UDMA, Bis-MPEPP, TEGDMA	S-PRG filler based on F-B-Al-Si-glass, prepolymer filler	87.0/74.5
QuixFil Hybrid RBC	Dentsply DeTrey Universal, 1209000241	Bis-EMA, UDMA, TEGDMA, TMPTMA, TCB-Resin	Sr-Al-Na-F-P-Si-glass	86/66

Abbreviations: Bis-GMA, bisphenol-A diglycidyl ether dimethacrylate; EBPDM/Bis-EMA, ethoxylated Bisphenol-A-dimethacrylate; TEGDMA, Triethyleneglycol dimethacrylate; UDMA, Urethane dimethacrylate; TMPTMA, Trimethylolpropan-Trimethacrylat; TCB resin, butane-1,2,3,4-tetracarboxylic acid, bis-2-hydroxyethyl methacrylate; Bis-MPEPP, Bisphenol A Polyethoxy-Dimethacrylat

n.s., not specified

Data are provided by manufacturers

**Table 2.** Influence of the parameters. Filler weight on the mechanical properties. Table contains the partial eta-square values. The higher the partial eta-square, the higher the influence of the selected factor on the measured property (p<0.001)

Parameter	Filler weight
$\sigma$	0.546
Eflexural	0.805
HM	0.759
HV	0.596
YHU	0.891
Creep	0.212

## 2. Materials and Methods

One giomer, one ormocer as well as the first launched high-viscosity bulk-fill RBC were compared with three established high-viscosity bulk-fill resin composites (Table 1) by assessing their mechanical properties at macroscopic ( $\sigma$  and  $E_{flexural}$ ) and microscopic scale (HM, HV,  $Y_{HU}$  and Creep).

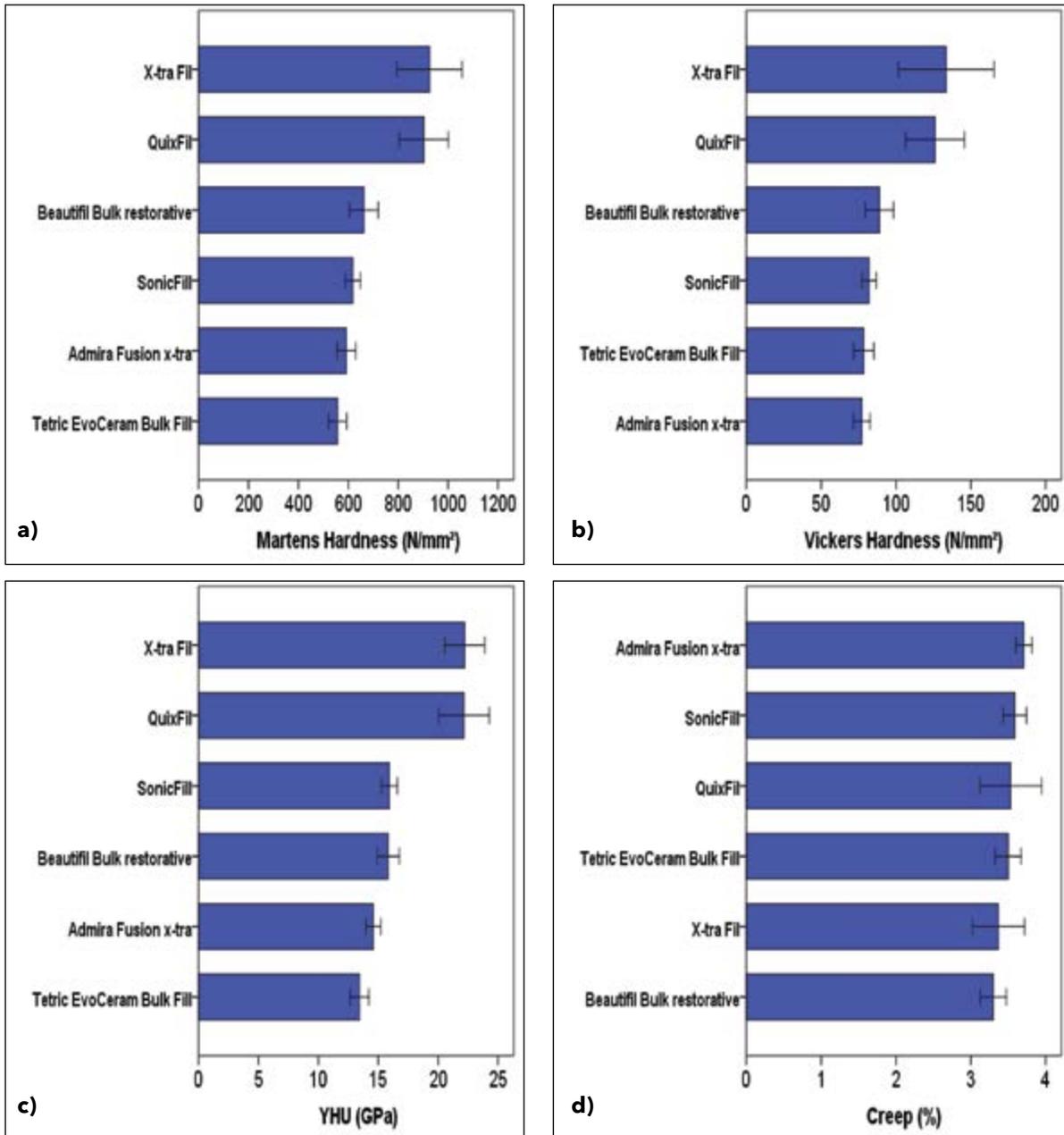
### 2.1 Macro-mechanical Characteristics

The flexural strength ( $\sigma$ ) and flexural modulus ( $E_{flexural}$ ) were determined in a three-point-bending test (n = 20). Therefore, specimens were made by compressing the composite material between two glass plates with intermediate Polyacetate sheets, separated by a steel mold having an

internal dimension of (2 x 2 x 16) mm. Irradiation occurred on the top and bottom of the specimens, as specified in ISO 4049:2009 standards;<sup>20</sup> the duration of the light exposures was 20s, with three light exposures, overlapping one irradiated section no more than 1 mm of the diameter of the light guide (Elipar™ Freelight 2, 3M ESPE, Seefeld, Germany, 1,241 mW/cm<sup>2</sup>) to prevent multiple polymerizations. After removal from the mold, the specimens were ground with silicon carbide sand paper (grit size P 1200/4000 (Leco)) to remove protruding edges or bulges, and then stored for 24 h in distilled water at 37°C. The specimens were loaded until failure in a universal testing machine (Z 2.5, Zwick/ Roell, Ulm, Germany) in a three-point-bending test device, which was constructed according to the guidelines of NIST No. 4877 with a 12 mm distance between the supports.<sup>21</sup> During testing, the specimens were immersed in distilled water at room temperature. The crosshead speed was 0.5 mm/min. The universal testing machine measured the force during bending as a function of the deflection of the beam. The bending modulus was calculated from the slope of the linear part of the force-deflection diagram.

### 2.2 Micro-mechanical Characteristics

Fragments (n = 10) of the three-point-bending test specimens of each group were used to determine the micro-mechanical properties (Martens Hardness (HM), Vickers hardness (HV), indentation modulus ( $Y_{HU}$ ) and creep) according to DIN 50359-1:1997-10<sup>22</sup> by means of a universal-



**Figure 2.** Micro-mechanical properties - a) Martens Hardness; b) Vickers Hardness; c) Indentation modulus, YHU; d) Creep

hardness device (Fischerscope H100C, Fischer, Sindelfingen, Germany). Prior to testing, the specimens were polished with a grinding system (EXAKT 400 CS, EXAKT, Norderstedt, Germany) using silicon carbide paper P 2500 followed by P 4000. Measurements were done on the top ( $n = 10$ ) of the slabs with 6 measurements per sample. The test procedure was carried out force-controlled, where the test load increased and decreased with constant speed between 0.4 and 500 mN. The load and the penetration depth of the indenter (Vickers pyramid: diamond right pyramid with a square base and an angle of  $\alpha = 136^\circ$  between the opposite faces at the vertex) were continuously measured during the load-unload hysteresis. Universal hardness (HM) is defined as the test force divided by the apparent area of indentation under the applied test force. From a multiplicity

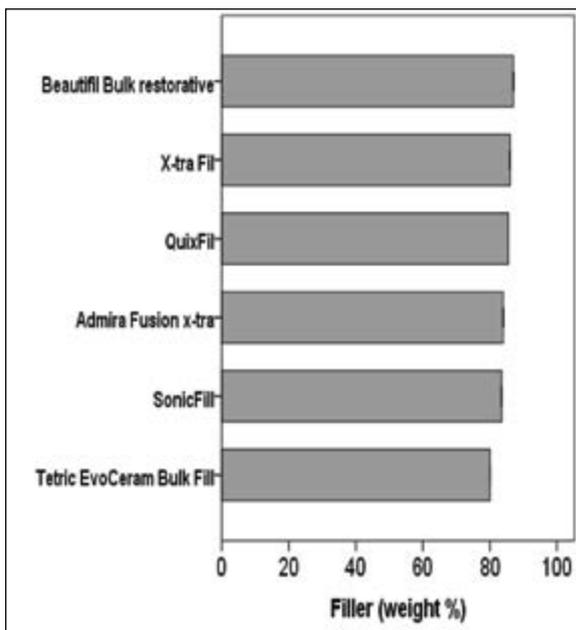
of measurements stored in a database supplied by the manufacturer, a conversion factor (0.0945) between HM and HV was calculated by the manufacturer and entered into the software so that the measurement results were also indicated in the more familiar HV units.  $Y_{HU}$  was calculated from the slope of the tangent adapted at the beginning (at maximum force) of the nonlinear indentation depth curve upon unloading. By measuring the change in indentation depth with a constant test force, a relative change in the indentation depth can be calculated. This is a value for the creep of the materials.

### 2.3 Statistical Analysis

The Kolmogoroff-Smirnoff test was applied to verify the data were normally distributed. Results were compared using one-way ANOVAs and

**Table 3.** Macro and micromechanical properties (mean standard  $\pm$  deviation) of the bulk-fill RBCs- flexural strength  $\sigma$  (MPa), flexural modulus  $E_{flexural}$  (GPa), Martens Hardness HM (N/mm<sup>2</sup>), Vickers Hardness HV(N/mm<sup>2</sup>), indentation modulus  $Y_{HU}$  (GPa), Creep (%)-. Superscript letters indicate statistically homogeneous subgroups within a column (Tukey's HSD test.  $\alpha = 0.05$ ). \* Data were partial presented in<sup>1</sup>

	$\sigma$	$E_{flexural}$	HM	HV	$Y_{HU}$	Creep
Tetric EvoCeram Bulk Fill*	120.8 $\pm$ 12.7 <sup>B</sup>	4.5 $\pm$ 0.8 <sup>a</sup>	557.3 $\pm$ 36.4 <sup>A</sup>	78.4 $\pm$ 6.7 <sup>a</sup>	13.4 $\pm$ 0.8 <sup>A</sup>	3.5 $\pm$ 0.2 <sup>bc</sup>
Admira Fusion x-tra	99.9 $\pm$ 10.7 <sup>A</sup>	5.3 $\pm$ 0.5 <sup>a</sup>	592.1 $\pm$ 38.0 <sup>AB</sup>	77.1 $\pm$ 5.6 <sup>a</sup>	14.6 $\pm$ 0.6 <sup>B</sup>	3.7 $\pm$ 0.1 <sup>d</sup>
SonicFill*	142.8 $\pm$ 12.9 <sup>C</sup>	6.9 $\pm$ 0.6 <sup>b</sup>	618.6 $\pm$ 30.1 <sup>B</sup>	82.0 $\pm$ 4.7 <sup>ab</sup>	15.9 $\pm$ 0.7 <sup>C</sup>	3.6 $\pm$ 0.2 <sup>cd</sup>
Beautiful Bulk restorative	106.0 $\pm$ 12.7 <sup>A</sup>	7.6 $\pm$ 0.4 <sup>b</sup>	662.6 $\pm$ 57.5 <sup>C</sup>	88.9 $\pm$ 9.5 <sup>b</sup>	15.8 $\pm$ 0.9 <sup>C</sup>	3.3 $\pm$ 0.2 <sup>a</sup>
QuixFil	138.6 $\pm$ 20.5 <sup>C</sup>	9.4 $\pm$ 1.8 <sup>c</sup>	902.8 $\pm$ 98.4 <sup>D</sup>	126.0 $\pm$ 19.6 <sup>c</sup>	22.2 $\pm$ 2.1 <sup>D</sup>	3.5 $\pm$ 0.4 <sup>bc</sup>
X-tra Fil*	137.0 $\pm$ 14.4 <sup>C</sup>	9.5 $\pm$ 0.6 <sup>c</sup>	925.6 $\pm$ 131.1 <sup>D</sup>	133.5 $\pm$ 32.0 <sup>c</sup>	22.2 $\pm$ 1.7 <sup>D</sup>	3.4 $\pm$ 0.3 <sup>ab</sup>



**Figure 3.** Filler amount (weight %)

Tukey's HSD post hoc test ( $\alpha = 0.05$ ). A multivariate analysis (general linear model) assessed the effect of the parameter filler weight on the measured parameters  $\sigma$ ,  $E_{flexural}$ , HM, HV,  $Y_{HU}$  and Creep. The partial eta-squared statistic reports the practical significance of each term, based on the ratio of the variation accounted for by the effect. Larger values of partial eta-squared indicate a greater amount of variation accounted for by the model effect, to a maximum of 1. Correlations among measured properties as well as filler amount, was assessed by a Pearson correlation analysis. In all statistical tests, p-values  $< 0.05$  were considered statistically significant when using SPSS Inc. (Version 23.0, Chicago, IL, USA).

### 3. Results

The effect of the parameter *filler amount (weight %)* was proved to be significant on all measured properties ( $p < 0.001$ ; partial eta squared varied among  $\eta_p^2 = 0.212$  for *Creep* and 0.891 for  $Y_{HU}$  (Table 2), while being higher on the modulus of elasticity, either measured at microscopic ( $Y_{HU}$ ;  $\eta_p^2 = 0.891$ ) or macroscopic scale ( $E_{flexural}$ ;  $\eta_p^2 = 0.805$ ).

The direct comparison of the properties measured as a function of RBCs revealed statistical lower flexural strength values for the ormocer-based material *Admira Fusion x-tra* (99.9 $\pm$ 10.7 MPa) and the giomer *Beautiful Bulk restorative* (106.0 $\pm$ 12.7 MPa), while the highest values were recorded for *QuixFil*, *X-tra Fil* and *SonicFill*. The difference in flexural strength among lowest and highest values does not exceed 40%, yet differences measured for  $E_{flexural}$  go beyond 100%. The significant lowest flexural modulus was measured for the group *Tetric EvoCeram Bulk Fill* (4.5 $\pm$ 0.8 GPa) and *Admira Fusion x-tra* (5.3 $\pm$ 0.5 GPa), while the group *QuixFil* (9.4 $\pm$ 1.8 GPa) and *X-tra Fil* (9.5 $\pm$ 0.6 GPa) showed the highest values in the range of the analyzed materials. This trend is maintained also for the indentation modulus  $Y_{HU}$  as well as for the hardness parameters. Lower variation among materials was identified for Creep (3.3 to 3.7%) (Table 3). The filler amount showed the best correlation with the flexural modulus (Pearson correlation coefficient = 0.724), followed by the indentation modulus (0.567) and the hardness parameters, while no correlation was identified with the flexural strength. An inverse correlation, yet low (-0.218) was identified between filler amount and creep. A moderate correlation was observed between the parameters measured at macroscopic scale ( $\sigma$  and  $E_{flexural}$ ; 0.425), while the correlation among the micro-mechanical parameters was high, except for Creep. The correlation among macro and micro mechanical parameters (except again for Creep) was low to moderate for  $\sigma$  and high for  $E_{flexural}$  (Table 4).

### 4. Discussion

The basic approach of this study was to compare modern high-viscosity bulk-fill RBCs in terms of their mechanical behavior assessed at macro and microscopic scale. All materials analyzed belong to the category of high-viscosity bulk-fill RBCs, which is characterized by enhanced mechanical properties when compared to the low-viscosity bulk-fill RBCs.<sup>1</sup> The materials analyzed are indicated to be used in bulk up to 4 or 5 mm, to restore the entire preparation, with no need to be capped by an auxiliary restorative composite. Under

**Table 4.** Pearson correlation coefficients among measured properties as well as filler content

	weight %	$\sigma$	$E_{\text{flexural}}$	HM	HV	$Y_{\text{HU}}$	Creep
weight%	1	ns	0.724	0.548	0.450	0.567	-0.218
$\sigma$	ns	1	0.425	0.279	0.229	0.381	ns
$E_{\text{flexural}}$	0.724	0.425	1	0.713	0.598	0.790	ns
HM	0.548	0.279	0.713	1	0.974	0.962	ns
HV	0.450	0.229	0.598	0.974	1	0.887	ns
$Y_{\text{HU}}$	0.567	0.381	0.790	0.962	0.887	1	-0.108
Creep	-0.218	ns	ns	ns	-ns	-0.108	1

the curing conditions used in the present study (20s exposure time, 1241 mW/cm<sup>2</sup> irradiance), the materials have proved in previous studies to be adequately polymerized in at least 4-mm increments.<sup>4,5,23</sup> Therefore, the macro-mechanical properties, which were assessed according to the valid standards<sup>20</sup> on 2-mm thick specimens, may be transferred to larger increments as well. Although low differences in filler amount were identified among the materials analyzed (81% to 87% by weight), the inorganic filler amount was directly reflected in the measured mechanical properties, since the highest filled materials *x-tra fil* and *Quixfil*, which contain both 86 weight % fillers, also reached the highest mechanical properties. Table 1 indicates for Beautiful Bulk restorative an even higher filler amount (87%). It must be pointed out that the material contains, beside inorganic bulk-filler, also large pre-polymer fillers, thus the total inorganic filler amount is accordingly lower as indicated. A similar conclusion applies for Tetric EvoCeram® Bulk Fill, in which the pre-polymer fillers amounted to 17% of the total indicated filler amount (Table 1).

All materials analyzed fulfill the ISO 4049 criteria (flexural strength  $\geq 80$ MPa) to be used in load-bearing areas as restorative materials.<sup>20</sup> Yet, the ISO 4049 does not specify a lower limit value for the modulus of elasticity, which represents the relative stiffness of a material and is related to the deformability of a restorative material under masticatory stresses.<sup>24</sup> Consistent larger differences among materials were identified with regard to the flexural modulus, which is directly related to the inorganic filler amount. As for the measured micro-mechanical properties, the present investigation revealed a strong dependence of all measured parameters on the filler amount. To assess both the elastic and the plastic part of the deformation, a depth sensing hardness measurement device was used in this study. Therefore, a dynamic measuring principle was applied by recording simultaneously the load and the corresponding penetration depth of the indenter.<sup>22,25</sup> Besides hardness, the indentation modulus is also indicated, since previous studies attested a good correlation between indentation modulus and the modulus of elasticity measured in the more familiar three-point bending test.<sup>26</sup> This relation was confirmed also by the present study. While flexural modulus

and indentation modulus might have attributed a similar clinical interpretation, both measured hardness parameters - Martens Hardness (or universal hardness) and the more familiar Vickers Hardness - are defined as the resistance a material oppose to penetration or indentation, and might be related to properties such as wear resistance or abrasion.<sup>27</sup> The last statement must however be put into perspective for bulk-fill RBCs, since many bulk-fill RBCs contain larger fillers (up to 20  $\mu\text{m}$ ) compared to regular RBCs,<sup>28</sup> which might have a negative impact not only on the wear behaviour of the materials, but also on their aesthetic properties. The materials analyzed in the present study are the result of a large variety of innovative technologies. The concept of bulk-filling, meaning the ability to place and cure a resin-composites in large increments (up to 4 mm) and thus to skip the time consuming layering technique, was first introduced with the high-viscosity bulk-fill RBC *QuixFil*. Yet, the low-viscosity bulk-fill RBC (SDR flow) of the same company, launched many years later, was the first bulk-fill material achieving a noticeable commercial success and establishing thus the aforementioned concept. This fact triggered a series of products from all other dental companies. As for *QuixFil*, the enlarge depth of cure was realized by enlarging the filler size and consequently reducing the filler-matrix interface and the scattering along this interface. Whether the refractive indices of the material components were modified in order to reduce differences among fillers and organic matrix, and therefore to reduce light scattering and enhance translucency,<sup>29</sup> is not stated nor analyzed so far. Besides, no remarkable changes in the composition of the organic matrix or photo-initiating system are noted (Table 1).

