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CE PROGRAM FAQs

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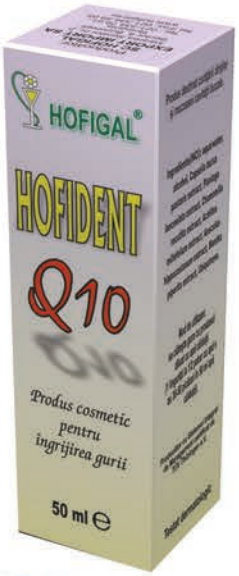

Product presentation: Solution for oral hygiene.

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 a antioxidant, detoxifier, deodorant. It is strongly recommended in gingivitis, stomatitis, thrush, compression pain causedby 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® 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 antiinflammatory, antiviral, antiseptic, it fluidifies the bronchial and pharyngeal secretions, antioxidant, cardioprotective, vasoprotective, it has antineoplastic antileukimic 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 milefolium, 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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Contents

EDITORIAL BOARD

Measuring quality in science

Jean-François ROULET
DDS, PhD, Dr hc, Prof hc, Professor
Editor-in-Chief

Using a reproducible and valid parameter is the base of every evaluation. Quality control means evaluation, which is divided into evaluation of the process quality and evaluation of the outcome quality. Process quality means that the manufacturer is required to define all processes that yield the product. The CE certificate of a company means that the company has proven that it meticulously sticks to the processes they have defined themselves. FDA basically does the same, when it comes to medical products. The outcome quality makes sure that the product meets its specifications and serves the intended purpose without showing negative, not tolerable side effects. So far so good for manufacturers. When it comes to dental products, of course the dentist has a big influence on the outcome and we should not forget his influence on the patient's behavior and life style.

You can consider publications or journals as products as well. So having some sort of quality control seems reasonable. The process control in publication is for sure a very stringent editorial process and peer review. With this, as done with the Stomatology Education Journal, the reader may know that the paper is sound and that they may be able to find out what was done, how it was done and how valid it is, so they can make up their own mind. But how to evaluate the quality of a journal? Eugene Garfield, the founder of the Institute for Scientific Information (ISI) came up with the idea to look at citations from a journal to evaluate its quality. The idea is, the more citations, the better the quality of the journal. The outcome is the impact factor (IF), which is calculated for every given year as the number of citations, received in that year of articles published in that journal during the two preceding years, divided by the number of articles published in that journal during the last two years.[1] At first glance it seems OK and logical, however, the IF has become very problematic over time, for many reasons. Since it looks at a mean of citations, one article may generate a lot of citations, while other articles may get very little or even none. So much about validity. I used to say "create a scientific scandal with your publication and you get a high IF, though the published thing may not be true at all". The second reason why it is problematic is that you cannot compare journals just based on the impact factor alone, since the number of citations is highly dependent on the size of the scientific community in the given specialty. This reduces the IF dramatically for journals reporting science of very small specialties such as ophthalmology or dentistry. When I was a member of the scientific committee of the Charité in Berlin, we rated journals according to their rank in their respective specialty in order to have comparable factors within the medical sciences. This leads to the third reason why it has become problematic. A new journal depends on the ISI to be listed to enter evaluation at all. Furthermore the IF is used by many Universities, against the advice of its inventor[2] to evaluate the scientific output of individuals for their carrier or departments for the allocation of funds. The very negative effect is that it gets extremely difficult for a new journal to obtain good manuscripts. The most productive individuals in the scientific community are usually young scientists working on their academic carrier. Therefore they will try to publish in journal with the highest possible IF. Since IF is used to allocate funds as well, experienced scientists also are usually not willing to submit a manuscript to a non IF journal, because it may hurt financially.

Finally the most critical point about IF is that it can be manipulated by Editors or Publishers. Here are some examples: Editors may choose to publish more reviews, hoping that they get more citations. Editors may decrease the number of published citable manuscripts, thus decreasing the number in the denominator of the equation to calculate the IF and thus increasing the IF. Furthermore papers with a higher probability to be quoted are published early in the year, because they have more time to generate citations.[3,4]

There are some more methods to increase the IF, which I consider unethical. One is that the editor actively promotes some papers from his journal as interesting and citable to his/her peers. Another step is that some editors tend to "help" authors to improve the article and have it published with the Editor ending on the author line in the hope to increase the IF of the journal as well the personal cumulative IF of the Editor. Finally some Editors and/or publishers practice something that is called "coercive citation".[5,6] At the end of the review process they confront the authors with a list of papers that have been published in "their" journal and require the authors to add them to their reference list as a prerequisite for publication!

The newest thing that has appeared is fake impact factor, used by so called predatory publishers. They create an IF with publications that are not listed with ISI.[7] Therefore, dear readers, think twice when you look at an IF! It is obvious that the IF is NOT a number indicating the quality of a paper. It is much better to look at the content to make your judgement!

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

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The strategy of information dissemination in a specific field

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

Dear readers,

As a member of the editorial board of our Journal, we have been trying, together with the other two Editors-in-Chief, Professor Jean-François Roulet (University of Florida) and Professor Rolf Ewers (Medical University of Vienna), to promote the Stomatology Edu Journal as much and as well as possible within the international academic community via all communication channels.

There has been no scientific event which I attended without my introducing our Journal and also asking for original manuscripts to be published by our young Journal.

If we analyze the calendar of editorial events of this year which is coming to an end, there are significant events that I am very pleased to share with you.

Due to the spirit of openness to make full use of dissemination of scientific information that promotes high quality research, and the extraordinary generosity of Professor Michael Glick, Editor of the American Dental Association Journal, JADA, Mr. Michael Springer, Publisher, JADA, Mr. Nawin Gupta, Director of Business Operations, ADA and Mrs Stefanie K. Jewell-Thomas, Elsevier, our readers are now the recipients of 1 article with CE Program FAQs for every one of our issues. This comes as an additional incentive for our readers. For this year's last issue of the Stomatology Edu Journal, the American Dental Association was so generous to provide our readers with access to Baking Soda Dentifrices and Oral Health articles; the five articles were published as a supplement to JADA's November 2017 issue (Volume 148, Number 11); readers may participate in the associated CE online activity (free-of-charge) to earn 2 CE credits.

Since the online edition of the Stomatology Edu Journal's first issue, in March this year there were over 94,000 readers, out of which over 23,000 in the US; now in early December, the fourth issue has more than 130,000 readers out of which over 45,000 readers in the US who visited more than 1,150,000 pages.[1]

This year as well, the visibility of the print and online editions of the Stomatology Edu Journal has been enhanced by Crossref's assignment of a unique alphanumeric string, the Digital Object Identifier (DOI). This DOI identification is assigned to all published articles starting with the first issue.

It was by using the DOI identifier that Professor David C. Watts, PhD, FADM, Professor of Biomaterials at the University of Manchester, Manchester, United Kindom, Editor-in-Chief of Dental Materials, published by Elsevier for The Academy of Dental Materials, found the Editorial written by Professor Roulet for the 2nd issue of the Stomatology Edu Journal.[2] Professor David C. Watts requested the full reproduction of the editorial written by Professor Roulet in Dental Materials. Academician Alexandru Surdu, Vice President of the Romanian Academy, in his capacity of responsible for publications, agreed on behalf of the Permanent Bureau of the Romanian Academy, on the condition

that a specification is made that the article was originally published by the Stomatology Edu Journal. Thus, a top article entitled "A consensus-based approach to evidence-based clinical practice" published by a young journal made internationally available by its publication in Dental Materials. This is the first dental journal rated with Impact Factor (IF): 4,070, 5-Year Impact Factor: 5,155, SCImago Journal Rank Indicator (SJR): 2,149 and H Index 114.[3] Stomatology Edu Journal, the publication that has been published online and in print since 2014, is recognized now by a number of databases, such as the National Library of Medicine (NLM), Crossref, SHERPA / RoMEO, Google Scholar, InfoBase Index (IBI Factor 2015: 2,76) and Academia edu. Currently, our journal is being evaluated by the Scientific Index Services (SIS) and the Directory of Open Access Journals (DOAJ) and in early 2018 it will be subject to admission to Medline, PubMed Central (PMC) and Emerging Sources Citation Index (ESCI).

For its vigorous entry into the value chain of quoted publications, as of this year's issue number 3, all references to articles that will be published online include DOI and active links from PubMed, Google Scholar and Scopus. This is an ample retrospective integrating process that will include all the 95 articles published so far. A laborious and noble activity that must be granted full participation by the editorial team.

Last but not least, we must acclaim Professor Adrian Bejan, J.A. Jones Professor of Mechanical Engineering at Duke University, North Carolina, USA, Honorary Member of the Romanian Academy, Department of Technical Sciences, Deputy Editor-in-Chief of the Stomatology Edu Journal, who has been honored by the award of the Medal "Benjamin Franklin" in Mechanical Engineering for 2018. The Franklin Institute, since its foundation in 1824, has publicly acknowledged the remarkable achievements in science and technology of Nikola Tesla, Marie and Pierre Curie, Thomas Edison, Albert Einstein, Stephen Hawking, Jane Goodall, Bill Gates, and many others. 118 of its medal recipients are Nobel Price laureats. Professor Bejan has distinguished himself by his "interdisciplinary contributions to thermodynamics and heat transfer through convection, as well as to his important contribution to constructal theory, which anticipates natural design and its evolution in engineering, science and social systems".[4]

At the very end of the year, I warmly invite the Stomatology Edu Journal Editorial Board to thoroughly analyze the work done for Stomatology Edu Journal as compared to their council colleagues. This is an invitation I am launching to improve the activity as service for the over 130,000 readers of the Stomatology Edu Journal, so that they could enhance the patents' quality of life by the treatments administered for better health.

I would like to take this opportunity, on behalf of the whole editorial board, to wish you and your loved ones a blessed Christmas, a Happy New Year, and a home full of peace, health, well-being and joy.

Happy New Year!

M-V Constantinescu
Editor-in-Chief

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Conferral of the Benjamin Franklin Medal to Professor Adrian Bejan in recognition of his complex activity

Professor Adrian Bejan, J.A. Jones Professor of Mechanical Engineering at Duke University, North Carolina, USA, Honorary Member of the Romanian Academy, Science Section, Deputy Editor-in-Chief of the Stomatology Edu Journal, has been awarded the 2018 Benjamin Franklin Medal in Mechanical Engineering.