The present study allows comparing two different bulk-fill materials from the same company - *X-tra Fil* and *Admira Fusion x-tra* - in which two different concepts in modifying the materials for bulk-fill placement were followed. While *X-tra Fil* is based on a traditional (methacrylates) organic matrix, containing monomers like Bis-GMA, UDMA, TEGDMA (Table 1), *Admira Fusion x-tra* is a purely ormocer-based material. As different from regular di-methacrylates, Ormocers are described as 3-dimensionally cross-linked inorganic-organic polymers, synthesized from multi-functional urethane- and

thioether(meth)acrylate alkoxy silanes as sol-gel precursors. Alkoxy silyl groups of silane permit the formation of an inorganic Si-O-Si network by hydrolysis and poly-condensation reactions, while the methacrylate groups are available for photochemical polymerization.<sup>19</sup> The reason beneath introducing Ormocers as dental materials was motivated in their reduced polymerization shrinkage and wear when compared to regular RBCs as well as in the very similar coefficient of thermal expansion compared to the natural tooth structure.<sup>19</sup> However, it was technically not possible for a long time to create commercial RBCs based integrally on ormocers. Therefore, ormocers were used in commercial materials only to replace parts of the regular organic matrix, which diminished the aforementioned positive effects. It might be worth mentioning that the first commercial ormocer-based restorative was *Admira (Voco)*, launched in 1999, followed by the nano-hybrid composite *Grandio* of the same company. Recently, new technologies allowed creating purely ormocer RBCs, as implemented also in the analysed material *Admira Fusion x-tra*. With respect to the mechanical properties, the direct comparison of both bulk-fill RBCs identified consistently higher values in *X-tra Fil* compared to *Admira Fusion x-tra*, which is mainly attributed to the higher inorganic filler content and the enlarged filler size. The aforementioned drawbacks related to enhanced filler size must however be considered, when trying to reproduce the in-vitro data to a clinical perspective. A further interesting material development was implemented in *Beautiful Bulk restorative*. The material is denominated as a Giomer, an acronym derived from the main material compounds - **G**lass **i**onomer (GIC) and **p**oly**m**er -, since the material category contains as filler a GIC derivate, which is implemented into a resinous matrix. The fillers contained in *Beautiful Bulk restorative* are named S-PRG, which means surface pre-reacted glass ionomer, and were developed by Roberts et al.<sup>18</sup> in 1999. In S-PRG, a fluoroaluminosilicate glass has been reacted with a polyalkenoic acid in the presence of water, to form a wet siliceous hydrogel. In contrast to GICs<sup>30</sup>, the acid-base reaction occurred in S-PRG fillers during manufacturing, thus resulting in a surface modified layer which is described to subsequently protect the glass core from the damaging effects of moisture.<sup>18</sup> S-PRG fillers were proved to release and recharge fluoride but also other ions such as Na<sup>+</sup>, Sr<sup>2+</sup>, Al<sup>3+</sup>, BO<sub>3</sub><sup>3-</sup>, SiO<sub>3</sub><sup>2-31-38</sup>. Besides S-PRG fillers, the material contains also large pre-polymerized fillers<sup>4</sup> comprising 87.0 weight % and 74.5 volume %, respectively. The bulk-fill giomer restorative proved in previous in-vitro studies to be adequately cured in increments up to 4-mm<sup>4</sup> and to induce low, yet statistical similar cusp deflection compared to the ormocer based bulk-fill restorative *Admira Fusion x-tra*, described

above.

As for *Tetric EvoCeram Bulk Fill*, the filler system is comparable with the filler system observed in the regular nanohybrid RBC *Tetric EvoCeram*. The enhanced depth of cure was realized not by enlarging the filler size, as observed in the majority of bulk-fill RBCs, but by implementing an additional photo-initiator, Ivocerin, along with the well-known photo-initiator system camphorquinone (CQ)/amine and an acyl phosphine oxide initiator. Ivocerin is described as a germanium-based photo-initiator with a higher photo-curing activity than CQ, which is attributed to its larger molar extinction coefficient ( $\epsilon\lambda$ ) when compared to CQ. Its maximal absorption is described at 411 nm wavelength,<sup>17</sup> therefore the initiator may be activated by regular curing units. A further advantage of Ivocerin is that it can be used without the addition of a co-initiator (amines) as well as its ability to form at least two radicals able to initiate the radical polymerization process. Therefore, Ivocerin is considered more efficient when compared to the CQ/amine systems, in which only one radical able to initiate the polymerization reaction is formed.<sup>17</sup> Regarding *SonicFill* it shows, similarly to *x-tra fil*, changes focusing primarily on the filler system, particularly on the filler size.<sup>1</sup> A previous study identified for *SonicFill* specimens of thicknesses up to 6 mm, lower blue light transmittance compared to *Tetric EvoCeram Bulk Fill* or *x-tra fil*. The amount of blue light transmitted is therefore comparable for *SonicFill* with values recorded in regular nano- and micro-hybrid RBCs.<sup>23</sup> Although enlarged fillers were observed also in *SonicFill*, the material is one of the lesser bulk-fill brands offered in regular shades.

Thus, the low light transmittance might be, at least partially, attributed to the pigments' necessity to adapt the color, which are present in lower amounts in other bulk-fill RBCs, offered mainly in the color "universal" (Table 1). Compared to regular composites intended for incremental use, the analyzed bulk-fill composites revealed comparable or even superior mechanical properties.<sup>1</sup> Nevertheless, the enhanced filler size as observed in many materials, as well as the reduced amount of pigments, may forfeit the esthetic or the wear behavior of the materials.

## 5. Conclusions

The analyzed high-viscosity bulk-fill RBCs differ consistently in the properties analyzed, which is directly related to the inorganic filler content. Innovative modifications as the giomers or ormocers were related to materials with moderate mechanical properties, yet comparable to regular RBCs. The changes in chemical composition might however create advantages in terms of polymerization shrinkage stress or a caries protective ability.

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## CV

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Doctoral degree in material sciences from the Ludwig-Maximilians-University, Dental School, München, Germany (1999-2004), followed by postdoctoral lecture qualification (habilitation) at the same university (2004-2009). Since 1999, assistant professor, associated professor (2009) and professor (2014) for biomaterials at the Dental School of the Ludwig-Maximilians-University in München.

## Questions

### The difference between a bulk-fill and a regular resin composite is given by:

- a. Incremental thickness, which is ca. 2-mm for regular composites and up to 4-5-mm for bulk-fill composites;
- b. Chemical composition of the organic matrix and filler system;
- c. Way to be cure;
- d. Mechanical properties.

### Bulk-fill resin composites are subdivided with respect to following particularities:

- a. Bulk-fill composites are a unitary material category, with less difference among individual materials ;
- b. Mechanical properties: low-viscosity bulk-fill resin composites are characterized by lower mechanical properties compared to high-viscosity bulk-fill resin composites ;
- c. Application technique: low-viscosity bulk-fill resin composites need to be finished by an additional layer of a regular resin composite, while high-viscosity bulk-fill resin composites are intended to restore the entire preparation;
- d. Incremental thickness .

### What are "Giomers" ?

- a. Resin-based composites with particular glass ionomer filler ;
- b. Resin-based composites able to release ions like F-;
- c. Glass ionomers, and therefore this material category does not need to be cure by blue light ;
- d. A sort of ceramic.

### What are "Ormocers" ?

- a. 3-dimensionally cross-linked inorganic-organic polymers ;
- b. A purely inorganic material;
- c. A purely organic material;
- d. A material able to release F- .

## COMMUNICATION SKILLS IN THE DENTAL PRACTICE: A REVIEW

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### ABSTRACT

**Background:** In recent years, there has been a lot of research on the relationship between dentists and patients on the factors that cause the patient to follow a treatment and be loyal to his dentist.

**Objective:** The purpose of this review is to study the literature related to communication in the dental practice.

**Data collection:** The articles reported in this literature review were searched on the PubMed database.

**Outcomes:** According to some authors, 65% of the information is transmitted by means of non-verbal methods and only 35% - verbally. In this respect, the following have been described: models of behavior dentist-patient; Harter's steps sequence of patients' involvement in the health care decision-making process; Sahm's, Bartsch's and Witt's research on the importance of communication, according to which the information properly received by the patient is related to the satisfaction of the treatment. Some assessment tools for the psychological state before and during the treatment have been described - scale Corah, Gale and Illig - (DAS) for measurement of the anxiety from dental treatment; (DFS) - measures the level of fear of treatment; Janke' study with its own developed and standardized questionnaires - (STAIDFS); Corah's tool for assessing the cognitive, emotional and behavioral satisfaction of patients- (DVSS).

**Conclusion:** The conclusion to be drawn is that dentists should be trained and in their work should apply adequate communication methods, tailored to the individual characteristics of each patient, to build confidence between each other.

**Keywords:** communication skills, dental practice, dentist-patient relationship.

### 1. Background

In modern health care it has become more important to involve the patient in his treatment decisions. There are many arguments to support this statement. With the increasing influence of the media, access to medical information is constantly increasing. It has been observed that patients increasingly demand more information and want to be involved in the decision-making process, which is, according to the World Medical Association Declaration of Lisbon on the Rights of the Patient, their inalienable right.<sup>1-3</sup>

In recent years, there has been a lot of research on the relationship between dentists and patients, on the factors that cause the patient to follow a treatment and be loyal to his dentist. The aim of those studies is to define the role of verbal and non-verbal communication used during the dental treatment.

The aim of the following research is to make a review of the literature related to communication in the dental practice.

### 2. Data collection

The articles reported in this literature review were searched on the PubMed database considering only scientific journals written in English and German. The keywords selected were "communication skills", "dental practice", "dentist-patient relationship".

### 3. Outcomes

Creating trust between a doctor and a patient plays a major role in the success of a therapy. To build this trust, before starting treatment, the dentist should inform his patient about: diagnosis and prognosis of the disease; upcoming tests; potential risks they carry and the subsequent therapy; treatment options. The approach, of course, must be strictly

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individual, to enable the patient to understand what is the forthcoming treatment and whether/how it will change the quality of his life. This kind of approach strengthens the relationship between doctor and patient and makes the patient trust the doctor and strictly follow the recommended treatment.<sup>4</sup>

A major role in understanding the information presented to the patient is the way in which communication is carried out. According to some authors, 65% of information is transmitted nonverbally and only 35% verbally.<sup>5</sup> It has been shown that when those two methods of communication complement each other, the information given can be accepted as a complete message.

To be successful, the dentist should be familiar with the various methods and techniques of communication, because it is a part of good medical and dental practice.

Ethics describes the different models of behavior between doctor - patient.

The most popular and implemented ones are:

- Paternalistic model;
- Autonomous model;
- Partnership model.

In the paternalistic model the doctor chooses the treatment based on his medical experience and knowledge, provides information to the patient, so that he is able to conduct his therapy. This type of treatment is based on medical evidence. The responsibility for the decisions lies with the doctor. The autonomous model is based on obtaining an informed consent. The information is also transmitted by the physician to the patient, but it contains details that are important for the treatment from the patient's point of view. So, after being fully informed, the patient understands the information and is involved in the decision to conduct the therapy.

In a partnership model, the information flows in both directions. Making a decision is being influenced by: important medical details; the value system of the patient; his lifestyle and his needs; his everyday life. All aspects of the treatment are discussed with the patient and he participates in the medical decision-making process, bearing part of the responsibility. Initially the model of partnership was introduced in the treatment of chronic diseases and of diseases with different alternatives for treatment, all evidence-based.<sup>6</sup> The goal is that both individuals become actively involved in the decision-making process, based not only on medical information, but also tailored to the individual characteristics of the patient. The roles of the doctor and the patient in the partnership model are determined by their mutual work and the parity of both parties. In the English literature, this is called "equipoise"<sup>7</sup> or "balanced solution". On the one hand, this balance relates to the different but equal treatments of a disease.

On the other hand, equipoise means that the physician and the patient have the same influence

on the medical decision-making process.<sup>8</sup> Knowing the different patterns of behavior, dentists can choose the most suitable method of communication with the patient, which affects the quality of service. The quality of the health service depends on how well it meets the individual needs of the patient. In the complex system of modern health insurance the best way to achieve high-quality care is to use a patient-centered approach. This includes respect for the dignity and uniqueness of the individual, based on the ethical and moral standards of health care.<sup>9</sup> Thus the patient is granted his right to receive quality health care.<sup>3</sup> There is evidence that if patients take an active role in their own health care, this leads to more accurate decisions, improved treatment outcomes, higher patient and physician satisfaction and more efficient use of resources in the health care system.<sup>10</sup>

Harter suggests a sequence of steps for the patients' involvement in the process of making decisions regarding subsequent health care.<sup>6</sup> With this approach of including the patient in the decision-making process, conversation has a strictly defined structure and elements:

1. Informing the patient about the necessity of decision-making;
2. Show equivalence in conversation;
3. Inform about the different choices;
4. Consider the patient's expectations and questions, understanding the problem;
5. Define the patient's desires;
6. Discuss the variety of options;
7. Carry out a decision;
8. Define ways to implement the decision.

In the dental practice the dentist should comprehend and use the art of communication in order to implement these steps successfully. The results of a study conducted by Gerbert show that, according to the patients, the most important skills of the ideal dentist are: professional competence - 86%; 71% are for the use of universal precautions; 63% stress the continuous training of the physician; 54% want painless treatment; 47% expect the dentist to soothe the patient and 47% - to be polite with the patient,<sup>11</sup> i.e. the majority of the responses are related to the ability of dentists to communicate properly.

The above-mentioned issue is the topic of a survey by Sahn, Bartsch and Witt at University "Julius Magnus" in Würzburg, Germany. The first study showed that 42% of those treated are anxious to speak about personal subjects, while this desire decreases with the increasing age of the patients.<sup>12</sup> Witt and Bartsch expanded the study in 1993, using video equipment, followed by questioning the patients to examine the impact of the information and communication during the initial orthodontic conversation. The conclusion was that due to the use of multiple medical terms, patients understood only a third of the information. The authors assume that the amount of information that patients have understood is related to the satisfaction with the

subsequent treatment.<sup>13</sup> This requires improving the methods and the amount of information that dentists share with the patient. But, to do that, the physician must be trained.

The results of their third survey entitled "Optimized orthodontist - patient communication" came out in 1996. They show that asking questions, providing explanations, engaging in careful listening and encouragement are important for successful communication. The authors come to the conclusion that the dentists' communication skills of dentists should not be taken for granted, but be integrated in their university training.<sup>14</sup>

Patients are increasingly willing to participate in the decision-making process and expect more information from their dentists to make an informed choice. They want to ask questions and talk about their oral health and at the same time they expect more concern. The dentist should ask the right questions, listen carefully and provide clear information without medical terms.<sup>15</sup> This was confirmed in a study conducted by Gürdal et al.; according to him, the factors that determine patient satisfaction are: personal relationships, good organization, the skills and knowledge of the treating dentist.<sup>16</sup>

The patients' desire to become informed regarding the duration and type of treatment, their expectation of compassion from the dentist, who refers to their fear, indicates the presence of a strong emotional component in the process of communication between the dentist and the patient. According to Enkling et al. patients assess the quality of the dentist mostly according to his interpersonal skills.<sup>17</sup> This is because during treatment, the patient cannot realize what professional skills the dentist has. This will come up later - for example durability of the completed restoration or denture. During treatment the patient evaluates the dentist according to his pain and how he communicates.

In dental practice, pain is associated with anxiety, fear and dental phobia. Studies show that about 70% of the population experiences certain discomfort before visiting a dentist, 20% are very anxious, and 5% avoid such visits.<sup>18</sup> The most common reason for dental phobia is a previous traumatic experience in the dental office, followed by dissatisfaction and lack of trust.<sup>19</sup> Anxiety, fear and dental phobia are experiences that require specific knowledge demonstrated by the dentist to determine the right approach to such patients. The assessment of the patient's condition stays before setting the correct approach.<sup>19</sup> A special scale has been developed to assess such conditions. To assess the mental condition of the patient before treatment, one can use the scale created by Corah, Gale and Illig - Dental Anxiety Scale (DAS).

It consists of 4 questions that measure the anxiety of the dental treatment.<sup>20</sup> Another similar tool is the Dental Fear Survey (DFS). With it, the authors measure the level of fear of the treatment.<sup>21</sup>

About two-thirds of dentists believe that treating patients experiencing fear is a major challenge.<sup>22</sup>

Choosing the right approach stimulates the patient's trust and satisfaction. Janke and other writers conducted a study with their own questionnaire and with a standardized questionnaire - (STAI and DFS).<sup>23</sup>

The results show that 36% of patients describe themselves as very fearful, while only 23% of them are identified as such by the dentist. The main reasons for their fears that patients point out are the uncertainty of what will happen and bad memories of previous visits to the dentist.<sup>24</sup> A number of authors have shown that fear elimination is an important success factor for dental treatment and must be taken into consideration. If the dentist is calm and friendly, if he provides moral support to the patient, if the patient does not feel pain during the treatment, fear can be overcome.<sup>23, 24, 25, 26</sup> Only if the patient does not feel fear, can there be satisfaction with the treatment.

Corah et al. have developed an assessment tool for the cognitive, emotional and behavioral patient satisfaction - Dental Visit Satisfaction Scale.<sup>27</sup> According to them, the patients evaluated the professional skills of the dentist based on their satisfaction with interpersonal factors such as communication and concern. This once again confirms the importance of the dentist having good communication skills.

The need of good communication in the medical practice has led to the development of a manual for teaching communication and social skills in medical universities in the German-speaking countries entitled "Basel Consensus Statement".<sup>28</sup> Its aim is to help teachers improve the educational programs in the field of communication and social skills. The main competences, which every graduate student in medicine and dentistry must possess, are:<sup>28</sup>

- Respect for the patient;
- Recognizing the own strengths and weaknesses;
- Recognizing the needs of the patient;
- Catching the non-verbal aspects of communication (gestures, facial expressions, posture, etc.).
- Respect the individuality of the patient and his personal views;
- Stick to their own values and norms of behavior;
- Intent to work in a team.

In addition to the better outcome and the satisfaction with the treatment, communication is also important for the patient's motivation. Sgan-Cohen explains that any health intervention, including oral hygiene instruction, should be based on scientific evidence and contains two components - inform about the risks and motivate the patient.<sup>29</sup> To motivate someone is to make him do something or change his behavior. According to Geisler the following statements are valid in medicine and dentistry:

- Successful treatment without motivation is unthinkable;
- Work with patients is based on motivation;
- Conversation is the number one tool while

motivating the patient.<sup>30</sup> To motivate the patient in order to take care of his oral health is not enough to constantly remind him of the reasons for his illness or show him how to protect himself. It is important to pay attention to the way this happens. If we make the process enjoyable for the patient he would be willing to change his oral hygiene habits.<sup>31</sup> This means that a successful relationship between dentist and patient is based on dialogue, which is the basis of the term "compliance".<sup>30</sup> Motivation does not mean the patient following blindly any advice of his dentist, but rather suggests an interaction between the two for an ideal treatment, which includes not missing appointments; following the instructions for oral hygiene; taking certain methods of treatment and others. A well-motivated patient has a better compliance, is presumably in good health due to better treatment outcome; patient and dentist are satisfied with the treatment; loyalty to the dentist increases.

Although there are various studies about communication skills, what they have in common is that all highlighted as a key competence of the dentists their ability to express themselves clearly and accurately, using comprehensive language, to listen to the patients and involve them in taking

decisions about their treatment.<sup>32</sup> According to some authors understanding the criteria for successful communication is easy, but using these skills in a real clinical setting can be a challenging task. Therefore, the aim in the daily practice of the dentist should be - building a patient - centered psycho - social model that serves the ailing person, not the disease, creates trust and promotes a holistic approach in the treatment of the dental patient.

#### 4. Conclusion

The review of the literature shows considerable interest to the problems of the communication in the dental practice.

The conclusion is that dentists should be trained and they should apply in their job adequate communication methods tailored to the individual characteristics of each patient. This is the only way trust can be built and at the end of the treatment both patient and dentist be satisfied with the outcome.

#### Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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## Questions

**What is the rate of the nonverbally transmitted information during dentist-patient conversation?**

- a. 35%;
- b. 50%;
- c. 65%;
- d. 75%.

**"Equipoise" in medical practice is part of the decision-making process and is based on...**

- a. The paternalistic behavior model;
- b. The partnership behavior model;
- c. The categorizing behavior model;
- d. The autonomous behavior model.

**Which quality of the dentist is mostly appreciated during treatment?**

- a. Good organization;
- b. Professional skills;
- c. Interpersonal skills;
- d. Durability of restoration.

**Which is the most common reason for dental phobia?**

- a. Dissatisfaction with the treatment;
- b. Previous traumatic experience;
- c. Lack of trust;
- d. The smell of the dental practice.

## MODIFIED CLINICAL APPROACH FOR IMPROVED AESTHETICS IN FULL-ARCH RESTORATION

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### ABSTRACT

**Aim:** to achieve a natural aesthetic outcome, function and stability using a minimally invasive, maximally effective technique in a reasonable time period.

**Summary:** A 50-year-old female patient presented a tooth mobility of Grade II to III. She wished to have a full arch fixed aesthetic restoration. After evaluation of the hard and soft tissue and minimally invasive planning, the decision was made to modify the clinical approach and create a special protocol for best aesthetic results. The treatment includes chairside and laboratory steps, such as aesthetic analysis, impressions, a functional analysis, X-rays, CT, and evaluation of the hard and soft tissue, a mock-up of the intended result and minimally invasive planning. The patient was happy with the desired outcome.

### Key learning points:

1. Improved aesthetic results for full arch restorations are achieved by immediate implant placement, immediate loading and platform switching.
2. Platform switching implant design, provisional and final abutment design, and paradigm shifts in treatment approaches lead to superior aesthetic results.
3. Thorough evaluation and manipulation of the hard and soft tissue provide the desired aesthetic outcome.

**Keywords:** aesthetic implantology, pink and white aesthetics, full arch restoration, inter-implant papilla length, platform-switching.

## 1. Introduction

This case study demonstrates that new philosophies concerning implant design, provisional and final abutment design, as well as paradigm shifts in treatment approaches, can lead to superior aesthetic results. In full-arch implant-supported restoration, immediate placement with immediate loading has been well documented. The literature shows a high success rate of 97% with this kind of treatment in the mandible<sup>11-17</sup> and of 96% in the maxilla.<sup>18-20</sup> Osseointegration of implants has been achieved routinely and with a high degree of success. Contemporary implant dentistry focuses on aesthetic success aside from functional results. One of the compromises in aesthetics in a situation of adjacent implants is the short papilla between two implants, where a maximum length of 3.5 mm can be achieved.<sup>1</sup> This can be explained by loss of the inter-implant bone. The advantages of a platform-switched implant design regarding

bone and tissue stability are well documented in literature.<sup>2-6</sup> The resulting stability of the bone is explained through the increased distance of the micro-gap from the bone (a minimum of 0.45 mm is adequate). Another way to preserve bone in the long term is by selecting an implant design with a micro-thread design at the collar. The positive influence of the micro-thread design at the collar of the implant has been biomechanically explained by Steigenga et al.<sup>7</sup> Bone is stronger when loaded in compression, and 30% weaker when subjected to tensile forces. During function, the shear forces are transformed into small compression and traction forces.

## 2. Papillary area

Another observed benefit of platform-switching is the non-surgical increase in tissue volume in the healing phase.

Additionally, Gargiulo<sup>8</sup> has demonstrated that the

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**Figure 1.** The platform-switching design of the implants facilitated preservation of bone at the collar and the gaining of supra-crestal fibres



**Figure 2.** Concave profile of the provisional abutment.



**Figure 3.** Convex profile of the final individual abutment



**Figure 4.** Narrow triangles between the final crowns, restoring the physiological and aesthetic contact points

higher the peri-implant soft tissue, the lower the risk of bone loss in the process of increasing the biological width.<sup>8</sup>

Through decreased bone loss and a resulting reduction in bone instability, as well as increased thickness of the tissue, more supra-crestal fibres can be gained (Fig. 1).

Owing to this concept in designing the provisional abutment, the final abutment and the crown, we were able to manipulate the soft tissue and gain an inter-implant papilla length comparable to the length of the papilla between two natural teeth (5 mm).

### 3. Abutment

The running room for the provisional abutment

was concave (Fig. 2).<sup>9</sup> After osseointegration, we modified the running room to a straight or slightly convex profile, especially approximately. The tissue extended from 0.5 to 1 mm in the direction of the contact point (Fig. 3). The final construction followed the natural parameters of the interdental contact points in the natural dentition, as defined by Chu et al.<sup>10</sup> Designing the interdental spaces as narrow triangles with slight convexities, we managed to guide this tissue by another 0.5 to 1 mm to the ideal contact point, and give the entire construction a natural appearance (Fig. 4).

### 4. Clinical case

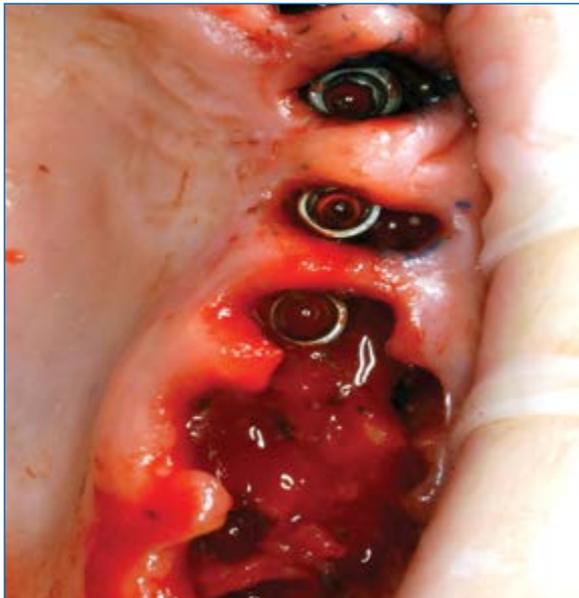
A 50-year-old patient presented a tooth mobility of Grade II to III (Fig. 5). He wished to have his



**Figure 5.** Periodontally damaged teeth, mobility Grade II



**Figure 6.** Horizontal bone loss



**Figure 7.** Immediate implant placement with immediate loading



**Figure 8.** PEEK abutments



**Figure 10.** Periodontally damaged teeth, mobility Grade II



**Figure 9.** Provisional PEEK abutment with concave running room



**Figure 11.** Situation after healing/osseointegration

aesthetic restoration fixed. In cases such as this, an alternative chairside and laboratory workflow can guide our treatment.

The chairside workflow included an aesthetic analysis, impressions, a functional analysis, X-rays, CT, and evaluation of the hard and soft tissue (Fig. 6). The treatment plan should be minimally invasive, of maximum effectiveness and aim for the best aesthetic results. This means immediate implant placement and immediate loading (Fig. 7).



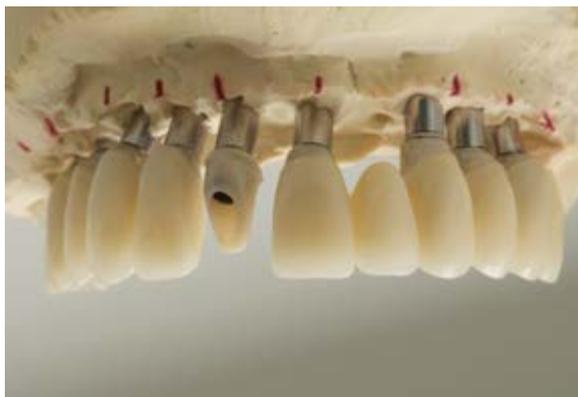
**Figure 12.** After healing



**Figure 13.** Modification of the soft-tissue biotype to a straight or slightly convex profile



**Figure 14.** Individually fabricated zirconia abutments (LAVA) on a titanium base, with a preparation limit of 0.5 mm below the gingival margin



**Figure 15.** Individually fabricated zirconia CAD/CAM abutments and IPS e-max lithium disilicate (Ivoclar Vivadent) ceramic crowns



**Figure 16.** Manipulation of the soft tissue to achieve the desired aesthetic outcome



**Figure 18.** Insertion of the abutments, allowing one minute of compression



**Figure 17.** Aesthetic gingival outcome shown on the model

At the laboratory, a mock-up of the intended result was created. Afterwards, the mock-up was

discussed with the patient and tried in chairside. At the next appointment, implant placement using a provisional and surgical, aesthetic-driven guide, fabricated by the laboratory in advance, and immediate restoration followed the chairside stage.

The implants were selected in order to allow immediate loading. For immediate loading, an implant's features and insertion protocol have to provide for high primary stability. Therefore, self-cutting threads and a drilling protocol



**Figure 19.** Positive effect on the length of the papilla



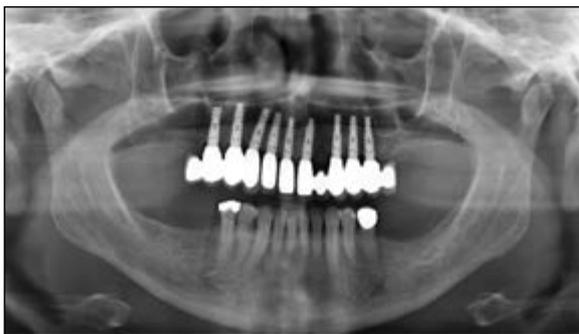
**Figure 20.** Revascularisation after one minute



**Figure 21.** Crowns inserted



**Figure 22.** Situation after inserting the crowns



**Figure 23.** Restoration



**Figure 25.** Pleasing aesthetic outcome



**Figure 24.** Natural-looking outcome

for undersized implant site preparation were necessary. Furthermore, the rough surface of the implant shoulder and the micro-thread design at the collar were important for long-term bone and soft-tissue stability. Platform-switched provisional abutments with concave running room and made of PEEK (polyether ether ketone) were additional

features that qualified the implant selected for immediate loading (Figs 8, 9).

Another important aspect covered the parameters applied in the immediate loading of the implants inserted in extraction sockets. Primary stability was achieved with an insertion torque of 35 N cm. About three quarters of the implant surface should be covered by the host bone. The gap between the implant and the buccal bone was augmented to a maximum of 1.5 mm (Tarnow, 1997). Owing to these conditions, we were able to insert immediate implants and to perform immediate loading with a rigid fixed bridge (Figs 10-12). Individual abutments were CAD/CAM fabricated from zirconia (LAVA, 3M ESPE) (Fig. 13). Tooth reconstruction was employed to produce the bridge (Figs 14-17).

Individually, the running room was modified to a slightly convex or straight profile, so that the tissue was shifted interdentally and another 0.5 to 1 mm

was gained in papilla length. The convexities of the crown contour at the gingival margin were produced with respect to the harmony of the pink and white aesthetics (Figs 18-22).

Symmetry, the golden proportion and the individual demands of the patient were given particular consideration (Figs 23-25).

### 5. Conclusion

The target of modern dentistry is the achievement of a natural aesthetic outcome, function and stability using a minimally invasive, maximally effective technique and in a reasonable period. The treatment method presented herein, with the main aim of imitating or even improving the natural dentition, has been used for 12 full-arch cases over the last two years. In order to obtain the natural gingival architecture between implants, we adhere to the following:

1. immediate implant placement in perfect implant position;
2. immediate loading of the implant under initial stable conditions;

3. use of implant systems with a platform-switching design;
4. use of provisional abutments with a convex profile;
5. use of provisional crowns with a flat profile;
6. use of final abutments with a slightly convex profile to move the tissue gained into the interdental space;
7. restoration of the natural proportion of the interdental spaces and contact points; and
8. creation of narrow triangles, forming space for the papillae.

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All images were created in Dental Master. Material copyright by MD Simulation Ltd ([www.dentalmaster.net](http://www.dentalmaster.net)).

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The authors declare no conflict of interest related to this study. There are no conflicts of interest and no financial interests to be disclosed.

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She is Director of DGOI Implantology Expert (German Society of Oral Implantology) and author of various research papers mainly covering the area of implantology and dental surgery.

**Questions****Which was not included in the treatment presented in this article?**

- a. MRI;
- b. CT;
- c. X-ray;
- d. Functional analysis.

**What tooth mobility did the patient have?**

- a. Grade I;
- b. Grade II to III;
- c. Grade 0;
- d. None of the above.

**What do the implant's features and insertion need to provide for high primary stability?**

- a. Low primary stability;
- b. Medium primary stability;
- c. High primary stability;
- d. None of the above.

**How much of the implant surface should be covered by bone?**

- a. None;
- b. All;
- c. Three quarters;
- d. One fifth.

## SPLINTS IN TMJ DYSFUNCTION. HOW EFFECTIVE? A REVIEW

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### ABSTRACT

**Background:** Temporomandibular disorders (TMD) are recognized as the most common non-tooth-related chronic orofacial pain conditions that confront dentists and other healthcare providers. Functional disturbances of the masticatory system can be as complicated as the system itself. Although numerous treatments have been advocated, the complex nature of TMD requires a multidisciplinary team. Effective treatment selection begins with a thorough understanding of the disorder & its etiology.

**Objective:** The purpose of this review is to examine the evidence concerning the management of temporomandibular dysfunction using various splints.

**Data collection:** The articles reported in this literature review were searched on PubMed/MEDLINE database, considering only the scientific journals written in English.

**Outcomes:** Occlusal splints must be chosen by dentists as therapeutic appliances based upon appropriate diagnosis, as opposed to a simple cure for all TMD conditions. Occlusal splints, and stabilization splints, in particular, have a positive effect as a treatment option for patients with TMD. Stabilization splints provide temporary and removable ideal occlusion. Providing an ideal occlusion by the use of splint therapy reduces abnormal muscle activity and produces "neuromuscular balance".

**Conclusion:** Occlusal splints are effective in many circumstances but not in all. Therefore, an accurate and specific diagnosis of a particular TMD condition is needed to effectively treat patients. In order to make definitive conclusions, the authors suggest a need for more myalgia specific clinical studies with larger sample sizes, which may enable us to evaluate the efficacy of occlusal splints in comparison with other modes of treatments.

**Keywords:** Temporomandibular disorders, occlusal splints, intraoral appliance.

### 1. Background

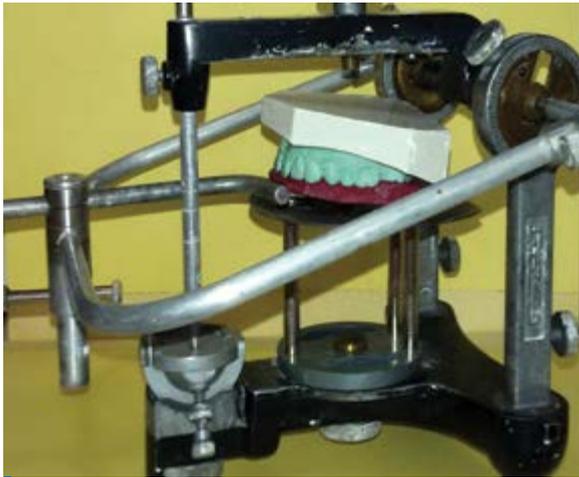
Temporomandibular disorders (TMD), according to the American Academy of Orofacial Pain, are defined as 'a collective term embracing a number of clinical problems that involve the masticatory muscles, the Temporomandibular joint (TMJ) and associated structures, or both'. TMD are a sub-classification of musculoskeletal disorders,<sup>1</sup> having a recurrent or chronic course with noticeable fluctuation over time.<sup>2</sup> Patients suffering from TMD often present with pain in the jaws, earache, headache, and myofascial pain. The pain is often aggravated by mandibular movements, like chewing and yawning. It is also frequently associated with disturbed function and limited and/or asymmetric movements of the lower jaw.<sup>3</sup> Myofascial pain represents a neurosensory disorder involving peripheral and centrally sensitized muscle nociceptors. It is characterized by pain

and dysfunction that arises from pathologic and functional processes in the masticatory muscles. In 1969, Laskin described the myofascial pain dysfunction syndrome (MPDS) as having certain clinical characteristics and denotes to any muscle disorder (not an intracapsular disorder).<sup>4</sup> Myofascial pain arises from hypersensitive areas in muscles called trigger points. These localized areas in muscle tissues and/or their tendinous attachments are often felt as taut bands when palpated, which elicits pain. The exact nature of the trigger point is not known.<sup>5</sup>

In most cases, the symptoms are the reason for the increased tension of the masticatory musculature, and the parafunctions.<sup>6,7</sup> Due to the large subjectiveness of the symptoms, TMDs are very difficult to diagnose, especially because patients usually search for help from other specialists besides dentists (e.g., neurologist,

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**Figure 1.** Face bow record transfer for centric stabilization splint



**Figure 2.** Centric stabilizing splint in use



**Figure 3.** Occlusal contacts in centric relation position



**Figure 4.** Corresponding contacts in mandibular arch during use of centric stabilizing splints

otolaryngologist or ophthalmologist).<sup>8,9</sup> Management of TMD aims at relief of pain, reduction of load on masticatory muscles and TMJ, and restoration of normal function. Several different therapies, most of them conservative and reversible, others irreversible, have been advocated for patients with TMD. A number of successful treatment outcomes have been reported. Therapies may include occlusal appliances, pharmacological interventions, physical therapy, physical self-treatment, psychological intervention, acupuncture, and biofeedback.<sup>10</sup> More complex TMD conditions are recommended to be managed using combinations of single therapies.<sup>11,12</sup> Orthopaedic appliances, also referred to as intraoral appliances, occlusal splints, orthotics, night guards, or bruxism appliances, have reported 70-90 % rate of clinical success.

## 2. Data collection

The articles reported in this literature review were searched on PubMed/MEDLINE database, considering only the scientific journals written in

English; case reports were excluded. The keywords selected were "temporomandibular disorders", "occlusal splints" and "intraoral appliances".