Professor Bejan has come to prominence by "his pioneering interdisciplinary contributions in thermodynamics and convection heat transfer that have improved the performance of engineering systems, and for his constructal theory, which predicts natural design and its evolution in engineering, scientific, and social systems".

Professor Bejan joins the other seven 2018 laureates of the prestigious Franklin Institute Awards, personalities whose breakthroughs have contributed significantly to transforming our world into their own fields, have helped improve the lives of billions of people around the world by paving the way for a future better.

Since its foundation in 1824 the Franklin Institute has acknowledged and publicly encouraged the remarkable achievements in science and technology of Nikola Tesla, Marie and Pierre Curie, Thomas Edison, Albert Einstein, Stephen Hawking, Jane Goodall and Bill Gates. Up to now, in its124 years of existence, 118 of the Franklin Institute members have been honored with the Nobel Prize.

The Franklin Institute's Award Ceremony and Dinner are the culmination of a series of events and programs organized over the course of a week to capitalize on the advancements in science and technology as well as an extraordinary business leadership. In addition to the series of events and symposia organized during the week, public and educational programs are designed to allow direct and unprecedented access to laureates.

In order to honor its new 2018 laureates, the Franklin Institute decided to hold an event on April 19, 2018 celebrating the tremendous impact on science, technology and business leadership these pioneers have had through their exceptional achievements.

M-V Constantinescu
DDS, PhD
Editor-in-Chief

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Impressions from Vienna at the CED-IADR / NOF Oral Health Research Congress

The biennial Continental European Division (CED) and Scandinavian division (Nordisk Odontologisk Förening, NOF) meeting of the International Association of Dental Research (IADR) was organized in Vienna at the end of September this year.

The congress included an intensive two-and-half day program of oral presentations, posters, keynote & symposia lectures. More than 800 participants, among whom more than 25% were students, from more than 50 countries attended the congress, which proved to be one of the most important European events in the field of dental research. The most recent research findings, focusing on the latest innovations, developments and trends in the various sub-disciplines of dentistry were discussed at this event. A lot of attention, while organizing each CED-IADR congress, is indeed paid to creating the possibilities of networking so as to imagine, invent and inspire each other. The modern congress venue 'Messe Wien' and the size of the congress had the advantage of facilitating easy interactions with colleagues, friends & peers in the broad field of dental research.

The main outcomes of the meeting confirmed the Association's main goal of encouraging high-quality Oral Health Research in Europe, especially among young people. Indeed, several innovative features were introduced in the meeting program as of this year, such as a greatly reduced registration fee for students and young researchers, a newly installed 'My First Research' poster award competition and a 'Young CED-IADR' symposium organized and delivered by young researchers. The latter one meant that young researchers under 35 years of age with a very promising career fully presented, organized and moderated the event. The purpose of this activity was to encourage young people to have a better understanding of a specific topic of dental research, that of the interactions between dental materials and oral biofilms, and to generate a productive discussion. The symposium was very well received, and it is hoped that this activity will be implemented in the program of the future meetings. The meeting also included a special full-day scientific program to celebrate the '100-year anniversary' of the NOF Division. A special clinical satellite symposium on selected new trends in restorative dentistry, as well as a session with clinical case poster presentations were also organized, their specific aim being to narrow the existing gap between dental researchers and clinicians.

The CED-IADR/NOF Oral Health Research Congress allowed further networking and getting in touch with each other during the two social events: the opening ceremony in the Vienna city hall and the 'Congress Get-together' which was held inside the University Dental Clinic of Vienna.

The next meetings of the Association are scheduled to take place in London, UK, July 25-28, 2018, as a General Session together with all the other divisions, and in Madrid, Spain, September 19-21, 2019 as CED-IADR.

For any information, please refer to the website of the organization: https://ced-iadr.eu/ and the secretariat email: ced.iadr@uzleuven.be.

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Competence in aesthetics extended to include digital competence

For the third time, Gernot Schuller (Senior Director Austria & Eastern Europe) and his team succeed in drawing participants from all over the world to Vienna. "Competence in Aesthetics" was held, by tradition, at the Austria Center Vienna from 10 to 11 November 2017. The key factors of this exceptional conference include: 1400 participants from 36 countries, 21 speakers from 10 nations and 15 exhibitors.
Digitization in dental technology has changed the industry in recent years and has also influenced the orientation of Ivoclar Vivadent as a company. Robert Ganley (CEO Ivoclar Vivadent) was in Vienna. In his opening speech, he told the audience that digitization is a megatrend predicted by reputable futurologists not only for the dental world. The question is not whether digitization is changing the industry, but at what speed.

Digitization and implantology
The conference focused on two areas: digitization and implantology. For the first time ever, participants were able to interactively shape the contents of the event. Ivoclar Vivadent developed an app that enabled the audience to pose questions to the speakers. The questions were discussed after each block of presentations.

Tailor-made digitization
Digitization is entering all areas of dentistry and dental technology. How high its involvement in the workflow is depends on the indication and treatment. Dr. Tim Joda spoke of "tailor-made digitization". With this term, he referred to technology that is backed by human know-how. Together with Dr. Stefan Röhling, Dr. Knut Hufschmidt and Prof. Dr. Irena Sailer, he was among the speakers who primarily presented topics on implantology and the effects of digitization on implantology and the selection of materials.

CAD/CAM overcomes barriers
CAD/CAM is capable of overcoming barriers of time and space. It was shown by the clinical cases presented by the practice teams of Prof. Dr. Stefan Koubi and Hilal Kuday as well as Dr. Florin Cofar and Lorant Stumpf. In both teams, dentist and technician are based in different countries. They focus on aesthetics and smile design from both a digital and analogue perspective. Accurate shade matching is key to high-end restoration design; this is one of the areas that has benefitted from the development of digital cameras and image processing systems. Sascha Hein proved this point with his shade system that is based on luminescence and colour components rather than on digital shade guides. "If you are working across distances, you have to be able to rely on the colour on the photo", he said.

Smart combination
Semi-digital is the intelligent combination of analogue and digital tools. Most of the clinical cases shown were solved in this way, because digital technologies still come up against their limits in some circumstances. For instance, digital impression-taking in the edentulous jaw is still unsatisfactory, as Prof. Dr. Florian Beuer explained. Similarly, Dr. Marko Jakovac and Alen Alic pointed out that they still preferred using an analogue layering technique for aesthetic restorations in the anterior region. Only premolars and molars are restored using a monolithic technique in their practice. Jakovac and Alic work in a team of three together with a digital technician, who is responsible for the CAD/CAM applications. Dr. Petr Hajny from Prague is both a dental technician and a dentist. He upgraded his practice to be digital and produces up to a 150 restorations per week as a one-man team. Digitization has turned a vision into reality and has become his favourite pastime. Dr. Gerwin V. Arnetzl also decided early on to go digital. Above all, he sees economic advantages in this technology.

Dental professionals have begun to promote themselves digitally
Digitization has not only changed technology, but it has also revolutionized the media landscape. Many speakers run their own YouTube channel to present their own cases and to arouse the patients'

interest. Milos Miladinov delved deeply into digital photography to be able to use his pictures on social media. "In this way a name becomes a brand and a part of practice marketing", he said.

Patient requirements become more specific

On the basis of information obtained from Instragram, Facebook & Co., today's patients visit the dentist with clear ideas about the treatment that they want. They know exactly which smile and which material they are looking for. "These requests require a reversal process in the planning", said Dr. Stefan Koubi. "We begin with the aesthetic design and then look at the function".

A digitally produced mock-up provides additional certainty that the final result will be successful and fully meet the patient's expectations. This approach is also used by Prof. Dr. Petra Gierthmühlen and Prof. Dr. Irena Sailer, who, at the conference, co-presented with Vincent Fehmer. A physical try-in model makes it easier for patients to visualize their prospective smile. Digitization makes communication easier. This statement was shared by all speakers equally.

Show-stopping applause for top presentation

A highlight was the presentation of Brazilian-born Dr. Ronaldo Hirata, who has made New York his new home. He is a master of staging and showed a video of himself and his way of working, for which he drew applause from the audience during the presentation. He also runs a YouTube channel to report about his work. In his practice, he focuses on non-invasive and minimally invasive restorations, he is a master of the composite resin and an expert on possible sources of errors during composite filling fabrication.

How important is the human factor?

We all have no concerns when it comes to digital technology on our smartphones or digital cameras. In the dental field, however, the change is accompanied by uncertainty. Will the new technologies replace the human factor and analogue know-how? All speakers refuted this statement unanimously. The same expertise is required for the digital workflow as for the analogue one. Digitization has changed the tool, not the solution, or "first learn to walk, then to fly", as the scientific chairman Prof. Dr. Thomas Bernhart aptly stated.