### 2.1. Occlusal splint therapy

To achieve the proper relation of the jaw, the centric relation (CR) should be restored. It is easily performed by occlusal splints. An occlusal appliance is any removable artificial occlusal surface used for diagnosis or therapy affecting the relationship of the mandible to the maxilla. Occlusal appliances may be used for occlusal stabilization, for the treatment of temporomandibular disorders, or for the prevention of dentition wear.<sup>13</sup> Occlusal splints are used in a vast majority of patients with TMDs to restore the static and dynamic symmetry of the stomatognathic system. Most commonly, they are used in cases with disc displacement.<sup>14, 15,16</sup> Different types of splints used in occlusal splint therapy include permissive, nonpermissive, hydrostatic, and soft rubber (silicone) splints. The type of splint utilized is dependent on the diagnosis. One of the most popular occlusal splints is the Michigan-type bite splint (Figs 1 - 4),

**Table 1. Classification of occlusal appliances**

Type of occlusal appliances	Activity	Recommendations
Reflex appliances e.g. Interceptor, Anterior Plateau, NTI-tss	Prevent habitual tooth contact prevent gnashing and clenching	Acute symptoms that can be attributed to overloading of the tissues
Stabilization appliances e.g., Michigan type splint	Synchronous tooth contact in a centric condyle position in static occlusion and an anterior tooth position with disclusion in the lateral teeth region in dynamic occlusion.	For acute or chronic symptoms and also in psychological and physiological overloading reactions.
Repositioning appliances e.g., Anterior repositioning splint	The temporomandibular joint or joints is/are set in a therapeutic position by the splint to support healing and to maintain a symptom-free joint posture.	Anterior disc displacement with and without reduction, temporomandibular joint compression, retral displacement of the condyle and osteoarthritis. Can be used as a short-term or long-term therapy.
Superior repositioning appliance	To allow complete reseating of the condyle disk assembles up the eminence to the superior centric relation axis.	Establish the correct skeletal relationship before the correct occlusal relationship is determined.
Anterior bite plane	To disengage the posterior teeth and thus eliminating their influence on the function of the masticatory system.	For treatment of muscle disorders related to orthopedic instability or an acute change in occlusal condition. Parafunctional activity may also be treated with it but only for a short period.
Posterior bite plane	To achieve major alterations in vertical dimension and mandibular positioning.	Advocated in case of severe loss of vertical dimension or when there is a need to make major changes in anterior positioning of the mandible. For disc derangement disorders.
Soft and resilient appliance	To achieve even and simultaneous contact with the opposing teeth.	Protective device for persons likely to receive trauma to their dental arches e.g. athletic splint. For patients exhibiting high levels of clenching and bruxism, they help dissipate some heavy loading forces encountered during parafunctional activity.

precisely described by Ramfjord and Ash Jr.<sup>17</sup> This splint could be used in both dental arches, but preferably in the maxilla. The mandibular splint is used when the posterior area misses teeth in the mandible and unwanted tooth movement must be avoided. The main purpose of this device is to disengage the occlusion, place the condyle in the centric position, relax the masticatory muscles and prevent further tooth wear due to nocturnal parafunctional activity. The main features of this splint are freedom in centric and canine guidance. It is important to note that the relation of the maxillary and mandibular arches may differ after the treatment when compared to the initial state,

especially when partial coverage splints are used.<sup>14,18</sup> The occlusal splints are also used in the initial phase of treatment in patients with mouth overclosure caused by a pathologic deep bite. Before the prosthetic rehabilitation of the severe tooth wear, one should remember that initially, splint therapy should be applied to adapt the stomatognathic system to the new occlusion.<sup>20</sup> A classification of the occlusal appliances with activities and recommendations is presented in Table 1. Normally, it is suggested that patients wear the splint only at night. The splint needs to be adjusted (rebalancing of the splint to the new position of the jaw by

grinding some of its surface points, since the lower jaw will adopt a new position as a result of wearing the splint) over several visits as the masticatory muscles relax until a consistent jaw relationship is reached.

The patients then should be reviewed at regular intervals.

After a period of successful splint therapy (normally between two and three months), patients can be weaned off the splint.<sup>8</sup>

### 3. Outcomes

There are various ways of evaluating the effectiveness of occlusal splint therapy such as:

1. Visual analogue scale (VAS).
2. Clinical stomatognathic examination
3. Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials (IMMPACT)
4. Research diagnostic criteria. RDC/TMD
5. Clinical and anamnestic index
6. Radiographs and CT-scans
7. MRI scans
8. Real-time ultrasonography
9. Vibratography
10. Electromyography
11. Jaw tracking device

Most of the patients who suffer from TMD problems of mainly muscular origin benefit from stabilization splints, but there is not enough evidence that they are better than placebo splints, soft splints or other conservative treatment methods.<sup>21</sup> Recently, randomized clinical trials (RCT) have found that stabilization splints are more effective than other treatments.<sup>22,23</sup> However, there are studies that have yielded contradictory results.<sup>24,25</sup> Because of these diverse opinions, there obviously is a strong need for further RCTs to identify if a stabilization appliance is really effective.

Walczyńska-Dragon and Baron<sup>8</sup> have proven that occlusal splint therapy using the SVED (Sagittal Vertical Extrusion Device) appliance decreases not only aches in the head and all parts of the spine but also disc displacements within 3 weeks of treatment. The next decrease in frequency of unwanted, unfavorable symptoms was observed after 3 months of treatment with splints. When properly performed, these splints also unblock a limited mouth opening.

Research performed by Lee et al.<sup>19</sup> in a group of 59 patients with somatic TMJ dysfunction showed that intraoral appliance could improve cervical spine alignment and alleviate symptom severity.

Meyer et al.<sup>26</sup> designed a special type of occlusal splint in which, the condyle-disc unit is largely intact and the interarticular space should not be constricted. The therapeutic approach consists in eliminating centric and eccentric occlusal disturbances, rebuilding lost support zones, and changing the mandibular motion pattern in order to improve muscle tone and neuromuscular coordination. As a rule, it also leads to a more physiological positioning of TMJ structures with

a positive, therapeutic effect. If TMJ pain persists nonetheless, targeted, geometric decompression of the very probably compressed articular structures should be performed. The splint described can be modified into a decompression splint by inserting an approximately 0.8 mm space holder craniodorsally into the condylar box of the articulator on the side of the joint requiring decompression (also possible bilaterally). This yields a corresponding vertical increase of the splint, which in the patient can produce a ventrocaudal decompression of the compressed articular structures.

Most comparative studies of different splint designs have relied only on medical history and clinical examination to diagnose disk displacement.<sup>27</sup> Soft splints, which are more convenient for patients than hard splints, can be used immediately after provisional diagnosis with TMD.<sup>28</sup> The rationale for using soft splints is that the soft resilient material may help in distributing the heavy load associated with parafunctional habits.<sup>29</sup> Hard splints are thought to reduce TMD symptoms by altering the occlusal equilibrium, changing the afferent impulses to the central nervous system, improving the vertical dimension, correcting the condylar position, and aiding cognitive awareness.<sup>30</sup>

Littner et al. reported that hard splints offer more successful outcomes than soft splints for patients with functional disorders of the masticatory system.<sup>31</sup> However, other studies have shown that both soft and hard appliances are equally beneficial in improving masticatory muscle pain in the short term.

The findings of one of the randomized controlled study show that stabilization splint treatment in combination with counseling and masticatory muscle exercises has no additional benefit in relieving facial pain and increasing the mobility of the mandible than counselling and masticatory muscle exercises alone over a 6-months' time interval. However, the efficacy of the stabilisation splint treatment on TMD in long-time follow-up remains to be confirmed.<sup>32</sup>

A systematic review which has included a total of 47 publications citing 44 RCTs with 2,218 subjects suggest Hard stabilization appliances, when adjusted properly, have good evidence of modest efficacy in the treatment of TMD pain compared to non-occluding appliances and no treatment. Other types of appliances, including soft stabilization appliances, anterior positioning appliances, and anterior bite appliances, have some RCT evidence of efficacy in reducing TMD pain. However, the potential for adverse events with these appliances is higher and suggests the need for close monitoring in their use.<sup>33</sup>

Because headache causes are manifold, diagnostics and therapy require an interdisciplinary medical approach. From the dental and maxillofacial standpoint, diseases and disorders of the teeth, periodontium, other craniofacial hard and soft tissues, as well as craniomandibular dysfunction

(CMD) must be taken into consideration in treating such patients.<sup>34</sup>

In case of reasonable suspicion of craniomandibular dysfunction, an estimate for the detailed clinical and possibly instrumental diagnostics and optionally (grinding teeth guard/bite splint) pre-treatment must be done. Only after pre-treatment definitive treatments can be planned and carried out.<sup>35</sup>

#### 4. Conclusions

Due to the diverse causes of these disorders, TMD pain management requires various methods of treatment that are compliant with the origin of the dysfunction. Most of the TMD patients are helped

by incorporation of a stabilization splint. There is not enough data on the long-term efficacy and effectiveness of this widely used therapeutic tool. In the future, there is a need for well-conducted randomized controlled trials paying attention to adequate sample size, blind outcome assessment, duration of follow up, and using standardized methods for measuring treatment outcomes. Occlusal splints must be chosen by dentists based upon appropriate diagnosis, as opposed to a simple cure for all TMD conditions.

#### Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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**Questions**

**Permissive splints:**

- a. Also referred to as muscle deprogrammers;
- b. Are designed to position mandible in a specific relationship to maxilla;
- c. They align the condyle-disk assemblies;
- d. Used when a centric relation should be corrected.

**Occlusal splint therapy can be recommended for the following purposes except:**

- a. To protect oral tissues in patients with oral parafunction;
- b. To eliminate occlusal interferences;
- c. To stabilize the unstable occlusion;
- d. To test the effect of changes in occlusion on the TMJ and jaw muscle function before extensive restorative treatment.

**A directive splint is contraindicated in following conditions except:**

- a. If condyle and disc can be aligned correctly;
- b. If discs can maintain their alignment with condyles during function;
- c. If it unlocks occlusal incline contacts;
- d. First two options.

**Indications of centric stabilization splints are all except:**

- a. TMJ arthralgia;
- b. Myospasm or myositis;
- c. Parafunctional activity;
- d. Disc-interference disorders.

## RELIABILITY OF PANORAMIC RADIOGRAPHS TO DETERMINE GONIAL AND FRANKFURT MANDIBULAR HORIZONTAL ANGLES IN DIFFERENT SKELETAL PATTERNS

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### ABSTRACT

**Background:** Gonial and Frankfurt mandibular plane angles are two of the most important measurements required for orthodontic treatment and orthognathic surgery.

Currently, lateral cephalograms are used for the determination of Go and FMA angles; however, in this method, measuring individual gonial angles becomes difficult due to the superimposed images of anatomical structures in a lateral cephalogram.

**Objectives:** The aim of the present study is to check the possible application of panoramic radiograph to determine gonial and Frankfurt mandibular plane angles.

**Material and Methods:** A total of 90 panoramic and 90 cephalometric radiographs were obtained retrospectively from patients who attended our orthodontic clinic. The mean age of the patients was  $18.9 \pm 5.9$  years. Gonial and Frankfurt mandibular angles were determined on both lateral cephalograms and OPGs and the patients were divided into three groups of horizontal, normal, and vertical growers. Pearson's correlation coefficient was used for data evaluation.

**Results:** Pearson's correlation coefficient showed that there were significant correlations between the means of Gonial and Frankfurt mandibular plane angles determined by OPG and Lateral cephalograms. ( $p < 0.01$ )

**Conclusion:** Panoramic radiograph can be reliably used to determine of gonial and Frankfurt mandibular angle and thus reduce the need for obtaining further cephalometric images from patients.

**Keywords:** orthopantomograms, lateral cephalograms, Gonial angle (Go), Frankfurt mandibular plane angle (FMA), skeletal patterns evaluation.

### 1. Introduction

Gonial angle (Go) and Frankfurt mandibular plane angle (FMA) are two of the most important measurements required for orthodontics, dentofacial orthopedics and orthognathic surgery. Go and FMA are commonly used to indicate the vertical or horizontal growth pattern of patients.

Go and FMA having mean values of  $130^\circ \pm 7^\circ$  and  $25^\circ \pm 5^\circ$ , respectively, are good indicators of vertical and horizontal growth pattern. Increased values of these angles show downward and backward rotation of the mandible which is characteristic of

high angle patients; while their decreased values would be indicative of upward and forward rotation of the mandible which is in return characteristic of horizontal growers.<sup>1</sup> Recognizing the growth pattern of patients is of utmost importance in the treatment planning phase.

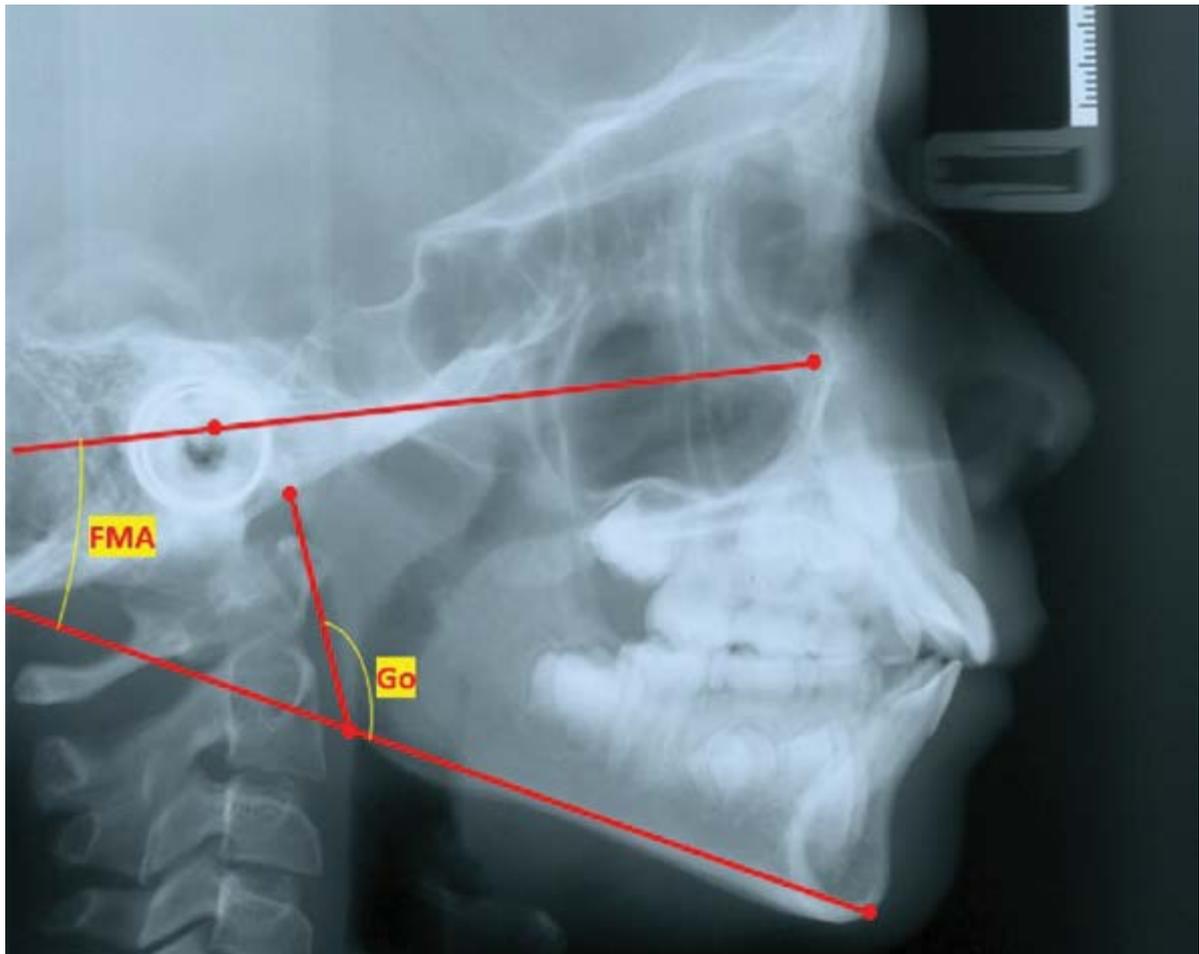
Currently, lateral cephalograms are used for the determination of Go and FMA angles; however, with this method, measuring individual gonial angles becomes difficult due to the superimposed images of anatomical structures in a lateral cephalogram. However, panoramic images have

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**Figure 1.** Gonial and Frankfurt mandibular plane angles shown on lateral cephalogram

got the advantage of reduced superimposition of anatomical structures.

Mattila et al.<sup>2</sup> reported that gonial angle can be determined from panoramic radiography with the same degree of accuracy as from lateral cephalogram; while, Fischer-Brandies et al.<sup>3</sup> stated that in determining the gonial angle, the lateral cephalometric radiograph should be preferred.

The aim of the present study is to check the possible application of panoramic radiograph to determine gonial and Frankfurt Mandibular plane angles.

## 2. Material and Methods

A total of 90 patients with the mean age range of  $18.9 \pm 5.9$  years who attended our orthodontic clinic were retrospectively selected for the current study. The radiographic data of the patients included lateral cephalometric and panoramic radiographs taken with the same digital machines. (Cranex D, Sordex Dental Imaging, Germany). The samples were allocated into three equal groups of 30 subjects based on the measurement of their Go angle on lateral cephalogram:

1. Horizontal growers:  $Go < 120^\circ$
2. Normal growers:  $120^\circ \leq Go < 130^\circ$
3. Vertical growers:  $130^\circ \leq Go$

The criteria for the selection of the patients radiographs had to be high quality and sharpness,

and all radiographs had to be taken by the same apparatus and same technician, with patients in the natural head position.

In lateral cephalograms, the gonial angle was determined in the intersection of the ramal plane (Ar-Go) and mandibular plane (Go-Gn) using a protractor with 1 degree accuracy. FMA was also determined as the angle formed by the intersection of Frankfurt Horizontal plane (FH) and the Mandibular Plane (Go-Gn). (Fig. 1)

In panoramic radiographs, the gonial angle was determined from two tangents which were drawn from the inferior border of the mandible and posterior borders of condyle and ramus of both sides. And FMA was determined as the intersection of the porion-orbitale line and mandibular plane (Go-Gn). (Fig. 2) One week after the first measurements, the tracings and measurements were repeated by the same investigator. Intraclass correlation coefficients (ICC) were used to measure the reliability of the results. ICC coefficients ranged from 0.813 to 0.92 indicating excellent reliability of the measurements.

## 3. Results

In this cross-sectional study, the agreement between Go and FMA measured in panoramic and lateral cephalometric radiographs was analyzed. The mean value of the gonial angle in lateral



**Figure 2.** Gonial and Frankfurt mandibular plane angles shown on panoramic radiograph

**Table 1. Mean and standard deviation of Go and FMA on lateral cephalograms and OPGs**

	Gonial Angle				FMA Angle			
	Lateral Ceph.		OPG		Lateral Ceph.		OPG	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Horizontal	115.5	3.3	113.8	4.3	21.3	3.9	20.5	3.9
Normal	123.3	2	121.1	2.4	25.8	3.1	25	3.2
Vertical	132.7	2.9	128	4	31	4.2	29	3.7
Total	123.8	7.6	121	6.9	26	5.5	24.9	5

**Table 2. Correlation coefficient between lateral and OPG for Go angle**

	Pearson's Correlation Coefficient	p Value
Horizontal	0.733	0.01
Normal	0.399	0.05
Vertical	0.425	0.05
Total	0.896	0.01

cephalograms and OPGs were  $123.8^{\circ} \pm 7.6^{\circ}$  and  $121^{\circ} \pm 6.9^{\circ}$ , respectively. The same value for FMA was  $26^{\circ} \pm 5.5^{\circ}$  and  $24.9^{\circ} \pm 5^{\circ}$ , respectively. (Table 1) Pearson's correlation coefficient showed a significant correlation between the means of the gonial angle in the lateral cephalogram and OPG for all three groups of horizontal, normal and vertical growers. In horizontal growers  $r$  was 0.733 ( $P < 0.01$ ), in normal growers it was 0.399 ( $P < 0.05$ ) and in vertical growers it was 0.425 ( $P < 0.05$ ). (Table 2) According to Table 3 there were significant correlations between the means of FMA determined by OPG and Lateral cephalograms ( $P < 0.01$ ).