André Büssers

Public Relations Manager
Ivoclar Vivadent AG

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IDEA 2017 - Etiopia - 3rd International Dental Exhibition Africa

Date: 14 - 16 December 2017
Location: Addis Ababa, Ethiopia
Event types: Conference, Exhibition
Visit event website: www.ideadakar.com/index.html

4th Implant Systems Global Conference

Date: 09 - 10 February 2018
Location: Dubai, United Arab Emirates
Event types: Conference, Hands-on, Exhibition
Visit event website: www.art-of-implantology.com

The 90th Annual Meeting of the American Prosthodontic Society

Date: 22 - 23 February 2018
Location: Chicago, Illinois, USA
Event types: Conference, Hands-on, Exhibition
Visit event website: http://www.prostho.org/annual_meeting_upcoming.html

21st Annual World Dental Summit

Date: 26 - 28 February 2018
Location: Paris, France
Event types: Conference, Hands-on, Exhibition
Visit event website: www.worlddental.conferenceseries.com

AO 2018 – Academy of Osseointegration Annual Meeting

Date: 28 February – 03 March 2018
Location: Los Angeles, CA, USA
Event types: Conference, Courses, Hands-on, Exhibition
Visit event website: http://meetings.osseo.org/2018/#schedule

ITI Congress Central America and the Caribbean

Date: 08 - 09 March 2018
Location: Cancun, Mexico
Event types: Conference, Courses, Hands-on, Exhibition
Visit event website: www.iti.org/ITI-National-Congresses

ITI Congress Brasil

Date: 03 - 10 March 2018
Location: Gramado, Brazil
Event types: Conference, Courses, Hands-on, Exhibition
Visit event website: www.iti.org/ITI-National-Congresses

Pacific Dental Conference 2018

Date: 09 - 11 March 2018
Location: Vancouver, Canada
Event types: Conference, Courses, Hands-on, Exhibition
Visit event website: www.pdconf.com

ASO 2018 - The 26th Australian Orthodontic Congress

Date: 09 - 12 March 2018
Location: Sydney, Australia
Event types: Conference, Hands-on, Exhibition
Visit event website: www.aso.org.au/australian-orthodontic-congress

Expodental Meeting 2018

Date: 15 -17 March 2018
Location: Madrid, Spain
Event types: Conference, Exhibition
Visit event website: www.ifema.es/expodental_06

2nd International Congress of the Faculty of Dental Medicine of the "Carol Davila" University of Medicine and Pharmacy

Date: 15 -18 March 2018
Location: Bucharest, Romania
Event types: Conference, Hands-on, Exhibition
Visit event website: www.congresmeddent.com

ITI Congress Germany

Date: 16 -17 March 2018
Location: Bonn, Germany
Event types: Conference, Hands-on, Exhibition
Visit event website: www.iti.org/ITI-National-Congresses

29th Annual American Dentistry Congress

Date: 22 -23 March 2018
Location: New York, USA
Event types: Conference, Exhibition
Visit event website: http://americandentistry.conferenceseries.com/scientific-program

3rd International Exhibition for the Dental Sector in Algeria

Date: 22 -24 March 2018
Algiers, Algeria
Event types: Conference, Exhibition
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Baking soda dentifrices and oral health.
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IN VITRO WEAR OF THREE BULK FILL COMPOSITES AND ENAMEL

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ABSTRACT **DOI: 10.25241/stomaeduj.2017.4(4).art.1**

Introduction: This in vitro study aimed at testing the hypotheses that (1) there is no difference in wear in vitro among 3 bulk-fill composites investigated and their respective antagonists, and (2) the tested bulk-fill wear is not different from enamel.
Methodology: X-tra fil (Voco; [X]), Tetric-N-Ceram Bulkfill (Ivoclar Vivadent; [T]), QuiXX (Dentsply; [Q]), and enamel [E] specimens (Ø=8 mm, depth=1.5 mm, n=8/material) were subjected to wear in a chewing simulator (CS 4.8, SD Mechatronik) with steatite antagonists (Ø=6mm). $1.2x10^5$ cycles (0-49 N, 0.7 mm lateral movement, 1 Hz) were performed while simultaneously thermocycling (5/55°C) every 90 s. The volumetric wear of the materials was measured with a 3D laser scanner.
Results: The total wear of bulk-fills was: [X]: 0.64±0.07 mm^3; [T]: 0.66±0.08 mm^3; [Q]: 1.58±0.14 mm^3. The total wear of enamel (0.24±0.03 mm^3) was significantly lower than that of the bulk-fills ($p<0.0001$). The total wear of the antagonists was: [X]: 0.32±0.02 mm^3; [T]: 0.24±0.04 mm^3; [Q]: 0.27±0.02 mm^3; [E]: 0.12 ±0.01 mm^3. The wear of the antagonists by [X] was significantly higher than by [T] and [Q] ($p<0.001$). Enamel produced the lowest wear of the antagonists ($p<0.0001$). The wear was linear between $5x10^3$ and $1.2x10^5$ wear-cycles. A negative correlation between the wear of the composite materials and that of the antagonists was found.
Conclusion: In vitro wear of Tetric-N-Ceram Bulkfill was in the expected range and equal to X-tra fil. QuiXX wear was 2.7 times higher. The antagonist wear was significantly lower, less than 50% of the wear of the composites and the enamel. Both hypotheses were rejected.
Keywords: chewing simulator, wear, bulk-fill composite, thermocycling, enamel.

1. Introduction

Approximately 5 years ago a new category of resin composites was introduced for bulk-filling deep and wide dental cavities. These new materials, called bulk-fill composites, are claimed to provide a faster and easier procedure than the traditional incremental restoration technique.[1-7] This innovation was introduced following the general marketing trend for faster, easier and more convenience in restorative dentistry. Bulk-fill resin composites are claimed to be placed up to 4 or 5 mm thick increments (bulks) skipping the time-consuming layering process, and cured with light exposure time of up to 20 s.[8] To accomplish this, the well-known and clinically proven resin chemistry and filler technology had to be modified in several aspects. The translucency of the material had to be increased to allow the blue light-curing wavelength to penetrate to the required depth of the material.[9] It was accomplished by either using less pigments and/or by matching the refractive index of the resin as closely as possible to those of the fillers in order to minimize the light scattering at the resin-filler interface.[8] Another possibility was to use more effective photo initiator systems (e.g. germanium-based light-initiators, such as Ivocerin, Ivoclar Vivadent AG, Schaan, Liechtenstein), which allow the composite to be cured with less light energy per cm^2.[10]
Furthermore, for bulk-fill composites it is beneficial to reduce the polymerization shrinkage stress, to reduce the stress challenge to the tooth-restoration interface, thus allowing a good seal of the restauration by the adhesive system. One way to accomplish this is to minimize the resin content of the composite by using rather coarse fillers (particle sizes much higher than 5-10 µm). Since the surface area of such particles is smaller, less resin is needed to wet it.[11] However, if this is done with conventional glass fillers, the surface characteristics and thus the polishability deteriorate.[12] A way around this is to use composite fillers having almost the same composition as the cured composite. They polish

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as well as a micro hybrid composite.[11] A further optimization can be reached by using multimodal filler compositions.[13] Another possibility is to use resins which shrink less (e.g. larger molecules, which means less double bonds to be reacted); however, these monomers should have a low viscosity in order to be able to wet the filler particles.[11] Finally, on the monomer side, longer spacers can be built between the reactive sites, which allow for stress relief after polymerization.[8]

Czasch & Ilie[5] showed that curing Sure Fill SDR (DENTSPLY DeTrey GmbH, Konstanz, Germany) and Venus Bulk-fill (Heraeus Kulzer GmbH, Hanau, Germany) in 4-mm bulks for 20 s can be recommended based on FTIR and micro hardness data. Ilie et al.[14] reported the same results with Tetric EvoCeram Bulk-fill (Ivoclar Vivadent) and X-tra base (VOCO GmbH, Cuxhaven, Germany). There is a growing body of literature demonstrating that the bulk-fill concept is validated, when considering curing depth, mechanical properties in the cervical area, and margin quality.[1-8] However, it is still not known if the modifications in the composition have an influence on the wear behavior of the bulk-fill composites. Therefore, the objective of the present study was to compare the wear behavior of different bulk-fill restorative materials as well as enamel *in vitro*.

The null hypotheses tested were: (1) bulk-fill composites show the same amount of wear and (2) the wear of composites is equal to the wear of the enamel.

2. Materials and Methods

The following bulk-fill materials were used: (X-tra fil, [X], Voco), (Tetric N-Ceram Bulk Fill, [T], Ivoclar Vivadent) and (QuiXX, [Q], Dentsply,). Eight samples were prepared for each brand according to the manufacturer recommendations.

Thirty-two aluminum sample holders (inner Ø 7.9 mm, depth 1.5 mm) were grit-blasted with 27 µm aluminum oxide particles (EtchMaster Tips Small, Groman, USA), then one coat of universal primer (Monobond Plus, Ivoclar Vivadent) was added and left for 60 s, 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 Bluephase G2 unit at "High" mode delivering 1450 mW/cm^2 and having a radiant exposure of 14.5 J/cm^2 at a distance of 1.5 mm (verified with MARC Resin calibrator, Bluelight Analytics Inc., Halifax, NS). The composites [Q], [T] and [X] were filled into 24 sample holders (n=8/each material) in one increment, then the top surface was flattened with a Mylar® matrix band and light-cured at high mode for 10s (Bluephase G2).

The composite surfaces were finished and polished by using silicon carbide discs (Sof-Lex , 3M, St. Paul, MN, USA), light orange disc for finishing and yellow disc for polishing, each for 15 s. All samples were then stored in distilled water at 37° C for 3 weeks.

Human enamel samples were obtained from extracted incisors, stored in 0.4% chloramine solution. The IRB1 of the University of Florida allowed the use of extracted teeth, if they are completely anonymized (IRB.UF 201500060). They were mounted with adhesive technology as described above for the steatite antagonists on eight grit blasted aluminum sample holders for the chewing simulator CS 4.8 (Mechatronik, Germany), perpendicular to the long axis of the sample holder. They were then ground flat and polished using the previously described protocol and materials.

Steatite balls (Ø 6 mm) mounted into aluminum holders using resin composite were used as antagonists. One antagonist per sample (n=24) was used, and then discarded after finishing all cycles. The antagonists were scanned with (Laser scanner LAS-20, Mechatronik, Germany) before starting the experiment. The samples were randomly distributed to the chewing simulator chambers (CS-4.8,) using random numbers.[15]

The chewing simulator was run according to the parameters listed in Table 1.

The composite samples were scanned after each round (Table 2). However, the antagonists were scanned only prior to the experiment and at the end of the experiment.

This resulted in 1.2x10^5 mechanical cycles and 1333 thermal cycles as a total.

Dedicated software (Geomagic® Control™ 2014, 3D Systems, Inc., Rock Hill, SC, USA), was used to analyze the scanned data. After each round, volumetric wear of the samples (composite and enamel) was determined by using the flat surface of the sample as a reference plane. With the "fill" command the software calculated the volume of the observed wear facet. The wear of the steatite antagonists was measured by superimposing the worn antagonist with the initial, unworn antagonist. Volumes under the reference plane were calculated using a common reference plane. The difference between the new and worn antagonist was considered to be the volumetric wear of the antagonist. Data were analyzed using ANOVA, linear regression and Tukey test after the normality of the data was confirmed with Komolgorov-Smirnov test (JMP, SAS, Cary NC, USA).

Table 1. Settings of Chewing Simulator.

Load	49 N
Upstroke	2 mm
Down stroke	1 mm
Horizontal movement	0.7 mm
Upward speed	60 mm/s
Downward speed	60 mm/s
Horizontal speed	40 mm/s
Frequency	1HZ
Thermocycling	5 °C-55 °C 30 s holding time, Transfer time 15 s, Total cycle 90 s
Direction	One way under load, back without load

Table 2. Number of mechanical cycles and time intervals for scanning.

Round No.	No. of cycles	Total
1	$1x10^2$	$1x10^2$
2	$4x10^2$	$5x10^2$
3	$5x10^2$	$1x10^3$
4	$1x10^3$	$2x10^3$
5	$3x10^3$	$5x10^3$
6	$5x10^3$	$1x10^4$
7	$1x10^4$	$2x10^4$
8	$1x10^4$	$3x10^4$
9	$1x10^4$	$4x10^4$
10	$1x10^4$	$5x10^4$
11	$1x10^4$	$6x10^4$
12	$1x10^4$	$7x10^4$
13	$1x10^4$	$8x10^4$
14	$1x10^4$	$9x10^4$
15	$1x10^4$	$1x10^5$
16	$1x10^4$	$1.1x10^5$
17	$1x10^4$	$1.2x10^5$

Table 3. Wear rate of the tested materials. Same superscript letters mean same statistical group ($p< 0.001$).

Material	Wear rate ($x10^3 \mu m^3$/cycle)	
	Mean ± SD	Stat. Group
Enamel	2.23±0.28	A
X-tra	4.64±0.41	B
Tetric	5.38±0.63	B
QuiXX	11.19±1.12	C

3. Results

One-way ANOVA of the volumetric wear of the composites and enamel, and respective wear of the antagonists after $1.2x10^5$ load cycles showed there were statistically significant differences between the four materials tested and the respective antagonists ($p<0.0001$). The results of Tukey's wear ranking for each material and respective antagonist along with the mean and standard deviation of the wear are shown in Fig 1. With exception of QuiXX, the antagonist wear was less than half of the wear of the materials. The wear-loading cycle plots of each test showed that a linear correlation could be identified between volumetric wear and number of load cycles in the range of $5x10^3$ to $1.2x10^5$ load cycles. Linear regression was performed for each test and the slope of the line was considered as the wear rate of each individual test. The degree of fit of linear regression was greater than 98% for each specimen. ANOVA of the wear rates showed there was statistically significant difference between the tested materials ($p<0.0001$). Fig. 2 shows the plot of mean wear vs the number of loading cycles. The straight lines associated with each material are the result of linear regression based on the mean wear values of 8 specimens for each material. The mean wear rates along with the standard deviation and Tukey's ranking are shown in Table 3. The wear behavior of Tetric N Ceram Bulk Fil and X-tra fil were almost identical, while QuiXX showed statistically significant more wear.

4. Discussion

4.1. Methodology

The new bulk fill materials selected for this study were from the group of the high viscosity ones, designed to be used as a regular filling material, but being easier and faster in their application, and thus being exposed to the occlusal stress of antagonists.

When looking at mechanical properties of composites, it is important to make sure that the composite is well cured, which means that the polymer network has reached its optimal degree of conversion. Thus one can expect the best possible mechanical properties of the material. Therefore, in this study it was decided to use the curing times recommended by the manufacturers. Furthermore, the total energy delivered to the composites was determined to be 14.5 J/cm^2. It is in agreement with the recommendations found in literature, showing that to adequately cure resin composites of 2-mm thickness, between 12 and 24 J/cm^2 of energy is needed.[16,17]

Wear is a very complex process; therefore, there is no single standard procedure for wear testing. Many wear testers use different approaches; however, lately two-body wear with a sliding component and preferably computer controlled forces and movements are the preferred approach.[18]

Since every wear tester has a different operational approach[18] different antagonists regarding material, shape and dimensions are used.[19-24] In the present study steatite antagonists with a spherical shape and 6 mm diameter were used due to their hardness, reproducibility, standard form similar to a cusp, and easy availability. Furthermore, most chewing simulator users prefer these antagonists which allow better comparisons with other studies. Standard parameters were used for operating the chewing simulator. Therefore, our data are well comparable for instance with the ones obtained by the Ivoclar Vivadent group in Schaan.[13] The slight difference in the measured wear between the Ivoclar group and the values presented in this study may be explained with the different antagonists used. In the present experiment spherical steatite antagonists were used, while Ivoclar Vivadent used standardized Empress (leucite ceramic) antagonists which had the shape of a molar cusp.[13]

The wear values obtained in this experiment were almost half as high as the ones obtained with similar composites in a former experiment using the same chewing simulator.[25] This difference may be explained by the different loads used. In the present experiment 49.05 N load was used as others do,

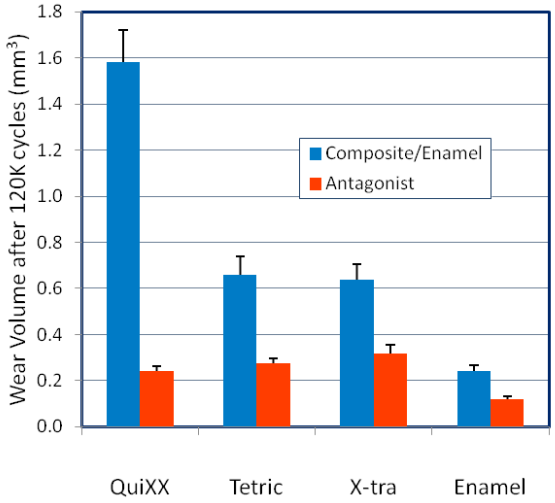

Figure 1. Total wear of 3 Bulk-fill composites and enamel (control) as well as the steatite antagonists after 12 x 10^5 cycles. Letters below the columns indicate Tuckey's group.

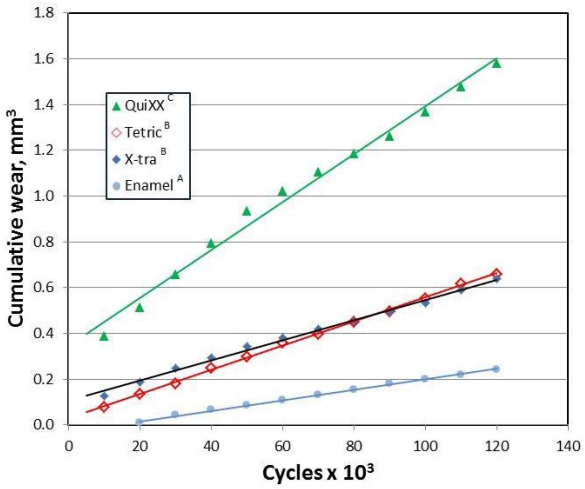

Figure 2. Linear regression of wear vs cycles for the tested composites and enamel (p<0.0001). Superscript letters next to the name of the materials in the legend show Tuckey's group.

while in the former experiment the load was 58.86 N , which seems to be too much since fractures of the samples had occurred. It is difficult to determine the actual chewing force under function. Literature data show high variability (20 – 120 N). The decision to use 49.05 N was based on a paper by Gibbs et al.[26] who reported that value to be the average chewing force under normal function.

To measure the wear facets a laser scanner was used. Heintze et al.[27] have indeed shown that there was no significant difference between a mechanical or optical profilometer and a laser scanner.

As in a former experiment,[25] the wear behavior in the first 5x10^3 cycles was inconsistent and had a higher variability. This is a known effect called "running in". Therefore, the analysis of the data began at 5x10^3 cycles. From that point on, the wear development was linear with an excellent fit (R2 > 0.98; Fig 2), which confirms the findings from Heintze et al.,[21,27] Wang et al.[28] and Matias et al.[25] It allows to calculate a wear rate (= volume loss/cycle) which is best expressed in µm3/cycle (Table 3). It is thus possible to make direct comparisons independently from the number of cycles run. Nevertheless, it is recommended to run at least 1.2x10^5 cycles, to exclude an unnoticed change in the slope of the wear rate. The latter may be in fact due to fatigue-induced catastrophic failure, as we have seen with a glass ionomer cement (unpublished data).

4.2. Results

With the exception of QuiXX, the results of this study can confirm Heintze's,[21,27] and Matias's et al data[25] that the antagonist's wear is about half the wear of the composite materials (Fig. 1). This may be explained by a different composition of QuiXX compared to the other composites, especially in its glass filler. That filler seems to be less hard than the fillers used in the other composites, thus being easier abraded, but at the same time being gentler with the antagonists.

QuiXX was worn three times more than the other two materials (p<0.001). Looking at the composition of QuiXX as indicated in the directions for use, one can see that besides UDMA and TEGDMA, Di- and Trimethacrylate resins, also a Carboxilic acid-modified dimethacrylate resin has been added. In addition, silanated strontium aluminum sodium fluoride phosphate silicate glass was used as filler. Furthermore, the material is delivered in a blister, obviously to prevent a ionomeric reaction between the carboxylic acid hydrolyzed by water that may diffuse into the material and the glass, which would make the material harden in its package The manufacturer claimed fluoride release as well. Both facts lead to the suspicion that compomer technology was used for that product, and that could at least partly explain the increased wear of that material.[29-32]

X-tra fill is characterized by the manufacturer as a hybrid composite with 70.1% vol filler content and BiS-GMA, UDMA, BHT and TDMA as resins. Multimodal filler distributions with prepolymerized composite particles have been used for that material. Similar composition can be found in Tetric N Ceram Bulkfil, which could explain the same wear behavior. It is not known by the authors, if Voco uses similar filler technology. Looking at the antagonist wear one may speculate that the filler used by Voco might be of a conventional type, and in average coarser than the one used in the bulk-filled material by Ivoclar Vivadent. An interesting fact, the composite with the highest wear (QuiXX) has worn the antagonists the least and the composite with the least wear (Xtra) has worn the antagonist the most. This could be partly explained by the particle size, particle size distribution, the properties of the fillers (composition, hardness) and the filler load. If the particle distributions and the composition of the fillers used were known, this statement could be verified.

Besides showing the least wear, enamel also showed the least antagonist wear. This can be explained with the structure of enamel, which is very dense. The size of the hydroxyapatite crystals is much smaller than the ones of the fillers used in the tested bulk-fill composites. Once polished, the enamel surface is very smooth and generates low friction.