#### 4. Discussion

The current study was performed to evaluate the measurements of gonial and FMA angles in panoramic radiographs and lateral cephalograms. The analysis of the two techniques suggests that Go and FMA can be reliably determined from

the panoramic radiograph. The finding of the current study corresponds with the results of the studies done conducted by Larheim and Svanaes<sup>4</sup> and Oksayan et al.<sup>5</sup> Panoramic radiography is frequently used in orthodontic practice to provide important information about the teeth and their axial inclinations. Thus, this technique would allow a reduction in the patient radiation doses before or during orthodontic treatment. Go and FMA have important roles in predicting growth direction and are good indicators for mandibular steepness. Go and FMA also act as a valuable diagnostic landmarks to determine a patient's growth pattern.<sup>6,7</sup> Since OPGs are routinely requested by dentists and orthodontists during clinical examination, being able to determine Go and FMA from OPGs would omit the need for further radiographic images such as lateral cephalograms. Matilla et al.<sup>2</sup> reported that the accuracy of the measurement of the gonial angle on panoramic radiograph is similar to lateral cephalograms. Oksayan et al also

**Table 3. Correlation coefficient between lateral and OPG for FMA angle**

	Pearson's Correlation Coefficient	pValue
Horizontal	0.798	0.01
Normal	0.538	0.01
Vertical	0.587	0.01
Total	0.827	0.01

reported that panoramic radiograph results were as reliable as lateral cephalometric radiograph in all angle classifications and mentioned that panoramic radiography can be used as an alternative radiographic technique to detect gonial angle in orthodontic patients. Shahabi et al.<sup>8</sup> also concluded that panoramic radiography can be used to determine the gonial angle as accurately as lateral cephalogram. They also mentioned that in panoramic radiography the right and left gonial angles can be easily measured easily without superimposition of anatomic landmarks, which occurs frequently in lateral cephalograms. However, in a study reported by Akcam et al,<sup>9</sup> regression analysis showed that the forecasting capability of vertical measurements on panoramic radiographs is 11-20% of lateral cephalograms. They stated that even though panoramic radiographs provide information on the vertical dimensions of craniofacial structures, clinicians should be cautious when predicting skeletal cephalometric parameters from panoramic radiographs, because of their lower predictability. Fischer-Brandies et al.<sup>3</sup> also reported that, the lateral cephalometric radiograph should be preferred in determining the gonial angle. They found gonial angle on panoramic radiograph 2.2-3.6 degrees less than lateral cephalograms, also these results showed significant difference between two radiographs. Shahabi et al.<sup>8</sup> mentioned that the discrepancy in the results could be because of the type of malocclusion and age of the samples while

their study was performed in adults with Class I malocclusion. Oksayan<sup>5</sup> also mentioned that their study was different in that it was constructed by either adult or adolescent patients. Moreover, various studies unanimously reported that effects of the age and gender on the gonial angle was very limited.<sup>5,8,10</sup> Determining landmarks and discrepancies from on single OPG would reduce the patients' radiation doses.<sup>11</sup> As an illustration, Gupta and Jain<sup>12</sup> used OPG as a preliminary tool in diagnosing mandibular asymmetry. Puricelli<sup>13</sup> also suggested a method for determining mandibular measurements on panoramic radiographs. Thus, a single OPG can be reliably used for various assessments which in the past would require other forms of radiographic images.

### 5. Conclusion

- Panoramic radiographs can be used as a reliable alternative to lateral cephalometric images for determination of Go and FMA.
- Panoramic radiographs can be used to predict the patients' growth pattern.
- Use of panoramic radiographs to determine Go and FMA can reduce patient radiation doses before or during orthodontic treatment.

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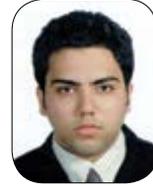
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One of his main research interest is orthodontics.

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## Questions

### Which one is the definition of gonial angle in lateral cephalogram?

- a. Intersection of the ramual plane and mandibular plane;
- b. Intersection of the ramual plane and occlusal plane;
- c. Intersection of the ramual plane and Frankfort mandibular plane;
- d. None of them.

### Which one is the definition of Frankfort mandibular plane angle in OPG?

- a. Intersection of the palatal plane and mandibular plane;
- b. Intersection of the porion-orbitale line and mandibular plane;
- c. Intersection of the porion-orbitale line and occlusal plane;
- d. Intersection of the porion-orbitale line and palatal plane.

### Which angle is used to determine vertical growth pattern?

- a. FMA;
- b. Gonial Angle;
- c. 1 and 2;
- d. ANB.

### Which one is the normal value of FMA?

- a.  $20^\circ \pm 5^\circ$ ;
- b.  $15^\circ \pm 5^\circ$ ;
- c.  $30^\circ \pm 5^\circ$ ;
- d.  $25^\circ \pm 5^\circ$ .

## WILLIAMS SYNDROME - A CASE REPORT

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### ABSTRACT

**Aim:** The aim of this case report is to describe the medical and dental features of an 18 year old female diagnosed with Williams syndrome (WS).

**Summary:** Williams syndrome is a rare, genetically determined multisystem disorder involving the cardiovascular system, musculoskeletal system, dysmorphic facies, intellectual disabilities and dental anomalies.

**Key learning points:** The short term and long term dental management of patients with Williams syndrome is discussed.

**Keywords:** Williams syndrome, diagnosis, cardiovascular abnormalities, dentofacial characteristics

### 1. Introduction

Williams syndrome (WS), also referred to as Williams-Beuren syndrome is a congenital, multisystem disorder resulting from the de novo hemizygous microdeletion on chromosome 7 (7q11.23). In 1961, Williams et al reported a condition with supraaortic stenosis, mental retardation, and abnormal facial features, based on their experience with 4 patients.<sup>1</sup> The following year, Beuren et al reported similar findings independently and expanded the phenotype to include peripheral pulmonary artery stenosis and dental malformations.<sup>2</sup> The incidence is around 1:10,000 live births. There is no gender or race predilection. Familial cases can occur, but are far less common than de novo cases.<sup>3</sup> The deletion involves 26 to 28 genes, including the *ELN* gene, which codes for the protein elastin. This has been demonstrated to be responsible for the vascular pathology in WS. The remaining deleted genes contribute to the phenotypic findings in these patients.<sup>4</sup> The disorder is characterized by growth and developmental deficiencies, cardiovascular defects (supraaortic stenosis) dysmorphic facial features (Elfin facies), hypercalcemia, renal and gastrointestinal disorders, dental anomalies and several conductive and neurological abnormalities. The characteristic facial features include wide mouth, thick lips, full prominent cheeks,

depressed nasal bridge, long philtrum, heavy orbital ridges, stellate irises, small chin and low ear implantation.<sup>5</sup> The dental anomalies include microdontia, abnormal tooth morphology, hypoplastic enamel defects, anterior crossbite, tongue thrusting, excessive interdental spacing and deep or open bite. Class II and III occlusions are also commonly seen in these individuals.<sup>6</sup> The clinical diagnosis of WS is based on recognition of the typical dysmorphic facial features, cardiovascular anomalies (supraaortic stenosis, pulmonary stenosis), developmental delay and hypercalcemia.

This is confirmed by the FISH (fluorescent in situ hybridization) test which detects the deletion of the elastin gene on the long arm of chromosome 7.<sup>5</sup>

There is no specific treatment for WS. The treatment is multidisciplinary and an individualized approach is used to address the systemic disorders and developmental and cognitive disabilities. The aim of this report is to present an 18 yr old girl with WS; her clinical characteristics, diagnosis, treatment, dental anomalies, dental management and short term and long term prevention plan.

### 2. Case report

An 18.3 year old female, R.S, with a diagnosis of Williams syndrome presented herself to the European University College mobile screening van

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**Figure 1.** Frontal View



**Figure 2.** Profile View



**Figure 3.** Intraoral Frontal View

in Dubai, United Arab Emirates.

### 2.1. Medical History

The patient was of Palestinian descent and was the youngest in a family of five children. The parents reported a consanguineous marriage and had no other children that were affected. According to the mother, the pregnancy and delivery were both normal. The diagnosis of WS was suspected only when the child was 11 yrs old, based on her slow learning abilities and distinct facial characteristics. A cardiology evaluation revealed mild to moderate supravalvular aortic stenosis. A FISH test was requested by the pediatrician which showed a mutation on chromosome 7, location q11.23, gene *ELN*, which confirmed the diagnosis of WS. The patient presented the following features, characteristic of the disorder:

*Medical:* Supravalvular aortic stenosis, low weight, low muscle tone, constipation.

*Physical facial features:* Small upturned nose, wide mouth, full lips, long philtrum, small chin and puffiness around the eyes.

*Personality:* Very engaging, overly friendly, strong expressive language skills. She had exceptional musical abilities, played the flute and was a singer.

*Developmental:* Learning and attention difficulties, visual - spatial deficits and difficulty with fine motor movements.

### 2.2. Dental History

A detailed history, extraoral examination, intra oral examination and radiographic evaluation were conducted.

*Extra oral examination* revealed the characteristic 'elfin facies' with broad forehead, small upturned nose, wide mouth, long philtrum, full lips and cheeks, small chin and puffiness around the eyes. (Figs 1 and 2)

*Intra oral examination* revealed a full complement of permanent dentition with class III molar occlusion bilaterally; generalized plaque induced gingivitis; existing amalgam fillings in teeth 16, 27 and composite fillings in teeth 17, 15, 14, 11, 21, 24, 25, 26, 36, 46. (FDI Notation System). Teeth 12,



**Figure 4.** Upper Occlusal



**Figure 5.** Lower Occlusal



**Figure 6.** Right Lateral View



**Figure 7.** Left Lateral View

23, 36 and 44 had brownish discoloration on the facial surfaces, indicative of enamel hypoplasia, which is commonly seen in patients with WS.<sup>6</sup> Recurrent caries were detected on teeth 25, 26 and 36 and deep fissures were noted on teeth 34, 35, 44, 45, 17, 27, 37 and 47. Vitality tests revealed all the teeth to be vital. There was no previous history of trauma reported (Figs 3-7).

The patient had very poor oral hygiene and brushed only once a day. Her diet consisted of sugary snacks throughout the day. She had been treated by a general dentist for the existing restorations prior to being evaluated by the authors. The treatment was accomplished under local anesthesia. According to the dental history reported by the parent, the patient had sporadic dental care through out and had not seen a dentist for the past two years. The family was very keen to reestablish dental care for the patient and decided to continue long term care with the European University College dental clinic.

### 2.3. Radiographic

A panoramic and bitewing radiographs were taken at the first visit. The panoramic radiograph revealed no signs of supernumerary teeth or of any pathology. The third molars were all present. No interproximal decay was noted on the bitewing radiographs. (Fig. 8)

Due to the systemic complications associated with the syndrome, the patient was referred to her physician for a medical consult prior

to proceeding with any dental treatment. A cardiologist was also consulted as the patient had a history of supravalvular aortic stenosis; no antibiotics were required for SBE prophylaxis.

An informed consent was obtained from the parents of the patient for the dental treatment. A comprehensive dental treatment plan was formulated. The short term dental plan included dental prophylaxis, scaling and fluoride varnish (Duraphat, 22600ppmF) application on all the teeth. Composite restorations were planned for teeth 25, 26, 36 and on the buccal surface of 44. Resin sealants were recommended for teeth 34, 35, 44, 45 and all second permanent molars.

The patient was very concerned about the brownish discolorations on her front teeth (12, 23) which were planned to be treated with microabrasion.

The treatment was accomplished using local anesthesia. An individualized preventive plan was put in place that included frequent follow ups every 3 months for dental prophylaxis and fluoride varnish application. Twice daily brushing with fluoridated toothpaste (1450ppm F) and flossing was recommended. Diet and nutrition counseling was provided. An orthodontic consultation was recommended due to the Class 3 malocclusion.

The behavior of the patient was rated as ++ on the Frankl behavior scale.<sup>7</sup>



**Figure 8.** Orthopantomogram

She was very friendly and engaging which is the characteristic 'cocktail party' nature of individuals affected by this syndrome. She also liked to sing after every visit.

### 3. Discussion

Williams syndrome is a rare, genetic disorder with the occurrence of characteristic physical and mental abnormalities. The incidence of the features noted in this condition are dysmorphic facies (100%), cardiovascular disease (most commonly supravalvular aortic stenosis [80%]), mental retardation (75%), a characteristic cognitive profile (90%), and idiopathic hypercalcemia (15%)<sup>5</sup> The deletion of the elastin gene is responsible for the connective tissue phenotype, which includes a hoarse voice, soft skin, lax ligaments, vasculopathy, mainly supravalvular aortic stenosis, the impression of premature aging and stiffness of joints.<sup>5,8</sup> The pathogenesis of other characteristics, such as hypercalcemia, mental retardation and unique personality traits may be explained by the loss of one or more genes contiguous to the *ELN* gene.<sup>5</sup> Diagnosis is often made in mid-childhood when characteristic features, cognitive profiles and cardiac findings become more apparent.

Our patient was diagnosed late at 11 yrs of age because the mother noticed that the child was a very slow learner and she was not growing as fast as her siblings. The pediatrician suspected Williams syndrome based on the child's facial characteristics and made a referral to the cardiologist who diagnosed the presence of supravalvular aortic stenosis. The diagnosis was confirmed by the FISH test. The lack of advanced care facilities in the area where the patient was born and raised in early childhood led to the delay in diagnosis.

The characteristic facial features noted in most children with WS are similar and often become more apparent with advancing age. Infants have full cheeks and a flat facial profile, whereas older

children and adults often have a long narrow face and a long neck accentuated by sloping shoulders (8). Blue- and green-eyed children with WS have a prominent "starburst" pattern to their irises (stellate iris).<sup>5,8</sup>

The reported patient did present the characteristic facial features such as small upturned nose, periorbital fullness, wide mouth, full lips and small chin, in addition to an aging facial appearance and presence of multiple white hairs. She also had low muscle tone, visual spatial defects, a slight developmental delay and a very engaging personality as seen with persons affected by this syndrome.

The patient was diagnosed with supravalvular aortic stenosis which did not require any surgery. A consultation was conducted by her cardiologist before any dental treatment was performed. According to the current AAPD guidelines,<sup>9</sup> antibiotics were not required for SBE prophylaxis prior to dental treatment. Individuals with cardiac manifestations should be followed regularly by their cardiologist as supravalvular aortic stenosis is an often progressive condition that may require surgical repair. Peripheral pulmonary artery stenosis is often present in infancy and usually improves over time. Because the elastin protein is an important component of elastic fibers in the arterial wall, any artery may become narrowed.<sup>5</sup>

In infants with WS, the presence of colic, irritability, vomiting, muscle cramps and constipation can be attributed to hypercalcemia. Symptomatic hypercalcemia usually resolves during childhood, but lifelong abnormalities of calcium and vitamin D metabolism may persist.<sup>10</sup> Multivitamins with Vitamin D are contraindicated in these patients.

The cognitive and behavior profile is one of the key elements of this syndrome. Patients often present mild intellectual disability, strong language skills and weakness in visuospatial construction. They

also exhibit personality traits such as empathy, overfriendliness, attention problems and anxiety.<sup>8</sup> This is an important factor to consider in the behavior management of children during dental treatment.

Many studies have reported increased frequency of dental abnormalities including malocclusion, hypodontia, malformed teeth, taurodontism, pulp stones, increased space between teeth, enamel hypoplasia, and high prevalence of dental caries. Affected patients usually have normal periodontium and are not predisposed to increased periodontal destruction, despite the presence of elastin gene haploinsufficiency.<sup>6,11</sup>

A high caries index is reported due to the enamel hypoplasia and hypomineralization which can be attributed to the hypercalcemia seen in these individuals.<sup>12</sup> The reported patient presented enamel hypoplasia, dental caries and a Class III malocclusion commonly seen in this condition. Periodontal evaluation revealed a healthy periodontium. Individuals with WS can exhibit hyperacusis, which is hypersensitivity to certain sound frequencies.<sup>13</sup> This is of great significance in the dental environment where instruments like the dental hand piece, ultrasonic scalers and high volume section generate high pitched sounds. The Tell Show Do behavior management approach<sup>14</sup> is very helpful where these instruments and their sounds are first demonstrated to the patient before being used. The patient was diagnosed with anxiety disorder for which she was undergoing psychological therapy. The Tell Show Do behavior management technique and reassurance helped

allay her anxiety and she was very cooperative during the dental treatment. The risk of sudden cardiac death is 25-100 times greater in patients with WS compared to the general population<sup>15</sup>, which confers a significant risk for patients undergoing general anesthesia. This is an important consideration for clinicians planning procedures requiring general anesthesia.<sup>16</sup>

Early dental examinations and parent counseling are important in the management of individuals with WS. Preventive and dietary programs must be customized for these patients and reinforced in children with severe enamel hypoplasia, high caries rates and vulnerable cardiac condition to help minimize the risk of infection in the oral cavity.<sup>16</sup>

#### 4. Conclusion

There is no cure for Williams syndrome. The care for these patients is mainly symptomatic and supportive. Individuals with WS need regular monitoring for potential medical and dental problems by health care professionals who are familiar with the disorder. The dental treatment protocol may require alterations or necessary precautions to be taken due to the underlying medical conditions. The pediatric dentist thus plays an important role in the overall care of these patients.

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She has been a guest speaker at various conferences and events.

**Questions****Williams Syndrome is a result of?:**

- a. *De novo* deletion on chromosome 7 (7q11.23);
- b. *De novo* deletion on chromosome 11 (11q. 7.23);
- c. Autosomal dominant condition;
- d. Autosomal recessive condition.

**Which is the most common cardiac condition in patients with Williams Syndrome?**

- a. Supravalvular aortic stenosis, Tetralogy of Fallot;
- b. Pulmonary artery stenosis, Ventricular septal defect;
- c. Mitral valve prolapse, Supravalvular aortic stenosis;
- d. Supravalvular aortic stenosis, Pulmonary artery stenosis.

**Which of the following are dental findings in Williams Syndrome patients?**

- a. Microdontia;
- b. Hypoplastic enamel;
- c. Increased interdental spacing;
- d. All of the above.

**A definite diagnosis for Williams Syndrome is obtained by?**

- a. Fluorescence in situ hybridization (FISH )test;
- b. Distinctive facial features;
- c. Cognitive and behavior profile;
- d. Presence of cardiovascular anomaly.

## SELF-PERCEIVED ESTHETICS, CHEWING FUNCTION AND ORAL HEALTH-RELATED QUALITY OF LIFE IN PATIENTS TREATED WITH NEW REMOVABLE DENTURES

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### ABSTRACT

**Introduction:** The aim was to assess treatment outcomes using the standardized questionnaires for assessment of self-perceived orofacial esthetics (OE), oral health-related quality of life (OHRQoL) and chewing function (CF) in patients treated either with new complete dentures (CD group) or with maxillary complete dentures and mandibular Kennedy Class I long saddle removable partial dentures (CD-RPD group). The aim was also to compare the two groups and to assess possible gender and age effects.

**Methodology:** One hundred twenty-six patients (72 female and 54 male) participated (mean age 67.8±9). They were divided into two groups: the CD group (68 patients) and the CD-RPD group (58 patients). The patients filled in the three standardized questionnaires (Oral Health Impact Profile-OHIP14; Orofacial Esthetic Scale-OES and Chewing function questionnaire-CFQ), twice, first at the baseline, and the second time at least 2 months after they had received their new removable dentures and all adjustments had been finished.

**Results:** All patients with new removable dentures (CD and CD-RPD group) reported improved aesthetics, chewing function and OHRQoL. Gender and age by itself yielded no significant effects. The type of RPD treatment (CD: CD-RPD) yielded statistically significant differences only with respect to orofacial aesthetics, while there was no significant differences with respect to CF and OHRQoL.

**Conclusion:** Better aesthetic outcomes in the CD group than in the CD-RPD group could be attributed to clasp visibility in the mandible. Clasps in the CD-RPD group did not significantly improve CF when compared with the CD group.

**Keywords:** patient-based outcomes, removable dentures, orofacial esthetics, chewing function, OHRQoL.

### 1. Introduction

Despite improvements of oral health care, the need for conventional complete and removable partial dentures has still been in high demand, especially in the elderly population and in lower income socio-economic groups.<sup>1</sup> Moreover, despite the growing trend to use implant supported removable dentures, conventional complete and removable partial dentures have still been the most common treatment option.<sup>2,3</sup> Many edentulous patients refuse implant placement due to their

financial limitations, general health problems, insufficient bone support, fear, or attitude.<sup>4-7</sup> The impact of oral disorders and interventions on individually perceived oral health outcomes has been increasingly recognized as an important oral health component. The most popular instrument for oral health assessment has been the Oral Health Impact Profile (OHIP) questionnaire (the long and the short form). The OHIP measures several dimensions of oral health related quality of life (OHRQoL).<sup>8-15</sup> Some other one-dimensional questionnaires have also been popular, such as

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Orofacial aesthetics scale (OES)	Oral Health Impact Profile (OHIP-14)	Chewing Function Questionnaire (CFQ)
How do you assess appearance of ..... during the last 7 days	Have you had (problems or feelings that) ..... because of problems with teeth, mouth, dentures? during the last 7 days	Have you had any difficulty chewing foods such as ..... (or similar)? during the last 7 days
1. The lower third of your face	1. Pronouncing words	1. Apple, pear, raw carrots
2. Your profile appearance of the lower third of your face	2. Sense of taste worsened	2. Bacon, firm meat
3. Your mouth (smile, lips, visible teeth)	3. Painful aching (mouth, teeth)	3. Biscuits, crackers
4. Your dental arches	4. Uncomfortable to eat any foods	4. Fresh bread, doughnut
5. Assess shape of your teeth	5. Been self-conscious	5. Nuts, pecan, almonds, peanuts, macadamia
6. Assess the color of your teeth	6. Felt tense	6. Lettuce, raw cabbage
7. Your gums or artificial gums	7. Diet been unsatisfactory	7. Biting different foods, incision
8. Assess the overall appearance of your lower third of the face, mouth and teeth	8. Interrupt meals	8. Chewing gum
	9. Difficult to relax	9. Have you felt insecure when chewing
	10. Feel a bit embarrassed	10. Have you noticed food catching on your teeth or tooth replacement
	11. Irritable with people	
	12. Difficulty doing usual jobs	
	13. Life in general less satisfying	
	14. Totally unable to function	
Scores 1-5; Summary score 8-40	Scores 0-4; Summary score 0-56	Scores 0-4; Summary score 0-40

**Figure 1.** A brief overview of questionnaires used in the study with their summary score ranges and questions (items)

the Orofacial Esthetic Scale (OES)<sup>16-18</sup> for patient's self-evaluation of orofacial aesthetics and the Chewing Function Questionnaire (CFQ)<sup>19</sup> for patient's self-evaluation of a chewing function (CF). The objective of this study was to assess treatment effects and after-treatment scores considering self-perceived OHRQoL, chewing function (CF) and orofacial aesthetics (OES) in patients treated with new complete dentures (CD group), and in patients treated with maxillary complete dentures and mandibular Kennedy Class I long saddle removable partial dentures (CD-RPD group). The aim was also to compare the two groups and to assess possible gender and age effects.

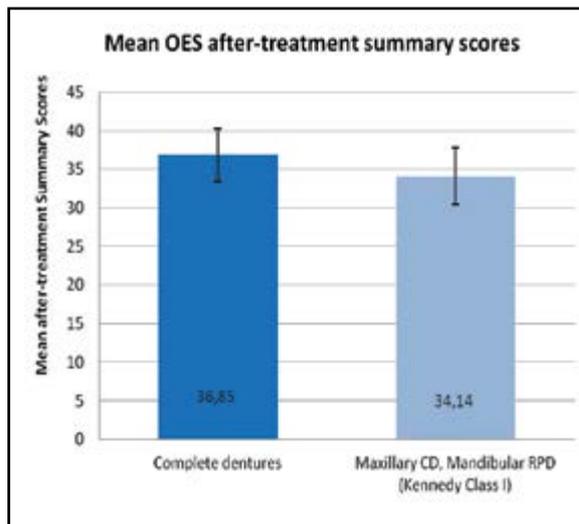
## 2. Methodology

The study was approved by the Institutional Ethics Committee. One hundred twenty-six (126) patients (72 female and 54 male) participated. The patients were divided into two groups: the CD group (rehabilitated with new complete dentures in both jaws) and the CD-RPD group (treated with new complete dentures in the maxilla and long saddle clasp-retained removable partial dentures in the mandible (Kennedy Class I, edentulous posterior areas bilaterally). There were 68 patients

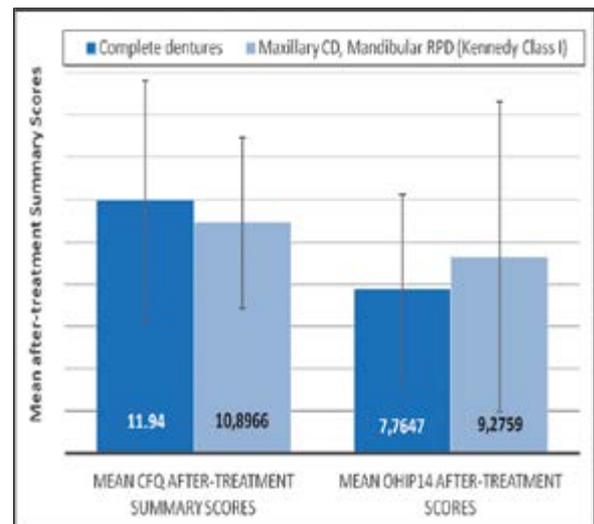
in the CD group (40 females, 28 males), mean age 69.58 years ( $\pm 11.17$ ) and 58 patients in the CD-RPD group (32 females, 26 males) mean age 66 years ( $\pm 8.0$ ). In the CD-RPD group there were no teeth present distally from cuspids and/or second incisors in the mandible. All dentures were made by postgraduate students during training courses for the Prosthodontics Specialist degree. Mandibular partial dentures were made of metal and acrylic resin in order not to break, while all complete dentures were made only of acrylic resin (Polymethyl methacrylate; PMMA).

All CD patients had old pairs of complete dentures. In the CD-RPD group all patients had their old complete denture in the maxilla and 74.1% of them had already old partial removable denture (RPD) in the mandible, while 25.9% patients were the first time removable partial denture wearers in the lower jaw.

The Croatian version of the OES-CRO was used to assess patients' self-perceived orofacial esthetics. The patients rated their orofacial aesthetics on a Likert scale ranging from 1 to 5 (1=completely dissatisfied; 5=completely satisfied; the summary score ranged from 8 to 40, the higher summary scores indicated greater satisfaction with orofacial



**Figure 2a.** Mean values and standard deviations of the after-treatment OES summary scores in the CD and the CD-RPD group of patients



**Figure 2b.** Mean values and standard deviation after treatment CFQ and the after-treatment OHIP summary scores in the CD and the CD-RPD groups of patients

aesthetics) (Fig.1). The OHRQoL was measured using the Croatian version of the OHIP-14-CRO questionnaire.<sup>6</sup> The patients filled in the OHIP-14 questionnaire using a Likert type scale ranging from 0=no difficulties to 4=maximum difficulties. The summary scores ranged from 0 (minimum) to 56 (maximum), the higher score represented more impaired OHRQoL (Fig. 1). The Chewing Function Questionnaire (CFQ) was used to measure patients' self-perceived chewing function. The CFQ consisted of 10 items (ratings were made on the Likert scale from 0=no difficulties to 4=maximum difficulties; summary scores ranged from 0 to 40; higher scores represented more impaired chewing function) (Fig. 1).

The patient had to assess their difficulties, or rate their aesthetics for a period covering the last 7 days, as recently recommended.<sup>15</sup> All three questionnaires have been psychometrically tested in previous studies and have demonstrated excellent psychometric properties.<sup>10, 17, 19</sup>

The patients filled in the questionnaires twice, first at the baseline, when they came to a dental clinic seeking therapy and the second time at least 2 months after they had received their new removable dentures and all adjustments had been finished.

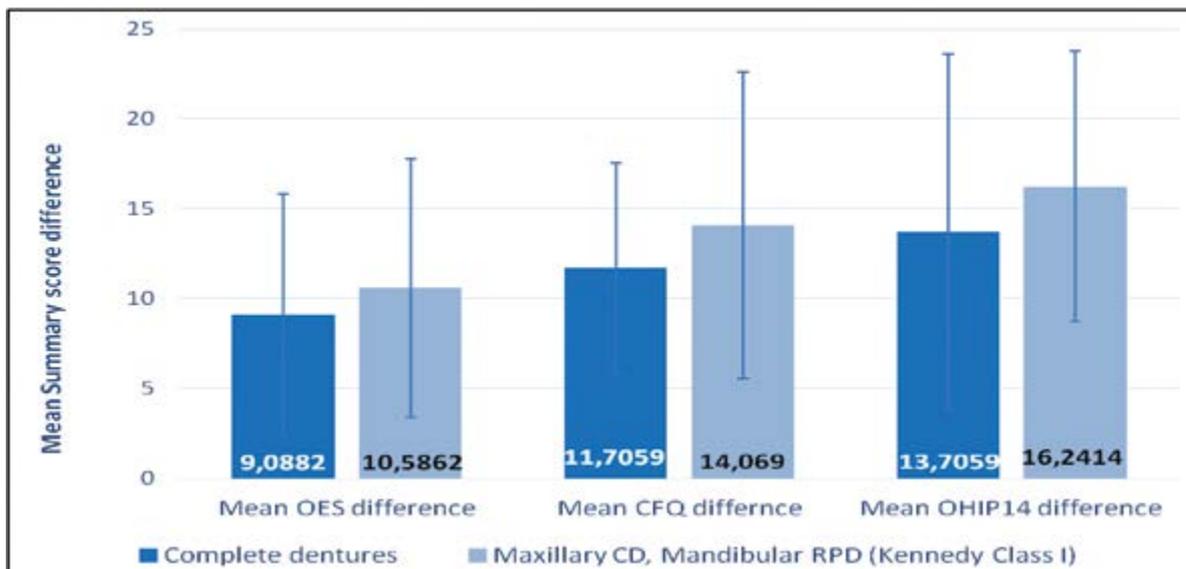
Statistical analysis (SPSS 20 for Windows, IBM) included descriptive statistics, paired t-test (to test the significance of the differences between the baseline and the after-treatment scores), independent t test to compare the two groups (the CD and the CD-RPD group), and the 2 factor ANCOVA with the after-treatment OES, the after-treatment OHIP 14, or the after-treatment CFQ scores as dependent variables: treatment groups (the CD and the CD-RPD group) and gender as fixed factors, and age as a covariate. P values of 0.05 or less were considered statistically significant.

### 3. Results

Mean after-treatment summary scores of the OES, the OHIP14 and the CF questionnaire in the CD and the CD-RPD groups are presented in Figure 2 a and b. All patients significantly improved aesthetics, chewing function and OHRQoL compared to the baseline scores ( $p < 0.01$ ). Significantly higher OES after treatment summary scores, were registered in the CD group than in the CD-RPD group ( $t = 4.3$ ,  $df = 124$ ,  $p < 0.01$ ) (Fig. 2a). Slightly lower CFQ after-treatment summary scores (better chewing function) were registered in the CD-RPD group than in the CD group, but the difference was not statistically significant ( $t = 1.14$ ,  $df = 124$ ,  $p > 0.05$ ) (Fig. 2b). However, slightly lower OHIP14 after-treatment scores were registered in the CD group than in the CD-RPD group. The difference was also not statistically significant ( $t = 1.46$ ,  $df = 124$ ,  $p > 0.05$ ) (Fig. 2b).

Mean differences (deltas) between the baseline and the after-treatment summary scores (score reduction) for the OES, the OHIP14 and the CFQ questionnaires are presented in Fig. 3. The CD-RPD patients benefited more from the treatment than the CD patient, although the difference was not statistically significant ( $p > 0.05$ ).

The two factor ANCOVA with the mean after-treatment OHIP14 summary score as the dependent variable, the type of treatment (CDs or CD-RPDs) and gender as fixed factors and age as a covariate, revealed no significant effect of the type of treatment ( $F = 0.89$ ;  $p = 0.35$ ), gender ( $F = 2.61$ ;  $p = 0.11$ ) and age ( $F = 3.25$ ;  $p = 0.08$ ) (Table 1). The same analysis was done for the dependent variable: the after-treatment CFQ summary score also revealed no significant effect of the type of treatment ( $F = 1.37$ ;  $p = 0.24$ ), gender ( $F = 1.65$ ;  $p = 0.20$ ), and age ( $F = 0.26$ ;  $p = 0.61$ ).



**Figure 3.** Mean differences between the baseline and the after-treatment scores of the OES, OHIP14 and CF questionnaires in the CD and the CD-RPD group of patients

However, with the mean after-treatment OES summary score as the dependent variable, the effect of the factor type of treatment was statistically significant ( $F=5.60$ ,  $p<0.01$ ), while gender ( $F=0.02$ ;  $p=0.9$ ) and age ( $F=0.8$ ;  $p=0.37$ ) showed no significant effects. Patients with CDs in both jaws rated their aesthetics significantly better (higher scores) than the CD-RPD group.

#### 4. Discussion

The treatment of complete or partially edentulous patients has long been a major challenge in prosthodontics. Many studies had confirmed significant benefit of an implant-prosthodontic therapy.<sup>20-22</sup> Removable dentures receiving support from dental implants have been improving patients' OHRQoL and/or chewing function better than the conventional removable denture therapy.<sup>20-22</sup> However, the conventional complete and removable partial dentures have still been the most common treatment in the world, mostly due to medical and/or economic factors.<sup>23-25</sup> Therefore we decided to analyze treatment results obtained by conventional removable dentures. The success of conventional treatment with removable dentures often depends mostly on the patients' adaptive capacity to overcome reduced retention and stability of dentures.<sup>26</sup>

Patient-based outcome measures using psychometrically verified questionnaires have been recognized as important measures necessary to understand problems regarding orofacial issues. The results of such specific measures help dentists in planning and decision making.<sup>27-29</sup>

We measured OES, CF and OHRQoL by standardized questionnaires to get better insight into the most common types of conventional removable denture therapy. The most frequent type of removable denture patients have been either completely edentulous patients in both jaws, or those who have been completely edentulous in

the maxilla and Kennedy Class I (with only incisors and incisors and canines left) in the mandible. Therefore we have chosen such groups of patients. As expected, both treatment options elicited significant treatment results and all after-treatment summary scores showed improvement of the issue measured (OHRQoL, CF, OES), compared to the baseline scores. The CD-RPD treatment showed slightly higher treatment effects than the CD treatment (although not significantly), which may be attributed to the fact that all CD patients had a previous pair of dentures, while some of the CD-RPD patients had no previous dentures in the mandible and therefore had worse baseline scores.

Significantly lower after-treatment ratings of orofacial esthetics in the CD-RPD group than in the CD group may be attributed to the visibility of denture clasps in the mandible. Slightly better after-treatment chewing function assessment in the CD-RPD group than in the CD group was attributed to the better retention of RPDs due to denture clasps as compared to complete mandibular dentures.

However, slightly lower OHIP14 after-treatment scores registered in the CD group (better OHRQoL) may be attributed to clasp visibility. Some studies reported that besides the type of treatment, gender and age may also influence clinical outcomes by new removable dentures.<sup>23,30</sup> To test the premise, the 2 way analysis of variance (ANCOVA) was performed with the OHIP14, the OES and the CFQ after treatment summary scores as dependent variables; gender and the type of treatment as independent variables, and the age as a covariate.

The results revealed that gender and age yielded no significant effects ( $p>0.05$ ), either for a chewing function, or for the OHRQoL or orofacial aesthetics. However, limitations of the study have to be mentioned, such as various pre-treatment summary scores, as well as variability in a number

and difference of periodontal status of remaining teeth in the mandible in the CD-RPD group.

## 5. Conclusion

All patients with new removable dentures (CD and CD-RPD group) reported improved aesthetics, chewing function and OHRQoL compared to the baseline scores. Gender and age by itself yielded no significant effects. The type of RPD treatment (CD: CD-RPD) yielded statistically significant effect only considering orofacial aesthetics with better

aesthetic outcomes in the CD group, which may be attributed to the clasp visibility in the CD-RPD group. Clasps had not significantly improved chewing function in the CD-RPD group compared with the CD group.

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## CV

Sanja Peršić was born on 9th February 1984 in Pula. She completed her elementary and high school studies in Labin and graduated from the School of Dental Medicine, University of Zagreb in 2008. In 2014 she finished her doctoral thesis earning her PhD degree. Since 2009 she has been working as a research assistant at the Department of Prosthodontics, School of Dental Medicine, University of Zagreb. In 2016 year she finished a 3-year training course and became a Prosthodontics Specialist. She received the „Roberto and Daniela Giannini“ award for the best scientific paper in Labin and the International College of Prosthodontists award in 2013. She was designated the best research assistant of the School of Dental Medicine in 2013 and 2014. She received the award for young scientists and artists from the Society of University Professors and Scientists in Zagreb.

## Questions

### Which instrument was used to assess patients' self-percieved orofacial aesthetics:

- a. Oral Health Impact Profile questionnaire;
- b. Orofacial Esthetic Scale;
- c. Questionnaire of Participants' Satisfaction with their Dental Appearance;
- d. Geriatric Oral Health Assessment Index.

### Which of the following statements about OHIP14 Questionnaire is false?

- a. It is an instrument which measures self-reported several dimensions of oral health-related quality of life;
- b. It consists of 14-items;
- c. The summary scores range from 0 (minimum) to 40 (maximum);
- d. Higher scores represent more impaired OHRQoL.

### The chewing function questionnaire has been developed to measure:

- a. How patients are satisfied with the new dentures;
- b. How patients rate their oral health-related quality of life;
- c. How patients rate difficulties while chewing different foods (including food incision) and the summary score shows the result;
- d. Difficulties only during food incision

### When using a structured questionnaire in a new cultural environment one needs to:

- a. Translate a questionnaire;
- b. Translate a questionnaire and check the back-translation;
- c. Translate a questionnaire and check the back-translation, as well as internal reliability (Cronbach alfa);
- d. Translate a questionnaire, check the back-translation and other psychometric properties, such as reliability (internal reliability and test-retest), validity (convergent, divergent, etc.) and responsiveness (when possible).

## COMPARISON OF DIFFERENT METHODS OF EXCAVATION CONTROL FOR MINIMALLY INVASIVE CARIES TREATMENT

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### ABSTRACT

**Introduction:** The change in the color of dentine, registered by visual and tactile control methods is an objective method for the assessment of demineralization of the in-depth carious process. The aim of the research is that, by means of an in vitro experiment, to study the changes in the in-depth color of dentine, during mechanical caries excavation, comparing two control methods, the visual and tactile and also by fluorescence.

**Methodology:** The subjects of the study were 32 extracted teeth, with dentine occlusal or proximal carious lesions similar in size (D3), excavated down to the healthy or affected dentine, controlled with two methods - visual and tactile (by Bjørndal) and fluorescent. Pictures were taken from the tooth samples and the resulting images were subject to a software color analysis with the use of the Hue, Saturation and Brightness color system.

**Results:** Visual and tactile controlled mechanical excavation down to the healthy dentine results in the dentine at the bottom of the excavation having the same characteristics as the healthy dentine, which indicates that the method is sufficiently objective but there is a risk of over-excitation. After applying the fluorescently controlled method and the fluorescence disappears after the excavation, the dentine at the bottom of the excavation has a much darker coloration than the healthy dentine.

**Conclusion:** The fluorescent method of control gives us the opportunity to leave non-infected, demineralized dentine at the bottom of the cavity and should be the preferred method in the light of minimally invasive treatment of dental caries.