Since there are considerable differences in the

different wear testing devices, it is not possible to directly compare the volumetric wear data from different approaches. Therefore, only studies done with Willitec/Mechatronik wear testing machines can be used to do direct comparisons with the present study. Lazaridou et al.[33] found for Tetric EvoCeram 0.33 mm^3, while Tetric N Ceram Bulk-fill showed 0.66 mm^3 in the present study, which is substantially higher. Differences in the methods may explain these different findings. Lazaridou et al were loading the samples in water at 37° C, while in the present study the samples were thermocycled, which represents an additional stress.

Heintze et al 2006[27] have used almost the same approach as used in this study and measured for Tetric N Ceram Bulk-fill, approx. 0.6 mm^3. D'Arcangelo et al.[22] reported mean wear values for different direct composites between 0.529 ±0.139 mm^3 and 1.425±0.245 mm^3. However, they used a different antagonist material (zirconia) and shape (round tip 3 mm diameter). Hahnel et al.[34] measured the wear of 16 different resin-based restorative materials and found that the wear of Quixfil was approximately three times that of Tetric Ceram, which confirms the findings of this study.

As all materials that have crosslinking in the resin matrix, flowable composites express some viscoelastic properties.[35] Thus, bulk-fill composites are not exempt from this property, as has been shown by Papadogiannis et al.[36] Stressing the composite in the chewing simulator may have created some creep, which could be seen as a confounder of the true wear that was measured in the present study.

5. Conclusions

In vitro wear of Tetric N Ceram Bulkfil was in the expected range and equal to X-tra fil. The wear of QuiXX was 2.7 times higher. Enamel was worn the least. The antagonist wear was significantly lower, less than 50% of the wear of the composites and the enamel.

Author contributions

Equal contribution to the paper.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Questions

Bulkfill composites

❑a. can be cured up to 8 mm thickness in 5 seconds
❑b. can be cured in 4-5 mm increments in up to 20 seconds
❑c. can be used in one increment for every restoration
❑d. have a very low translucency

In the experiment, the load of the chewing simulator was

❑a. 29 N
❑b. 39 N
❑c. 49 N
❑d. 59 N

The wear of enamel after 120'000 cycles was

❑a. significantly less than the one of the composites
❑b. significantly more than the one of the composites
❑c. equal to the one of the composites
❑d. 8x higher than the wear of the composites

The wear of the antagonists after 120'000 cycles was

❑a. equal for all tested composites
❑b. significantly lower than the wear of the composites
❑c. significantly higher than the wear of the tested composites
❑d. the same as the one of the tested composites

KNOWLEDGE AND PATTERNS OF ANTIBIOTIC PRESCRIPTION AMONG DENTAL PRACTITIONERS IN HAIL, SAUDI ARABIA

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ABSTRACT

Introduction: Presence of various bacterial strains resistant to antibiotics is a genuine issue to medical professionals. Unjustified over prescription of antibiotics by dental practitioners (DP) is well recognized. The aim of this study was to explore the knowledge and patterns of antibiotic prescription and related antibiotic resistance among dental surgeons working in Hail, Saudi Arabia.
Methodology: A questionnaire was distributed to 150 DP working in the district of Hail, Saudi Arabia. The questionnaire sought answers to the common dental conditions for which antibiotic would be prescribed. The possible contributing factors in development of antibiotic resistance were also sought.
Results: Out of the 150 questionnaires sent out 101(67%) were filled in by the DP. About 85% were males and 15% were females. Most of the DP would prescribe antibiotics for elevated temperature (86.1%), diffuse swelling (75.2%) and swelling causing eye closure (90.1%). Antibiotic prescription would be considered for pericoronitis, cellulitis and trismus by 68.3%, 89.1% and 40.6% of the DP respectively. However, 55.4% would prescribe antibiotics for fluctuant localized swelling, 75.2% to reduce postoperative complications and 73.3.8% for surgical extraction.
Generally, amoxicillin was the most preferred drug of choice, and nearly 36% of the DP preferred amoxicillin-clavulanate in treatment of cellulitis. About 67% thought that the widespread use of antibiotics was the main contributing factor in development of antibiotic resistance.
Conclusion: Despite of the moderate knowledge of DP, a substantial percentage continue to prescribe antibiotics indiscriminately and irrationally. The results reveal that further work and efforts are required to acquaint the DP of the risk of unjustified antibiotic use and bacterial-resistance development.
Keywords: antimicrobial, dental practitioner, use of antibiotics, bacterial resistance.

1. Introduction

Antibiotic therapy is playing major role in treatment of various infectious diseases. There is no doubt that the safe use of systemic antibiotics has improved the quality of life dramatically and increased life expectancy for millions of people worldwide.
Despite the crucial benefits of systemic antibiotics, there has been an explosion in the number of bacteria that have become resistant to several drugs in use. In fact, not the antibiotics per se is the offender, as they remain one of the most powerful biological armaments against ailments caused by microbial infection. Nevertheless the inappropriate and irrational use of the antibiotics resulted in catastrophic situation attributed to development of bacterial strains resistant to a wide range of antibiotics.
Furthermore, use of antibiotics for self-medication has been documented in general population in various developing and developed countries.[1] Several studies have demonstrated high prevalence of self-medication with antibiotics among medical and non-medical students.[2] The misuse of antibiotics is of risk to both the individual and the community at large as it leads to increased risk of adverse effects and emergence of bacterial resistance.[3] Among the many factors that contribute to misuse of antibiotics is the liberal dispensing of antibiotics by pharmacists without prescription.
The flora of the oral cavity is comprised of diverse range of microorganisms including bacteria, fungi and protozoa. However, a small percentage of these microorganisms can be isolated by the conventional culture technique. Recently, the use of molecular biological methods demonstrated many novel phylotypes that cannot be recognized by

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conventional techniques.[4]

Dentists prescribe medications for the management of several oral conditions, mainly orofacial infections.[5] Since most human orofacial infections originate from odontogenic infections[6] prescribing antibiotics by dental practitioners has become an important aspect of dental practice. Thus, antibiotics account most medicines prescribed by dentists.[7] Dentists prescribe between 7% and 11% of all common antibiotics (betalactams, macrolides, tetracyclines, clindamycin, metronidazole).[8] For instance, in the United Kingdom, dentists accounted for 7% of all community prescriptions of antimicrobials.[9] On the other hand, the National Center for Disease Control and Prevention estimate that approximately one-third of outpatient antibiotic prescriptions are unnecessary.[10] Antibiotic prescribing may be associated with unfavorable side effects ranging from gastrointestinal disturbances to fatal anaphylactic shock and development of resistance. The increasing resistance problems of recent years are probably related to over- or misuse of broad-spectrum agents such as cephalosporins and fluoro-quinolones.[11]

We have now entered an era where some bacterial species are resistant to the full range of antibiotics presently available, with the methicillin-resistant *Staphylococcus aureus* being one of the most widely known example of extensive resistance.[7]

Understanding the enemy is the best way to win the battle. Thus, the rational choice and use of antimicrobial agents begins with the knowledge of the microorganisms most likely responsible for the common dental infections.

It is well known that the oral microbial flora is dynamic and subject to changes continuously throughout life. In dentistry antibiotics are mainly used to manage or prevent spread of odontogenic infection. Other uses; may include prophylaxis against infective endocarditis, selected joint surgery and in conditions related to systemic diseases, such as diabetes mellitus. Hence, the number of dental conditions that need use of systemic antibiotics remain limited. In fact, most of the dental emergencies, including acute dental pain need only local intervention.[12] Pain associated with acute pulpitis for example is not a justification for antibiotic therapy. The latter should be reserved for more serious conditions associated with evidence of systemic spread.[13]

The literature shows strong evidences that the dental surgeons have immensely contributed to antibiotic abuse and development of bacterial resistance.[14-16] Several authors have widely examined the multiple factors related to improper prescription of antibiotics including but not limited to uncertainty or failure of making definite diagnosis, lack of knowledge of adverse reactions, over-prescription, self-medication, and lack of time for immediate treatment (convenience) or inability to find out the causative agent.[17-21]

The rationale behind carrying out this preliminary study is the increasing number of dental patients who are unnecessarily prescribed antibiotics.

In developed countries, not a single dose of antibiotics can be obtained without prescription, whereas in developing countries, including Middle East region, except narcotics, most of drugs including antibiotics are obtainable without prescription from any community pharmacy.

Despite of the available reports on the rationale use of antibiotics by the practicing dental surgeons in Saudi Arabia, the available information are still inadequate. Therefore, our objectives are to explore the knowledge and attitude of the dental surgeons practicing in Hail towards antibiotic therapy and its resistance.

2. Methodology

The study has obtained approval from the Research Ethics Committee, University of Hail, reference No.(H-2016-051).

In the current study, a validated self-administered questionnaire used by Alkhabuli et al.[22] in a similar study was utilized to collect information from the practicing dental surgeons in district of Hail, Saudi Arabia. A hundred and fifty questionnaires were printed and distributed randomly to the practicing dentists including general dental practitioners (GDPs), specialists and consultants working in various sectors, such as government hospitals, private clinics and dental centers and were recollected after 10 days. In addition to the demographic information, the questionnaire inquired about the clinical and non-clinical parameters including symptoms and treatment modalities related to their patients, which dictates the dental practitioner's decision of prescribing antibiotics.

The practitioners were asked how would they assess the various clinical signs and symptoms such as pain, fever, swelling, limitation of mouth opening, difficulty in swallowing and closure of eyes due to swelling in prescribing antibiotics.

Dental surgeons may prescribe antibiotics for conditions other than infection, just to mention few, delay of treatment, convenience, social background and prevention of post-operative complications.

Moreover, the participants were requested to provide their opinion and judgment about prescribing antibiotics for specific clinical conditions, such as acute and chronic pulp diseases related to dental caries, gingivitis, periodontal abscesses, routine extraction and surgical extraction as well as tooth replantation and trismus.

The questionnaire also investigated the favored antibiotics by the dental surgeons in cases of cellulitis, periapical infection, pericoronitis, apicectomy, trismus and other dental infections. The suggested antibiotics were amoxicillin, amoxicillin-clavulanate (such as Augmentin), erythromycin, metronidazole, tetracycline and cephalosporin. In addition, the study sought the participants' opinion about the factors contributing to development of antibiotics resistance. These factors are the wide use of antibiotics particularly the broad-spectrum antibiotics, poor access to culture and sensitivity

tests, inappropriate duration, lack of guidelines and patients' demand and expectations.
In this study, all descriptive data were projected as frequencies and percentages and compared using chi-squared test, while quantitative data were presented as means and standard deviations (SD) and compared using t-test.