**Keywords:** dentin, excavation, fluorescence, minimally invasive caries treatment.

### 1. Introduction

In recent years the treatment with minimal intervention has been the subject of studies in all fields of modern medicine. With regard to deep dental carious lesions, dental science focuses on researching and developing new methods related to the choice of technique of excavation, control during excavation and stimuli for internal remineralisation.<sup>1,2,3,4</sup> The goal is to prevent or detect the disease in its early stage, modern diagnostic and treatment procedures with minimal

intervention for the maximum preservation of dental structures to be used. The minimally invasive excavation in the treatment of deep dental caries requires a controlled, selective and sparing approach. Various techniques for selective excavation only of irreversibly damaged dentine have been developed.<sup>3,5,6,7</sup> The concepts for step excavation have been created. Control during excavation is getting to be an important condition for a selective removal only of irreversibly damaged dentine and preservation of that which minimally infected is and that has preserved remineralizing

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**Table 1. Distribution of the extracted teeth included in the experiment**

Control method	Mechanical excavation	
	Up to affected dentine	Up to healthy dentine
Visual/tactile (Bjørndal)	Group 1	Group 2
Fluorescence with Facelight	Group 3	Group 4

**Table 2. Criteria for evaluating dentine**

Visual criteria - color of dentine	Tactile criteria [with dental probe] - dentine texture
black	very soft dentine - the probe penetrates easily and flakes off pieces of it;
dark brown	soft dentine - the probe penetrates and leaves the dentine without resistance;
light brown	medium-hard dentine - slight resistance when probing;
yellow	hard dentine - when driving on dentine light resistance and a white trail remains;
light yellow	hard non carious dentine - when probing slightly creaking and resistance.

properties (relatively preserved three-dimensional collagen structure, preserved intrafibrillar mineral). In practice the most often method applied to control the excavation is the classical - visual and tactile, assessing the color and texture of carious dentine. The method is highly subjective, and requires the development of other methods to control the excavation by staining with dyes, by stimulating of the dental structures' fluorescence etc.<sup>1,8,9</sup> In recent years FACE (Fluorescence Aided Caries Excavation) technology was established as an innovative method for the detection of infected dentine. It uses the principle of fluorescence, wherein a substance by light of a certain wavelength (most often in the blue or ultraviolet range, it can be also laser light) irradiated is and it absorbs the photons, which secondarily emits to a longer wavelength light. Control of excavation is based on different fluorescence of various dental tissues and on red fluorescence of bacterial products.<sup>10</sup> Such a device is *Facelight* light probe (W&H Dentalwerk Bürmoos GmbH, Bürmoos, Austria), where the tooth is illuminated with violet light (405 nm). Infected dentine can be seen in red and healthy structures in green color.<sup>7</sup> SOPROLIFE (SOPRO ACTEON Imaging, La Ciotat cedex, France) is a similar device consisting of an intraoral camera with the capability of high magnification device for detecting caries by black green fluorescence due to the loss of mineral and control excavation in dentine.<sup>11,12</sup> There are studies that use a diode laser fluorescence (DIAGNOdent pen, KaVo Dental GmbH, Biberach, Germany) to control the excavation of carious dentine not with standing that the apparatus itself is designed primarily for the diagnosis of initial carious lesions.<sup>9,13</sup> Comparative studies with regard to accuracy, sensitivity and specificity of various methods for assessment

of the residual dentine have been conducted. Usually these are in vitro experiments on extracted teeth, where as a standard a histological findings, visualized by confocal microscopy, scanning electron microscopy or confocal laser scanning microscopy, etc. are evaluated.<sup>14,15</sup> The results give priority to the modern fluorescent techniques that objectify in best way the infected dentine and give the possibility of minimally invasive excavation in the deep dentinal caries treatment.<sup>11,16,17</sup>

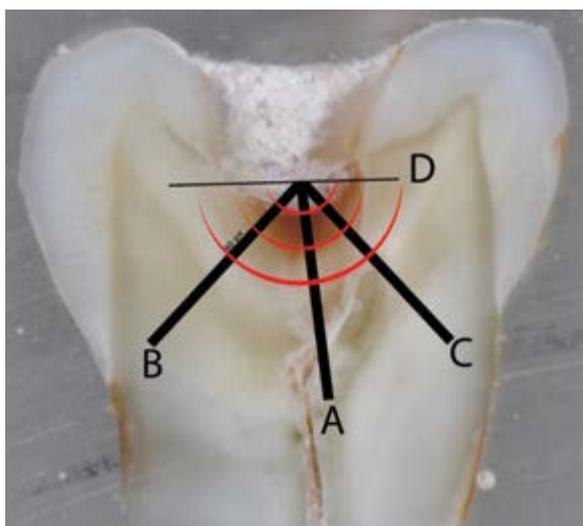
The purpose of this study is to investigate changes in the in-depth dentine color at mechanical caries excavation using two *in vitro* control methods, the visual and tactile and the fluorescence with *Facelight*.

## 2. Material and methods

The subject of our experiment were 32 extracted teeth with similar sized dentinal occlusal or proximal carious lesions (D3), divided into 4 groups of 8 teeth each (Table 1).

During the excavation, the samples were evaluated clinically by two methods: A visual tactile method<sup>18</sup> and the fluorescence method with a caries detector - *Facelight* (W&H Dentalwerk Bürmoos GmbH, Bürmoos, Austria) - an innovative method for detection of infected dentine, in which the tooth is illuminated with violet light up to 405 nm. Glasses with filter up to 500 nm of the optical spectrum are used. Infected dentine can be seen in red and healthy structures in green-like color.

The criteria used for dentin evaluation are presented in Table 2. We used the following criteria for healthy and affected dentine specified in our previous study.<sup>19</sup> Criteria for excavation up to healthy dentine (Table 2):



**Figure 1.** Scheme of the arrangement of the lines in the object of the analysis

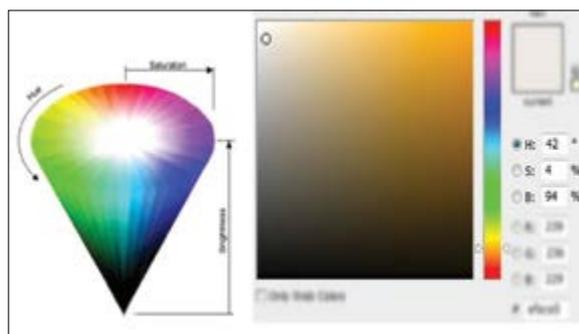
- In the visual and tactile control method - yellow or light yellow dentine; hard consistency, slightly creaking and resistance when probing;
  - In the fluorescence control method with Facelight - pale red fluorescence disappears.
- Criteria for excavation up to affected dentine:
- In the visual and tactile control method - dark yellow or light brown dentine; medium-hard consistency, a slight resistance when probing with a white trail;
  - In the fluorescence control method with Facelight - a weak pale red fluorescence only at the bottom of the cavity.

The cavity preparation was conducted by one examiner and the evaluations were made by 3 examiners after preliminary calibration.

### 2.1. Preparation of extracted teeth for the experiment

The extracted teeth used in this study were stored in a solution of distilled water with thymol. At least 24 hours prior to the excavation they were left in pure distilled water. After completion of the excavation and clinical assessments the roots were separated from the clinical crowns, then the samples were dried in alcohol solutions of increasing concentrations (30%, 70%, 90%). The cavities were isolated by restoration using temporary filling material (Adhesor, SpofaDental a.s. HQ, Jičín, Czech Republic). Then samples were packed with an epoxy resin in plastic cylinders 1.5 cm in diameter of and 3.5 cm in height. After resin polymerisation, the specimens were bisected in the axial axis of the tooth in the mesio-distal direction. Temporary restorations were removed from both halves, and then they were used for the purposes of that in vitro study about the applying of photographic equipment for dentinal changes characterisation during the excavation.

**2.2. Original authors method.** Developing of methods for valuation of changes in dentine during excavation, using highly specialized digital photographic equipment and software:



**Figure 2.** Hue/Saturation/Brightness (HSB) scheme

Dental samples were documentary evidenced using highly specialised digital photographic equipment consisting of the following components: body - Nikon D90, lens - Nikon AF-S Micro-Nikkor 105mm f/2.8G VR, flash - Nikon SB-R 200 Speed light Remote Kit R1 (Nikon Corp., Tokyo, Japan). Photographing the objects was carried out under the following conditions - focal distance 105 mm, coefficient of approximation - 1: 1. The resulting images underwent software analysis of the color under the developed original methodology, as follows: First we put Line D - parallel to the enamel dentine junction. Then Line A - forming an angle of 94° with the line parallel to the enamel dentine junction and intersecting the pulp chamber, Line B and Line C - bisectors of the angle between Line A and Line D, were drawn.

Three levels of depth were determined:

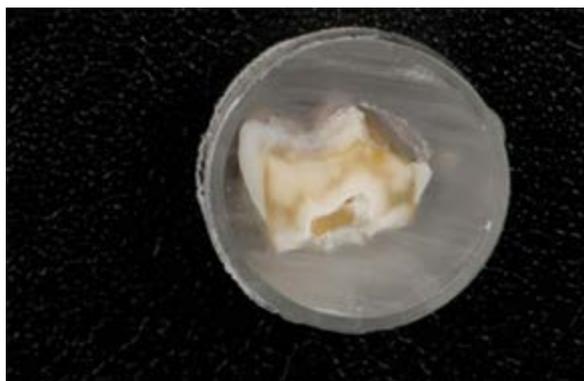
- Level 1 - on the surface of the excavation
- Level 2 - 80 pixels (0,4 mm) down the non excavated dentine
- Level 3 - 160 pixels (0,8 mm) down the non excavated dentine

The points where the three Lines cross the three Levels (Fig.1) were analysed with the use of specialised digital software (Adobe Photoshop CS 5.5, Adobe Systems, San Jose, CA, USA). A randomly chosen point on the area of healthy dentine was used as control point.

In each of the three points, as well as in the control point the color was measured for each parameter according to the color system - HSB (Hue, Saturation, and Brightness) (Fig. 2). HSB system is defined as a device-independent way for determining the color, i.e., once the color defined by this system; it can be reproduced isometrically by different devices. This system presents a color as a relationship of three parameters:

- **Hue** - shade of color. Practically it is the color itself. Measured in linear degrees - 0 - 360°; 0° = red, 60° = yellow, 120° = green, etc.
- **Saturation** - color saturation. Measured in percentages - 0% = no color, 100% = highest color intensity.
- **Brightness** - the brightness of the color. It is expressed in percentage of the black (0%) to white (100%).

Changes in the color of all points were used to



**Figure 3.** Mechanical excavation to an affected dentin evaluated with visual and tactile control method



**Figure 4.** Mechanical excavation to a healthy dentin with visual and tactile control



**Figure 5.** Mechanical excavation to affected dentin with Facelight control



**Figure 6.** Mechanical excavation to "non-infected" dentin with Facelight control

analyse the change of the basic parameters and comparison of the samples.

### 2.3. Statistical methods.

The data were statistically analysed with SPSS-19 software (SPSS Inc, Chicago, IL, USA).

## 3. Results

### 3.1. Color characteristics (HSB) of healthy dentine (control point) in the four studied groups

The following table 3 presents the color characteristics of healthy dentine, which serves as control when comparing the color characteristics of the three investigated points in depth of excavated caries lesion. It is notable from the table that the color characteristics of healthy dentine in the four studied groups showed similar values for parameter H (hue) without any statistically significant differences when comparing between groups [ $p > 0,05$ ]. It should be noted that the hue substantially reflects the primary color. Values between 39.00 and 41.00 are perceived by the eye close to the value of 60 (yellow color), which is considered as a characteristic of healthy dentine by Bjørndal's visual tactile scale.

The values for Saturation and Brightness complement the basic color. Saturation of the 4 surveyed groups range between 3 - 10%, which is an indicator of low intensity, typical of the

lighter colors, such as yellow color and nuances of yellow, which characterizes the healthy dentine we studied.

Brightness, which is measured as a percentage from black (0%) to white (100%), in our studied samples was over 77%, which is an indicator of approaching white. Differences between groups in terms of saturation and brightness show greater variation, which is understandable due to the fact that their values are influenced mainly by the individual terms of object capturing.

### 3.2. Color characteristics (HSB) of dentine in the bottom of excavated cavity in depth

In the following tables characteristics of color in the center of dentine in excavated cavities (in solid or stagy dentine) in depth - 3 levels on a distance of 80 pixels (0.4 mm) or a common depth - 0.8 mm are given.

Table 4 presents the changes in the color of dentine in Group 1, after mechanical excavation to affected dentine, controlled in depth by the visual and tactile method (Fig. 3).

Table 4 shows that the surface of the remaining affected dentine at the bottom of the cavity has a color completely different when compared with the control group [shades of yellow] towards the brown shades that are darker at the surface and become brighter in depth without reaching the color of healthy dentine in depth of around 1 cm [control]. Saturation in various test points decreases from

**Table 3. Color characteristics of control point in different groups**

HSB Group	H (Hue) °		S (Saturation) %	B (Brightness) %
	n	Mean ± Std. Dev	Mean±Std. Dev	Mean ± Std. Dev
1 group affected with the visual and tactile method	8	40.25 ± 4.20	8.25 ± 4.74	83,88 ± 5,89
40.63± 1.768.00 ± 5.242 group healthy with the visual and tactile method	8	39.00 ± 5.39	3.75 ± 3.11	77,38 ± 4,66
83,63 ± 1,92 4 group healthy with the fluorescent method 3 group affected with the fluorescent method	8	40.88 ± 4.22	6.63 ± 2.26	77,5 ± 4,11
PS T-test	t <sub>1,2</sub> = 0.52 (p= 0.61) t <sub>2,3</sub> = - 0.81 (p=0.43) t <sub>1,3</sub> = - 0.20 (p= 0.82) t <sub>2,4</sub> = - 0.77 (p= 0.45) t <sub>1,4</sub> = - 0.30 (p= 0.77) t <sub>3,4</sub> = - 0.15 (p= 0.88)		t <sub>1,2</sub> = 2.25 (p=0.04) t <sub>2,3</sub> = -1.97 (p=0.07) t <sub>1,3</sub> = 0.10 (p=0.90) t <sub>2,4</sub> = -2.12 (p=0.05) t <sub>1,4</sub> = 0.87 (p=0.40) t <sub>3,4</sub> = 0.68 (p=0.57)	t <sub>1,2</sub> = 2.45 (p=0.02) t <sub>2,3</sub> = 3.51 (p=0.00) t <sub>1,3</sub> = 0.11 (p=0.91) t <sub>2,4</sub> = 0.57 (p=0.95) t <sub>1,4</sub> = 2.51 (p=0.03) t <sub>3,4</sub> = 3.82 (p=0.02)

**Table 4. Changes in the color of dentine in Group 1**

HSB Level	H (Hue) °		S (Saturation) %	B (Brightness) %
	N	Mean ± Std. Dev	Mean ± Std. Dev	Mean ± Std. Dev
1-st level	8	32.75 ± 4.10 42.13 ± 9.70	68.63 ± 8.94	
2-nd level	8	35.58 ± 4.54	30.38 ± 1.15	73.13 ± 8.79
3-rd level	8	34.13 ± 6.58	18.50 ± 13.41	75.63 ± 8.45
Control group	8	40.25 ± 4.20	8.25 ± 4.74	83.88 ± 5.89
PST-test	t <sub>1,k</sub> = -3.28 (p=0.01) t <sub>1,2</sub> = -1.97 (p=0.09) t <sub>2,k</sub> = -1.98 (p=0.08) t <sub>1,3</sub> = -0.71 (p=0.05) t <sub>3,k</sub> = -2.46 (p=0.04) t <sub>2,3</sub> = 0.98 (p=0.36)		t <sub>1,k</sub> = 8.65 (p=0.00) t <sub>1,2</sub> = 2.45 (p=0.04) t <sub>2,k</sub> = 6.27 (p=0.00) t <sub>1,3</sub> = 4.56 (p=0.00) t <sub>3,k</sub> = 2.79 (p=0.03) t <sub>2,3</sub> = 3.45 (p=0.01)	t <sub>1,k</sub> = -5.86 (p=0.00) t <sub>1,2</sub> = -3.72 (p=0.01) t <sub>2,k</sub> = -4.88 (p=0.00) t <sub>1,3</sub> = -5.19 (p=0.00) t <sub>3,k</sub> = -3.82 (p=0.01) t <sub>2,3</sub> = -4.41 (p=0.00)

42.13% to 18.50% and the brightness increased from 68-63% to 75.63% (p < 0.05). In comparison to healthy dentine the values of saturation and brightness did not reach the values of control (p < 0.05). Table 5 presents the changes in the color of dentine in Group 2, after mechanical excavation to healthy dentine, controlled in depth with visual and tactile method (Fig. 4).

The colors of all studied depths are as close as possible to the control (healthy dentine) (p > 0.05). The same relationship is also seen in terms of the saturation and brightness of the obtained average values obtained of the test points in the three levels of the depth (p > 0.05). When controlling the excavation with Facelight (Fig. 5), the color of dentine is estimated as affected when a light pink fluorescence is noticed, localized only in the bottom of the cavity. The affected dentine is reliably darker than the control (healthy dentine) (p < 0.05), saturation stands out from control in the entire depth of examined dentine, and brightness authentically distinguishes authentically from control only on the surface of the dentine (Table 6). It is notable that in depth, the color of the points studied remains constant and reliable; differences

in depth are not found.

We introduce the “non-infected” dentine term because the presence of fluorescence at the bottom of the cavity is due to microbial bio-products in dentinal tubules during the carious process, and the absence of fluorescence in the dentine is assumed as dentine without microorganisms, which we refer to as “non-infected dentine” (Fig. 6). It differs in color from the healthy dentine registered by the visual and tactile control, which will be shown in the following results (table 7). When excavating to “non-infected dentine” (excavation stops when the fluorescence disappears, which is considered to be a lack of micro-organisms), the color of the surface is fairly darker than the control (healthy dentine) and lighter than the affected (Table 7). Differences in hue and saturation as compared to control are supported by statistical confidence (p < 0.05). This is different from the trend observed in group 2 (with excavation also to healthy dentine but with visual and tactile control), where the values are very close to the control (p > 0.05). The second feature that we observe in this group is that the color remains constant in depth, but becomes less intense and with higher brightness (p < 0.05).

**Table 5. Changes in the colors of dentine in central point of group 2**

HSB Level	H (Hue) °		S (Saturation) %	B (Brightness) %
	N	Mean ± Std. Dev	Mean ± Std. Dev	Mean ± Std. Dev
1-st level	88	38.00 ± 5.29	10.50 ± 4.38	75.00 ± 6.70
2-nd level	88	35.50 ± 9.63	9.13 ± 4.19	75.50 ± 7.37
3-rd level	8	37.63 ± 5.73	8.63 ± 5.73	
Control	8	39.00 ± 5.40	3.75 ± 3.11	77.38 ± 4.66
PS T-test		$t_{1,k} = -0.42 [p=0.69]$ $t_{1,2} = 1.13 [p=0.29]$ $t_{2,k} = -1.12 [p=0.30]$ $t_{1,3} = 0.15 [p=0.88]$ $t_{3,k} = -1.02 [p=0.34]$ $t_{2,3} = -0.67 [p=0.52]$	$t_{1,k} = 3.35 [p=0.01]$ $t_{1,2} = 1.29 [p=0.24]$ $t_{2,k} = 2.34 [p=0.05]$ $t_{1,3} = 0.87 [p=0.42]$ $t_{3,k} = 2.31 [p=0.05]$ $t_{2,3} = 0.28 [p=0.89]$	$t_{1,k} = -1.19 [p=0.27]$ $t_{1,2} = -0.61 [p=0.56]$ $t_{2,k} = -0.95 [p=0.38]$ $t_{1,3} = -1.08 [p=0.32]$ $t_{3,k} = -1.01 [p=0.35]$ $t_{2,3} = -0.60 [p=0.57]$

**Table 6. Changes in colors of the dentine in central point of group 3 (affected with Facelight)**

HSB Level	H (Hue) °		S (Saturation) %	B (Brightness) %
	N	Mean ± Std.Dev	Mean ± Std.Dev	Mean ± Std.Dev
1-st level	8	31.00 ± 9.34	35.25 ± 17.90	70.00 ± 7.54
2-nd level	8	34.25 ± 5.70	36.75 ± 22.95	71.00 ± 8.28
3-rd level	8	34.25 ± 6.78	27.13 ± 23.90	74.13 ± 5.64
Control	8	40.63 ± 1.77 8.00 ± 5.24	83.63 ± 1.92	
PS T-test		$t_{1,k} = -3.00 (p=0.02)$ $t_{1,2} = -1.38 (p=0.21)$ $t_{2,k} = -3.37 (p=0.01)$ $t_{1,3} = -1.43 (p=0.20)$ $t_{3,k} = -2.60 (p=0.03)$ $t_{2,3} = -0.00 (p=1.00)$	$t_{1,k} = 3.35 (p=0.01)$ $t_{1,2} = 1.29 (p=0.24)$ $t_{2,k} = 2.34 (p=0.05)$ $t_{1,3} = 0.87 (p=0.42)$ $t_{3,k} = 2.31 (p=0.05)$ $t_{2,3} = 0.28 (p=0.89)$	$t_{1,k} = -6.40 (p=0.00)$ $t_{1,2} = -1.21 (p=0.26)$ $t_{2,k} = -5.16 (p=0.00)$ $t_{1,3} = -1.96 (p=0.09)$ $t_{3,k} = -4.86 (p=0.00)$ $t_{2,3} = -1.59 (p=0.16)$

**4. Discussion**

Our hypothesis was based on the studies referred in the literature,<sup>12,22</sup> which presented evidences that changes in the color of carious dentine were comparable to the rate of carious process progression - partial or complete carious destruction, degree of demineralization and infection of the dentine during the carious process. There is a directly proportional relationship between the color of dentine and the extent of its destruction by caries (demineralization) on the one hand and the degree of infection on the other, on the basis of which a system of visual tactile control during excavation is created.<sup>3,16,20</sup> On the other hand, the degree of infection of the dentine is comparable to the degree of fluorescence with Facelight detector by which we controlled the mechanical excavation.

The color of the dentine is characteristic for the level of demineralization of dental hard tissues. Our study showed that from the three parameters of color, the hue is the most stable indicator that can be used as a basis for comparative study, and saturation or brightness are complementary for

color characteristic. The color of healthy dentine is close to yellow, where similar values with those of the controls are prerequisite for reliable comparative results in each group and between groups. The results indicate that the visual and tactile assessment of the excavation to healthy dentine is sufficiently precise and objective, when the purpose of the excavation is to reach a healthy dentine. This is not recommended in modern trends for minimally invasive excavation, when uncontrolled removal of dentine until reaching healthy dentine is rejected and "over excavation" is considered as harmful as insufficient excavation. There is evidence that reaching the area of healthy dentine results in a greater probability of microorganisms penetration in the depth of dental tubules, and further risk of dentine infection.<sup>15,21</sup>

According to the results obtained in our study, we can conclude that dentine evaluated as affected by Facelight control has a degree of demineralization, which remains uniform in depth and differs significantly from healthy dentine. If we make analogy between color changes and the degree of dentine demineralization in depth, due to the advancing front of the carious process, we could

**Table 7. Changes in the colors of dentine of Group 4**

HSB Level	H (Hue) <sup>0</sup>		S (Saturation) %	B (Brightness) %
	N	Mean ± Std. Dev	Mean ± Std. Dev	Mean ± Std. Dev
1-st level	8	37.38 ± 3.02	23.38 ± 7.11	73.63 ± 5.29
2-nd level 8	36.75 ± 3.69	15.75 ± 8.12	75.88 ± 4.36	
3-rd level	8	34.75 ± 4.74	11.38 ± 6.19	78.00 ± 3.67
Control	8	40.88 ± 4.22	6.63 ± 2.26	77.50 ± 4.11
PS T-test	$t_{1,k} = -1.99$ (p=0.09) $t_{1,2} = 1.17$ (p=0.28) $t_{2,k} = -2.30$ (p=0.05) $t_{1,3} = 1.74$ (p=0.13) $t_{3,k} = -2.87$ (p=0.02) $t_{2,3} = 1.28$ (p=0.24)		$t_{1,k} = 5.99$ (p=0.00) $t_{1,2} = 3.07$ (p=0.02) $t_{2,k} = 3.06$ (p=0.02) $t_{1,3} = 2.88$ (p=0.02) $t_{3,k} = 2.38$ (p=0.05) $t_{2,3} = 1.31$ (p=0.23)	

say that in fluorescence control, affected dentine remains demineralized to a greater extent in the studied depth of 1 cm. Our results show another very interesting trend that “non-infected dentine” does not necessarily have the classical yellow characteristic of healthy dentine. The non-infected dentine, obtained by fluorescence control is partially demineralized and it must be preserved without the need of “over excavation” of dentine. A similar *in vitro* study was carried out by Benarjee et al. on 12 extracted carious molars.<sup>3, 22</sup> Researches for micro hardness (at Knoop), emission of auto fluorescence signal [using a confocal laser scanning microscope], and digital photo images on the sliced surfaces of tooth samples in set points were conducted. The results obtained are used for direct comparisons between color, auto fluorescence and micro hardness of each lesion. The authors demonstrated that a correlation, which is not absolute, exists between the changes in the analyzed parameters. According to them, the transmission of fluorescent signal stops before reaching a dentinal layer, which micro hardness values are close to those typical for healthy dentine. This dentine layer is of a light yellow to light brown color and a relative hardness.<sup>3, 16, 22</sup> That allows researchers to propose the use of auto fluorescence signal emitted by carious lesions as an objective and reliable criteria for control during excavation.

According to the results obtained in our previous study,<sup>19</sup> there is a reverse-proportional relationship between the color of the dentine and the intensity of the fluorescent signal. A similar conclusion, however for a correlation between the hardness of the dentine and intensity of the fluorescence signal is observed in other studies.<sup>11, 20, 22</sup> There is also evidence for *in vivo* studies demonstrating the close association and relationship between the texture and color of carious dentine and quantity of microorganisms in it.<sup>14, 15</sup> The overall conclusion that can be drawn is that at the bottom of the excavated cavities, the remaining

affected dentine differs in all 3 characteristics of the color, which is in the area of the brown tones and in depth hue changes to yellow, the saturation to low rates, which is indicative of a reduction in saturation and brightness changes in the direction of increasing the percentage (towards white). This indicates the presence of remaining demineralized dentine as the degree of demineralization decreases in depth when using the visual and tactile control and remains more uniformly demineralized when uniformly fluorescent control is used. Excavation to healthy dentine with visual and tactile-controlled method differs in color from “non-infected dentine” registered with the fluorescent control method, whose color is an indicator of a partial demineralization but with no microorganisms or microbial bio-products, which is a prerequisite for such dentine to be retained and it is preferred to over excavating to healthy dentine or reaching the underlying pulp. In the first case, the color is fairly close to the color of healthy controls, and the second is distinguished reliably from it.

### 5. Conclusions

Our study shows that changes in the color of dentine registered by HSB system can be used as an objective method for monitoring the degree of demineralization in depth of the carious process in *in vitro* studies.

The methods for excavation under the visual and tactile method for control provide inconsistent and non-satisfactory results: Mechanical excavation to affected dentine under the visual and tactile method for control leads to remaining of demineralized dentine up to the depth of 0.8 mm. The demineralization zone does not acquire the characteristics of healthy dentine, and cannot be defined as non-infected. In excavation to healthy dentine, the characteristics of dentine in depth match those of healthy dentine, but with high possibility of over excavation.

On the other hand, during excavation controlled by the fluorescent control method, the color characteristic of the dentine when the fluorescence signal disappears indicates the presence of partially demineralized but non-infected dentine, which can be preserved doing cavity preparation. Thus the fluorescent control allows selective and gentle excavation, which is recommended in minimally invasive treatment of dentinal caries.

### Acknowledgements

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## CV

Nadezhda Georgieva Mitova graduated from the School of Medicine in 2006 and from the School of Dentistry in 2011. In 2012 she was appointed Assistant Professor at the „Children Dental Medicine“ Department of the School of Dentistry, Medical University-Sofia, Bulgaria.

She has specialized in Pedodontics. Her scientific interests are focused on dental caries and prophylactics of oral diseases.

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## Questions

### **What does the fluorescent control method of excavation rely on?**

- a. Different fluorescence of mineralized and demineralized dentine;
- b. Lack of fluorescence of bacterial products;
- c. Different fluorescence of dental tissues and bacterial products;
- d. Intense fluorescence of healthy dentine.

### **What is the main disadvantage of the visual and tactile control method of excavation?**

- a. Dentine on the bottom of the excavation remains demineralised;;
- b. Risk of over-excitation;
- c. Excavation leaves infected dentine in the cavity;
- d. There are no disadvantages.

### **What is the color of dentine after applying the fluorescently controlled method and the fluorescence disappears?**

- a. Much darker than the color of healthy dentine;
- b. The same color as that of healthy dentine;
- c. Lighter than the color of healthy dentine;
- d. Can be lighter or darker than the color of healthy dentine.

### **Changes in the color of dentine registered by HSB system...**

- a. Can be used as a subjective method for monitoring the degree of demineralization in depth of the carious process;
- b. Do not relate with the degree of demineralization in depth of the carious process;
- c. Cannot be used as an objective method for monitoring the degree of demineralization in depth of the carious process;
- d. Can be used as an objective method for monitoring the degree of demineralization in depth of the carious process..

# Textbook of Dental Anatomy, Physiology and Occlusion

**Author: Rashmi GS Phulari**

**Publisher: Jaypee Brothers Medical Publishers (P) Ltd**

Language: English

ISSN: 978-93-5025-940-5

Edition: 1/e

Publish Year: 2013

Pages: 369

Price: £42.00

The Textbook of Dental Anatomy, Physiology and Occlusion by Dr. Rashmi GS Phulari is a complete guide to dental anatomy, physiology and occlusion for undergraduate and postgraduate dental students.

The book is divided into nine sections and 24 chapters, as follows:

Section 1, Introduction and Nomenclature, has two chapters which give a detailed description of the tooth morphology, on primary and permanent dentition, and various notation systems.

Section 2, Chronology of Tooth Development, which includes two chapters that present the chronology of tooth development, form and function.

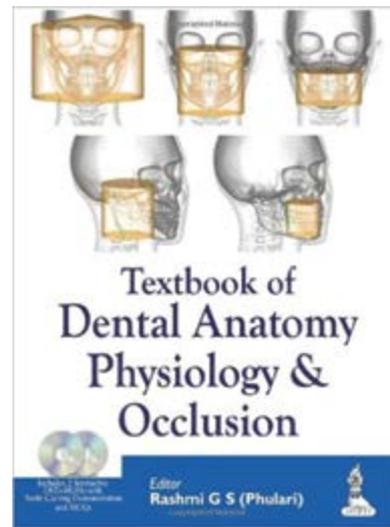
Section 3, Deciduous Dentition, presents in two chapters a detailed description of each primary tooth and the differences between primary and second dentition.

Section 4, Permanent Dentition, its eight chapters present a detailed description of each permanent tooth from all aspects.

Section 5, Class arch and type traits of teeth, divided in four chapters which give the common characteristics, the major differences between the maxillary and mandibular class of teeth.

Section 6, Dento-osseous Structures: Temporomandibular Joint, which includes two chapters on the anatomy, blood supply, lymphatics and innervation of craniofacial complex and Temporomandibular Joint.

Section 7, Occlusion, in one chapter describes



the characteristics of occlusion and malocclusion in primary and second dentition: types of cusps, centric occlusal contacts, tooth guidance, and imaginary occlusal planes and curves.

Section 8, Evolution of Teeth, Comparative Dental Anatomy and Forensic Odontology, has two chapters which give a detailed description of the evolution of teeth, comparative dental anatomy, forensic odontology and dental anthropology.

Section 9, Tooth Carving, in the last chapter explains the rationale, armamentarium, basic principles and step-by-step methodology of the carving procedure.

Each chapter includes multiple choice questions (MCQs) and the additional MCQs in ancillary DVDs to help students prepare for exams, and features numerous high quality photographs and diagrams with descriptions.

The Textbook of Dental Anatomy, Physiology and Occlusion is useful for undergraduate and postgraduate students of dental sciences and dental auxiliaries to teach the concepts of dental anatomy, physiology and occlusion in a simple and logical style.

**Florin Eugen Constantinescu**, DDS, PhD Student

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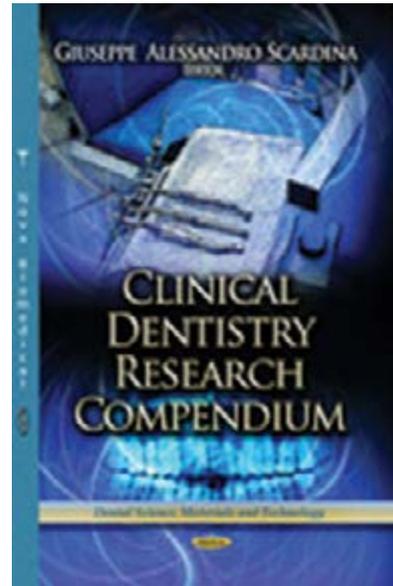
e-mail: dr.vladimir.constantinescu@gmail.com

The Book Review is drafted in the reviewer's sole wording and illustrates his opinions.

## Clinical Dentistry Research Compendium

**Author: Giuseppe Alessandro Scardina**  
**Publisher: Nova Science Publishers, Inc.**

Language: English  
 ISSN: 978-1-62257-574-9  
 Edition: 1/e  
 Publish Year: 2013  
 Pages: 411, illustrated  
 Price: \$220.00

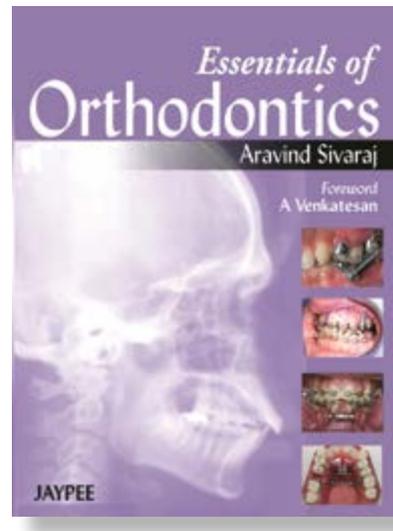


This book compiles the articles published in Volume 4 of the International Journal of Clinical Dentistry. The book is a multidisciplinary forum for publications from all fields of dental medicine. This book builds a bridge between basic and clinical sciences, promoting the exchange of information and progress of dental medicine for the benefit of patients and clinicians. It offers comprehensive coverage of new techniques, important developments, and innovative ideas in all fields of clinical dentistry.

## Essentials of Orthodontics

**Publisher: Jaypee Brothers Medical Publishers (P) Ltd**

Language: English  
 ISBN: 978-93-5090-329-2  
 Edition: 1/e  
 Publish Year: 2013  
 Pages: 573, illustrated  
 Price: £36.00



The Essentials of Orthodontics by Aravind Sivaraj is a clear and a comprehensive guide to clinical and surgical orthodontics useful for dental students, postgraduate students and general practitioners.

The textbook is divided in 15 chapters. In the first three chapters the author talks about to the history and scope of orthodontics, the type of growth and development of dentition and occlusion, and different circumstances that may require orthodontic treatment. The following chapters discuss diagnosis and treatment planning, the mechanics of tooth movements, the preventive and interceptive orthodontics, as well as removable and fixed appliances, orthopedic and functional appliances, and

retention and relapse.

The other chapters describe surgical orthodontics from minor surgical procedures to orthodontic surgery and distraction osteogenesis, multidisciplinary orthodontics and medicolegal considerations. The last chapter presents and suggestively illustrates the instruments and materials used in orthodontics. The book achieves its purpose as a support for the theory and practice of current orthodontics.

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The Book Review is drafted in the reviewer's sole wording and illustrates his opinions.

## Le guide esthétique Comment réussir le sourire de vos patients

**Authors: Jean-Christophe Paris / André-Jean Faucher**

**Publisher: Quintessence International**

Language: French

ISSN: 978-2-91255-023-1

Edition: 1/e

Publish Year: 2004

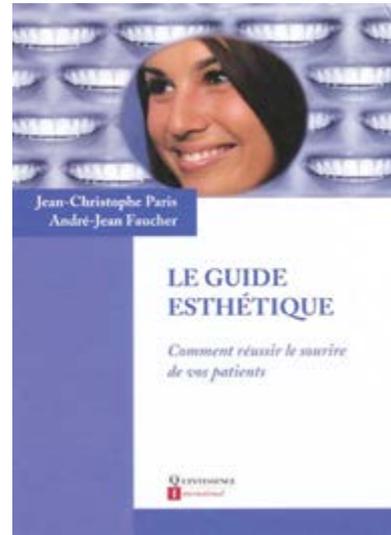
Pages: 309

Price: €181.00

The book *Le Guide Esthétique* (The Aesthetic Guide) presents the joint effort of educators and practitioners to answer a fundamental question of dental aesthetics, namely "how we can improve the patient's smile."

The authors propose an original analysis of the criteria that influence the success of an aesthetic treatment.

The book is divided into seven chapters eloquently and amply illustrated. After a psychological approach to aesthetics, the authors go to its visual perception, the fundamental rules of aesthetics and beauty canons, which are amply described. The macrophotography and photographic materials needed as well as the protocol are presented in a



separate chapter.

The last two chapters develop a detailed aesthetic guide which is illustrated by a series of clinical cases.

The book is accompanied by a booklet summarizing the authors' major principles and is a pedagogical and methodological support for any practitioner who wants to add a new side to his practice.

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The Book Review is drafted in the reviewer's sole wording and illustrates his opinions.

## Zahnmedizinrecht Von A wie Aufklärungsfehler bis Z wie Zahnarzthaftung

**Authors: Tim Oehler**

**Publisher: Georg Thieme Verlag KG**

Language: German

ISBN: 978-3-13-170941-7

Edition: 1/e

Publish Year: 2013

Pages: 320

Price: €79.99

Tim Oehler's book entitled Zahnmedizinrecht Von A wie Aufklärungsfehler bis Z wie Zahnarzthaftung (Dentistry Law from Error Solving to the Dentists' Legal Responsibility) addresses dentists and also those who are interested in legal issues connected to the contemporary dentistry current practice.

The reader can benefit from the inductive method which allows him an easy approach to this legal field. At the same time, the book also addresses patients, as it is a genuine information source.

The book describes a series of court decisions and presents a number of standard legal decisions. The court rulings also include quotations from previous court cases. The author also describes various aspects pertaining to his own personal cases.

The content of the book is absolutely unique, as it illustrates legal issues arising in the daily dental practice. The cases selected and presented in detail involve the dentist directly (as plaintiff or defendant) or indirectly.

The reader may compare his own case with the decisions taken by the court in a similar case presented in the book.

The author describes a series of typical legal examples which can occur in a dental practice, as well as the examination and solution to the case, the court ruling and also his criticism with respect to the decision. The book is indeed original as it



refers to legal issues which occur in the current dental practice.

The chapters are built around a number of similar cases followed by a standard court ruling.

The reader can become acquainted with the legal provisions and is given the possibility to move on the legal «minefield».

While reading the book, a patient can assess his own case against the backdrop of current case law.

Based on the court rulings pertaining to dental practice, the reader can develop his ability to become aware of the legal framework.

«Becoming aware of the legal situation» is also useful for dentists in order to avoid malpractice cases and provide patients with better certainty.

An appropriate presentation of standard court rulings facilitates the development of a critical legal thinking in the dental office, while playing a role in the daily monitoring of dental practice.

Tim Oehler's book provides rich, significant and useful information on the legal issues related to the contemporary dental practice,

**Marian-Vladimir Constantinescu, DDS, PhD**

ROPOSTURO - Holistic Dental Medicine Institute, Bucharest, Romania

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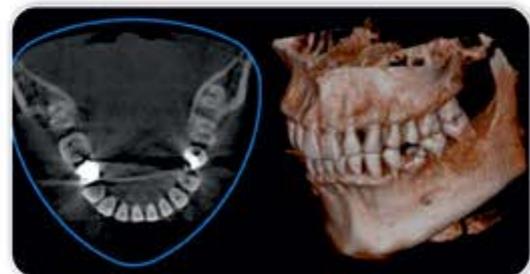
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