3. Results

A hundred and one completed questionnaires were considered valid. Any questionnaire with missing or insufficient data were excluded. The response rate was 67%. Males represented 85.1% of the respondents, while females represented 14.9%. The demographic and professional characteristics of the respondents are shown in Table 1. Most of the participants were general practitioners or interns (66.3%), specialists (30.7%) and only a few were consultants (3%). Nearly 60% of the participants practiced dentistry for more than 5 years.
Indications for antibiotic prescription in relation to the clinical signs and symptoms and general considerations by the practicing dental surgeons are demonstrated in Table 2. Most of the dental practitioners would prescribe antibiotics if there is a sign of fever (86.1%), swelling causing eye closure (90.1%) or diffuse swelling (75.2%).
A considerable percentage would prescribe antibiotics for a localized fluctuant swelling (55.4%). Patients presented with difficulty in swallowing would be given antibiotics by 56.4% of the participant dental surgeons. A significant percentage (52.2%) of dental practitioners would prescribe antibiotics postoperatively to prevent potential complications. In cases where the diagnosis is inconclusive or a decision to postpone the treatment has been taken, 44.6% and 75.2% of the participants would prescribe antibiotics respectively.
Table 3 demonstrates the patterns of antibiotic prescription by the participants for the clinically diagnosed conditions. The table reveals diverse variation among the respondents. The respondents would consider antibiotic therapy for pericoronitis, cellulitis and trismus by 68.3%, 89.1% and 40.6% respectively. A large percentage of the respondents (73.4%) would still prescribe antibiotics for surgical extraction, whereas 34.7% of the respondents would consider the same for routine extraction. Treatment of dry socket by antibiotics is a choice of 48.5% of the respondents. Acute periapical infection and acute pulpitis both are considered for antibiotic therapy by 57.4% and 38.6% of the respondents, respectively.
Dental infection may be manifested as maxillary sinusitis. About 67% of the dental professionals would prescribe antibiotics for such conditions. Substantial percentages of dental surgeons (70.3%) and (60.4%) would use antibiotics in treatment of periodontal abscesses and ulcerative gingivitis, respectively. Nearly 52% of the respondents are inclined to use antibiotics in treatment of chronic periodontitis. About 89% of the respondents would prescribe antibiotics for cellulitis and 68.3% for pericoronitis cases. Patients with trismus would be prescribed antibiotics by approximately 41% of the dental surgeons. Post root canal treatment apical surgeries are common procedures. Antibiotic therapy is considered for apicectomy by 65.3% of the respondents. A considerable percentage of dental surgeons (61.4%) would prescribe antibiotics for root canal surgery postoperatively, whereas 41.6% would do the same preoperatively.
Less than 24% of the dental surgeons would probably prescribe antibiotics for scaling and polishing, direct pulp capping and indirect pulp capping cases. Antibiotic therapy is considered by 56.4% of the respondents in case of teeth replantation.
Table 4 indicates the motivation for using certain antibiotics in treatment of specific clinical conditions. Out of the 6 listed antibiotics, amoxicillin remains the drug of choice in management of all clinical conditions. Probably, amoxicillin-clavulanate is the second drug of choice after amoxicillin in treatment of cellulitis. The respondents are not inclined to use a combination of antibiotics in their routine dental treatments. The table shows that tetracycline and cephalosporins were scarcely prescribed by the dental surgeons.
The study has assessed the dental practitioners' opinions regarding the contributing factors in development of antibiotic resistance (Fig. 1). More than 65% of the respondents thought that wide spread use of antibiotics is a very important contributing factor in development of antibiotic resistance. Inappropriate antibiotic course duration was rated as the second among the very important contributing factors.
Moreover, about 52% of the respondents thought that use of broad spectrum antibiotics and lack of

Table 1. Demographic and professional characteristics of practicing dental practitioners.

Variable	n (%)
Gender:	
Male	86 (85.1)
Female	15 (14.9)
Age (years):	
20-29	28 (27.7)
30-39	35 (34.7)
40-49	32 (31.7)
50-59	06 (05.9)
Professional rank:	
General practitioner/Intern	67 (66.3)
Specialist	31 (30.7)
Consultant	03 (03.0)
Years in practice:	
< 5 years	41 (40.6)
> 5 years	60 (59.4)

Table 2. Antibiotic prescription patterns among dental practitioners for selected clinical signs, symptoms and general considerations.

Conditions	Number of dental practitioners (%) who responded "yes"
Elevated temperature + evidence of systemic spread	87 (86.1)
Localized fluctuant swelling	56 (55.4)
Gross or diffused swelling	76 (75.2)
Unrestricted mouth opening	39 (38.6)
Difficulty in swallowing	57 (56.4)
Closure of the eye due to swelling	91 (90.1)
Convenience (e.g. prophylaxis against foreseen complication, patient's demand)	45 (44.6)
Patient's social background (e.g. patient's economic condition, expectations, occupation etc.)	38 (37.6)
Prevention of post-operative complication	76 (75.2)
Delay of treatment	35 (34.7)
Uncertain diagnosis	26 (25.7)

prescribing guidelines are no less of significance. Nearly 36% of the respondents thought that antibiotic brand promotion by the pharmaceutical companies is an important contributing factor in antibiotic resistance development. About 27% of the practicing dental surgeons thought prescribing antibiotics on patients' demand is of less or no significance in development of antibiotic resistance.

4. Discussion

Antibiotic overuse among dental practitioners is a global concern and it seems progressing rapidly causing problems to the health care and community settings.

Unfortunately, many practitioners are still prescribing antibiotics inappropriately and indiscriminately for no valid cause.[25] Most of the conditions presented to the dentist are primarily due to inflammation of the pulp causing pain and discomfort. Thus, these conditions are treated by local intervention rather than prescribing antibiotics. The use of antibiotic in cases of chronic inflammatory periodontitis per se is also not indicated. Generally, systemic antimicrobial therapy should be reserved for conditions where the debridement is difficult to achieve or where there is a sign of local spread, and for patients suffering from systemic debilitating illnesses.

Although, similar studies have been conducted in Saudi Arabia,[26-28] Hail district was not explored. It is worth to further investigate and find out the changes in the antimicrobial therapy trends among dental practitioners.

In the current study, only approximately 15% were females and this probably reflects the predominance of males in this profession.

A substantial percentage of the surveyed candidates were general practitioners or interns and these are the main dental working force in the community. Almost 60% of the respondents have experience more than 5 years. Nevertheless, long experience is not necessarily associated with updated knowledge on antibiotic therapy. Alkhabuli et al.[22] found that the practitioners with less than 5 years' experience had better knowledge on antibiotic and prescribing guidelines compared to those practicing for more than 5 years.

In principle, elimination of source of infection is the primary approach for any odontogenic infection. Therefore, where possible, incision and drainage of abscesses should be instituted immediately and antibiotics are basically adjunct and prescribed in the light of the presented clinical signs and symptoms.

Fever is a response of the host defense against microbial invasion, which further instigate an immune reaction. About 86% of the participants would prescribe antibiotics for patients presented with elevated temperature. These figures are in line with the previous regional studies.[20,29,30] Facial cellulitis, commonly associated with periapical infection spread that may extend beyond midface causing eye closure is obviously another condition which mandates use of antibiotics. Over 90% of the surveyed practitioners are aware of the seriousness of the condition and the need for immediate antibiotics cover. In fact, the previous two conditions represent fundamental bases of infection spread and its sequel, which are known to all medical professionals. Therefore, lower percentages of agreement would be unacceptable. In contrast, it is alarming to see significant percentages of practicing dentists who would still prescribe antibiotics if they were unconfident of the diagnosis or on patients' request. This tendency of antibiotic abuse is not uncommon and well documented.[20,29] Such practices of antibiotic abuse are unjustified and the dental surgeons should be aware of the unforeseen effects on long run.

It seems to be that management of localized fluctuant swelling is still confusing among dental practitioners including specialists. Although, primarily drainage of such abscesses is what is needed, over 55% of the respondents tend to prescribe antibiotics. However, no differences were

Table 3. Clinically diagnosed conditions for which dental practitioners would prescribe antibiotics.

Conditions for antibiotic prescription	Number of dental practitioners (%) who responded "yes"
Acute Pulpitis	39 (38.6)
Acute periapical infection	58 (57.4)
Chronic infection	63 (62.4)
Periodontal abscess	71 (70.3)
Acute ulcerative gingivitis	61 (60.4)
Chronic marginal gingivitis	34 (33.7)
Chronic periodontitis	52 (51.5)
Pericoronitis	69 (68.3)
Cellulitis	90 (89.1)
Sinusitis	68 (67.3)
Dry socket	49 (48.5)
Trismus	41 (40.6)
Routine extraction	35 (34.7)
Surgical extraction	74 (73.3)
Apicectomy	66 (65.3)
Root canal surgery pre-operative	42 (41.6)
Root canal surgery post-operative	62 (61.4)
Scaling and polishing	24 (23.8)
Restorative treatment (fillings with composite, etc.)	24 (23.8)
Replantation of teeth	57 (56.4)
Deep caries without pulpal involvement (indirect pulp capping)	20 (19.8)
Direct pulp capping	17 (16.8)

found between the specialists and the general practitioners in prescription patterns of antibiotic therapy for this condition.

Difficulty in swallowing and mouth opening restriction are common signs of fascial spaces infection and spread and may end up with serious complications. About 56.4% would prescribe antibiotics for cases associated with difficulty in swallowing. In other regions of the world, probably the dental surgeons are more aware of these conditions thus higher percentages were noticed.[22,31]

Fascial spaces are poorly vascularized and antibiotics may not reach the deepest zone of the infection. Consequently, these conditions require thorough surgical intervention as sole antibiotic therapy is unlikely to clear the infection.

Unfortunately, antibiotic is still injudiciously prescribed. It seems that around 45% of the dental surgeons would prescribe antibiotic for cases where definitive diagnosis could not be made. Surprisingly, such unjustified antibiotic prescription has been reported in developed countries survey as high as in our study, and in countries where the use of drugs is much better controlled.[31,32] Nevertheless, a recent survey from the United Arab Emirates revealed much lower percentage (16.6%).[22] In the current study, almost 45% of the respondents are likely to dispose their patients under antibiotic cover if the treatment could not be completed or differed. Obviously, this is unethical and unjustified approach.

It is a common practice to see dental surgeons prescribing antibiotic post-operatively to prevent unanticipated complication. Although this remains baseless, a substantial percentage of the surveyed candidates (75.2%) would cover their patients with antibiotics after surgical procedure. More specifically, patients undergoing apicectomy procedure for example would be prescribed antibiotics by 65% of the dental practitioners. In fact, if the procedure is performed under aseptic and atraumatic condition infection of the oral soft tissues as a complication is seldom. A comparative study of clindamycin prophylaxis and placebo in prevention of postoperative infection in endodontic surgical procedures showed no differences.[33]

Surgical extraction of impacted teeth is invariably followed by a course of antibiotics. Salako et al.[20] reported that as high as 89.3% of the respondents would prescribe antibiotics for surgical extraction. In the current survey, the percentage is to some extent comparable (73.4%). There has been long contentious discussion about the benefits of using antibiotics postoperatively. Recent studies deemed use of antibiotics in post-surgical extraction unnecessary.[34,35] In another study by Lodi et al.[36] despite no differences were found between antibiotics and placebo surgical extraction groups

Table 4. Preferred antibiotics for selected clinical conditions by dental practitioners

	Number of dental practitioners (%) who preferred one or more of the antibiotics mentioned in the received questionnaire						
Conditions	Amoxicillin	Amoxicillin-clavulanate	Erythromycin	Metronidazole	Tetracycline	Cephalosporins	More than one antibiotic
Periapical infections without penicillin allergy	54 (53.5)	27 (26.7)	14 (13.9)	6 (5.9)	0 (0)	0 (0)	0 (0)
Dental infections without penicillin allergy	62 (61.4)	23 (22.8)	12 (11.9)	3 (3.0)	1 (1.0)	0 (0)	0 (0)
Pericoronitis	36 (65.6)	25 (24.8)	19 (18.8)	18 (17.8)	0 (0)	3 (3.0)	0 (0)
Cellulitis	46 (45.5)	36 (35.6)	6 (5.6)	6 (5.6)	1 (1.0)	6 (5.9)	0 (0)
Apicectomy	61 (60.4)	26 (25.7)	9 (8.9)	3 (3.0)	2 (2.0)	0 (0)	0 (0)
Trismus	56 (55.4)	23 (22.8)	14 (13.9)	2 (2.0)	4 (4.0)	2 (2.0)	0 (0)

in terms of swelling, trismus or fever outcomes, the authors thought a small percentage may be benefited from antibiotics. However, antibiotics are encouraged for patients undergoing contaminated, long-duration surgery.[37]

Etiology of alveolar osteitis, also known as dry socket, is multifactorial in origin and its incidence is low.[38,39] Nearly 49% of the respondents would prescribe antibiotics to patients suffering from dry socket. There is no sound evidence to support the notion that dry socket is a complication caused by infection, therefore, antibiotics are of no value in curing the condition.[40]

A quite sensible percentage (56.4%) of dental practitioners would prescribe antibiotics for replantation of teeth. Systemic use of antibiotics for such conditions has been questioned and the clinical studies do not recommend such regime, as no value was achieved. Nevertheless, immersing the avulsed teeth in antibiotic solution, such as tetracycline has been advocated. Experimental studies however, revealed some positive benefits and this is the reason behind its current recommendation by the scholars of dental traumatology.[41,42]

The most worrying malpractice is the unjustified overuse of antibiotics in conditions related to pulp pathology. The only therapy needed for these cases is local clinical intervention. In periodontal conditions, except those associated with abscess, most of the cases require local management. A percentage like 52% of the respondents who are motivated to prescribe antibiotics for chronic periodontitis cannot be underestimated. On the other hand, consideration of antibiotic therapy for pericoronitis by 68.3% is acceptable. Nonetheless, mild to moderate pericoronitis without signs of spread can be treated effectively by normal saline irrigation avoiding systemic antibiotic therapy. Necrotizing ulcerative gingivitis is caused by anaerobic microorganisms and warrants specific antibiotic therapy. About 64.4% of the dental practitioners would prescribe antibiotics treatment of such conditions, though the management should emphasize on local debridement and antimicrobial mouth rinses, and systemic antibiotics should be reserved for cases associated with signs and symptoms of infection spread.

Antibiotic therapy for odontogenic sinusitis was considered by 67% of the dental practitioners. Because of the vicinity of upper apices of posterior teeth to the floor of maxillary sinus, there is no doubt of potential odontogenic infection spread. However, diagnosis of such cases needs to be meticulous to avoid unnecessary or overuse of antibiotics.

Cellulitis is a serious acute condition and warrants systemic antibiotic. As nearly as 90% of dental practitioners would prescribe systemic antibiotics to avoid further complications. Trismus is the hallmark of a masticatory space infection or infection in the anterior compartment of lateral pharyngeal space and about 41% of the respondents opted to prescribe antibiotics. Both cellulitis and sever trismus are considered as serious medical conditions, therefore, proper diagnosis and management including referrals are crucial.

On the other hand, it is very painful to see a considerable percentage (34.7%) of the surveyed dental surgeons would still prescribe antibiotics for normal extraction, acute periapical infection (57.4%) and for acute pulpitis (38.6%). These conditions need immediate intervention rather than systemic antibiotic therapy. Many dental surgeons believe that antibiotics reduces acute pulpal pain. Nevertheless, there is insufficient evidence to support this concept.[43] Use of antibiotics for various apical pathology are still high and would be considered by more than 60% of the respondents. The available evidence does not provide clinicians with reliable and proper guidelines for treating periapical lesions,[44] therefore, use of antibiotics in such conditions is questionable.

Unfortunately, many dental practitioners would still prescribe antibiotics for simple dental procedures;, such as restorative treatment, pulp capping, scaling and polishing, and the current percentages are higher compared to those reported by Alkhabuli et al.[22]

When a question regarding antibiotic preference

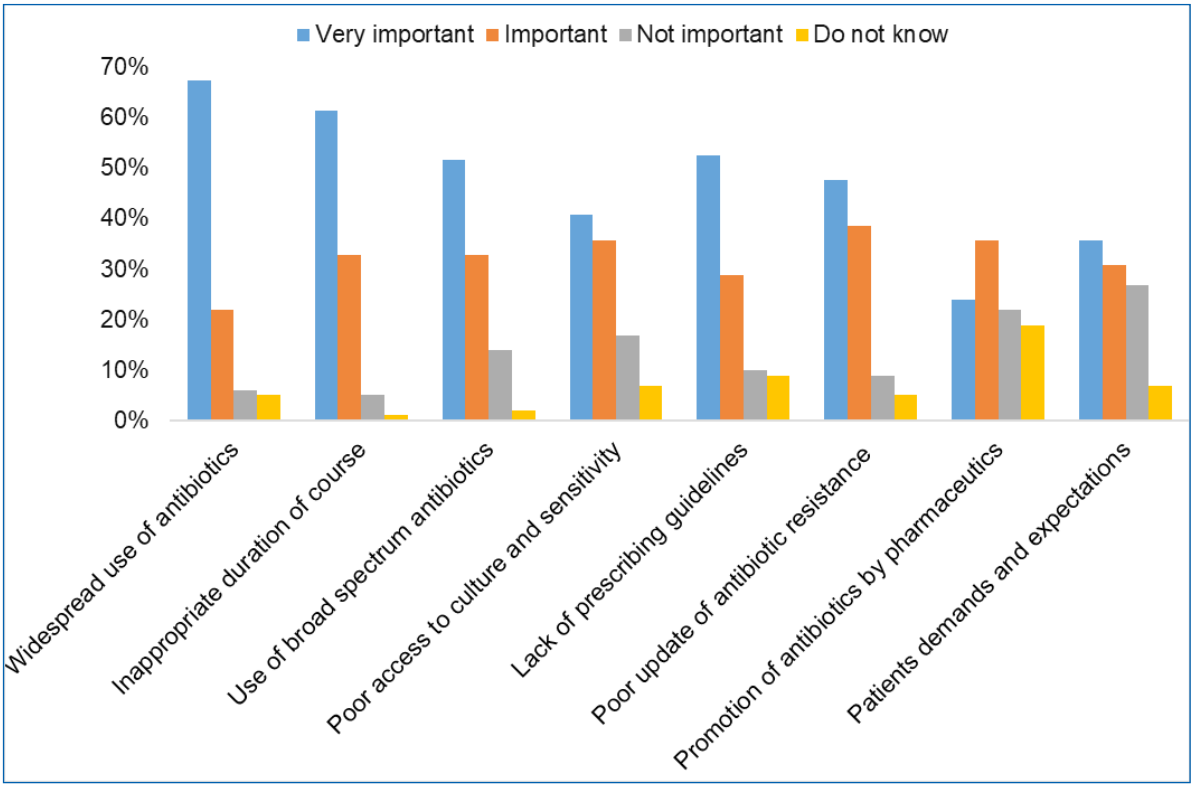

Figure 1. Percentages of dental practitioners' assessment of factors contributing to antibiotic resistance.

was raised, amoxicillin remained the most commonly used antibiotic in treatment of odontogenic infection for non-penicillin allergic patients (Table 4). Amoxicillin-clavulanate was the second drug of choice after amoxicillin, particularly in treatment of cellulitis. Clindamycin is also a good alternative drug for penicillin allergic individuals. In this study, erythromycin would barely be prescribed by the dental surgeons.

The predominant microorganisms involved in odontogenic infections are the viridans streptococci and the anaerobic bacteria, such as: *Prevotella*, *Peptostreptococcus*, *Porphyromonas* and *Fusobacterium*. Some recent studies demonstrated that many oral bacterial isolates showed resistance to erythromycin and questioned the benefit of this antibiotic in the treatment of severe orofacial infection.[45] Some authors believe that erythromycin is a historical antimicrobial drug in treatment of odontogenic infections and no more exists on the list of the antibiotics to be prescribed for such infections.[46]

Metronidazole is one of the drugs of choice in treatment of pericoronitis, however, only 18% of the practitioners would recommend its use and a similar percentage was reported by Salako et al.[20] Metronidazole is only effective against anaerobes. Therefore, it should be used in infections where anaerobic strains are expected.[47]

Tetracycline and cephalosporins were the least prescribed antimicrobials. Cephalosporins are not the first-line of treatment of odontogenic infection.[46]

Therapy with more than one antibiotic is not uncommon, particularly in treatment of periapical infection, cellulitis and trismus cases. Odontogenic infection is mostly a mixture of facultative and anaerobic microorganisms. Therefore, combination of antibiotics is advocated in certain conditions.

Most of the antibiotics used by the dental practitioners are broad spectrum in nature and this enhances the prevalence of antibiotic resistance. It is interesting to see that some dental practitioners, Norwegian dentists for example, rely on narrow spectrum antibiotics and their prescription is conservative and relatively low compared to physicians.[48]

Antimicrobials drug resistance is a critical issue for dental professionals. Out of the eight-listed potential contributing factors, widespread use of antibiotics was rated as the most important factor in developing antibiotic resistance (65%). This is followed by the inappropriate duration of antibiotic course and use of broad spectrum antibiotics in order. More than 50% of the respondents thought lack of prescribing guidelines is another significant factor. Despite the inconsistency, recently several guidelines have been published,[49-52] but lack of follow up and updates by the dental practitioners is unfortunately the prevailing scenario.

About 41% of the surveyed dental surgeons thought poor access to culture and sensitivity test is another factor. Dental clinics rarely send samples from patients to microbiological laboratory for cultures and antimicrobial susceptibility testing. However, a vast recent retrospective study of odontogenic infections revealed no significant change in the microbiological picture over the last 3-4 decades,[53] and therefore, the current

antibiotic therapy regimes are adequate to clear such infections. However, it should be beard in mind that in cases presented with severe infections threatening life and vital structures, cultures and antibiotic susceptibility testing should be performed.

The practitioners also thought that the other factors, such as antibiotic promotion by manufacturer companies and patients' demand and expectation play role in the problem and should not be taken lightly.

5. Conclusion

The current survey of the dental practitioners of Hail district, Saudi Arabia, reveals moderate level of knowledge towards the use of antibiotics and development bacterial resistance. The dental professionals' responses demonstrate variation in the rational prescription of antibiotics for various dental conditions, indicating the lack of compliance with the general antibiotic guidelines and good practices. For all dental conditions amoxicillin remained the most commonly prescribed drug. Widespread of antibiotic use and inappropriate duration of course were thought the most important contributing factors in development of antibiotic resistance. Statistically, there were no differences in antibiotic prescription by practitioners' qualification or gender.

Development of antibiotic resistance is a worldwide problem and the dental professionals are accountable for a substantial stake in this conundrum. Therefore, there is a lot of effort awaited from the dental community to increase the awareness of antibiotic resistance problem and reduce the burden.

Author contributions

Equal contribution to the paper.

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Questions

The National Center for Disease Control and Prevention found that many of the out-patient antibiotic prescriptions are unnecessary. What is this percentage?

❑a. 1/4;
❑b. 2/3;
❑c. 1/2;
❑d. 1/3.

What is the percentage of antibiotic prescription in cases where definitive diagnosis could not be made?

❑a. 45%;
❑b. 55%;
❑c. 35%;
❑d. 25%.

Which of the following statements is FALSE?

❑a. Most of the antibiotics used are broad spectrum;
❑b. Antibiotics are of no value in dry socket treatment;
❑c. Post-surgical extraction antibiotic cover is essential;
❑d. Use of antibiotic in treatment of periapical pathology is baseless.

The most contributing factor in development of antibiotic resistance is the:

❑a. Self-antibiotic medication;
❑b. Widespread use of antibiotics;
❑c. Lack of prescription guidelines;
❑d. Poor access to culture and sensitivity test.

IMPACTION OF TEETH - FREQUENCY AND MOST OFTEN USED TREATMENT PROTOCOLS

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ABSTRACT

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Introduction: Tooth impaction is a biological phenomenon that can affect every tooth group, but most often third molars, canines and second premolars.
Methodology: The aim of our survey is to find out the prevalence of impacted teeth in different tooth groups. Another aim is to prove the following hypothesis, namely that there is a relationship between impaction teeth and treatment protocols using the method of distalization of the upper molars with the Pendulum appliance and also releasing space in the arc by the extraction of permanent teeth. The study analyzed 182 patients diagnosed with impacted teeth and excluded patients with impacted third molars. The analysis used the statistics packet SPSS version 13.0.
Results: The most common impacted teeth are the upper canines - 137 teeth, followed by upper second premolars - 50 teeth, the lower second premolars - 27 teeth, the lower canine - 20 teeth, the lower second molar - 11 teeth, the upper central incisor - 8 teeth, the lower lateral incisor - 3. Significant statistical relations were found between tooth agenesis, odonthoma collections and tooth transposition with impaction. Patients in the early growth period stand a better chance not to undergo non-extraction treatment than those for whom the formation of the constant dentition has been finalized and who have passed the peak of their puberty growth.
Conclusion: The early diagnosis of the problem is an important factor for a successful treatment. The growth potential of the patient is the leading factor that supports the processes.
Keywords: impaction teeth, tooth agenesis, tooth transposition, odontoma.

1. Introduction

Tooth impaction is a biological phenomenon that can affect every tooth group. Impaction is the process of tooth retention in the bone after its period of eruption and even a change in its position and location. The space for the impacted teeth in the dental arch is often small and even missing. This is the reason why teeth move and what most often occurs is mesial movement of the posterior teeth. The incisive point is mismatched to the middle line. There are also tooth discrepancies in the opposite side of the impacted tooth. Tooth eruption itself is a sequence of biological processes that are largely genetically guided and changed by the action of external factors. The reasons for impaction are researched by many authors. Here are some of them: genetic influence (enamel hypoplasia, aplasia of the second premolars, peg-shaped lateral incisors or their absence and others),[1] supernumerary teeth, changed position or shape of the roots of adjacent teeth (dilacerations), odonthoma collections, lack of space, crowding of the adjacent teeth, persistent or ankylosed primary teeth, cysts or bone formations that are obstacles to the eruption path, clefts and syndromes, bone or root resorption process, childhood traumas and others.[2]

Impaction diagnosis is based on clinical and x-ray examination. Orthodontic examinations are usually supported by 2D X-ray images. In case impaction is observed, a CBCT is assigned. There are a lot of prognosis methods[3,4,5,6] techniques and factors for the probability of impactions of canines[7] which allow early prognosis and assessment. One of the factors for a successful treatment is the age of the patients. The management of the treatment[8,9] of an impacted tooth should go as follows: localization of the impacted tooth according to the planes (vestibule-oral, and central alveolar position of the germ), depth in the bone, prognosis for surgical access and technique. In case of cysts and other collections, what comes first is to determine the urgency of the case and whether orthodontic or surgical treatment is necessary. With respect to shaping and space gaining for the impacted teeth, the following solutions are possible: alignment of the teeth and space distribution; space gaining due to transversal expansion, distal movement, teeth proclination or slenderizing; space gaining due to tooth extraction; surgical exposure and orthodontic traction of the impacted tooth; finishing and retention of the case.

The treatment plan often includes the extraction of the impacted canine. This decision is taken after assessing

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Table 1. Relationship between retention and other dental phenomena.

Index		Patients without impacted teeth	Patients with impacted teeth	Total	p
Patients without	N	1405	175	1580	
supernumerary teeth	%	98,8	96,2	98,5	
Patients with	N	17	7	24	
supernumerary teeth	%	1,2	3,8	1,5	0,014
Patients without	N	1420	177	1597	
Odonthoma	%	99,9	97,3	99,6	
Patients with	N	2	5	7	
Odonthoma	%	0,1	2,7	0,4	<0,001
Patients without	N	1413	177	1590	
transpositions	%	99,4	97,3	99,1	
Patients with	N	9	5	14	
transpositions	%	0,6	2,7	0,9	0,015
Patients without	N	1400	176	1576	
cysts	%	98,5	96,7	98,3	
Patients with	N	22	6	28	
cysts	%	1,5	3,3	1,7	0,122
Patients without	N	1395	176	1571	
microdontia	%	98,1	96,7	97,9	
Patients with	N	27	6	33	
microdontia	%	1,9	3,3	2,1	0,259
	N	1422	182	1604	
Total	%	100,0	100,0	100,0	

its localization and coherence with the neighboring compact structures (ankylosis zone, compacta of the sinus wall et cetera.). The treatment procedure can continue with the transplantation of the canine in the alveolar rugae or placing an implant[10]. This problem is frequently met among modern patients and many authors report similar occurrence percentages.

2. Materials and methods

2.1. Aim. The aim of our survey is to find out the prevalence of impacted teeth, which tooth group is most likely to be affected, gender ratio, multiple impaction and the relation among them as well as to find out if the hypothesis that there is a relation between the treatment protocol and the group of impacted tooth holds true.

2.2. Material and methods. We analyzed the documentation (clinical and X-ray) of 182 patients treated in our practice for the last 8 years. These 182 patients have been selected out of all 1604 patients. They are patients diagnosed with impaction of various tooth groups, while the excluded patients cover the group with impacted third molars. The average patient age is 14.7±3.5 years, this youngest patient being 9 years old and the oldest 32 years old. The gender ratio is the following: 62 males (14.4±3.1 years) and 120 females (14.8±3.7 years), which means male/female - ½ or 34.1% males and 65.9% females.

Three clinical protocols have been used in the treatment of these patients:

The first group - in the area reserved for the impacted tooth in the tooth arc, the supporting teeth are leveled, the impacted tooth is exposed surgically and then it is orthodontically puled out and the inserted one is positioned on its place in the tooth arc.

The second group - if there is lack of space in the upper tooth arch, the first step is to create space by distalization of the upper molars using the Pendulum appliance. After insuring the space, the protocol of group one is used.

Third group – if there is a lack of creating a space using the conservative means in the tooth arch, the impacted or the neighboring tooth of the arch is extracted in order to open the space and then protocol one is applied, or after the extraction of the impacted tooth, the arch is level and the occlusion is normalized without it.

In our study, we compare the second and third group treatments because for the first group routine treatments have been used, which do not require individual approach. Patients with impacted teeth and a reserved space for them in the dental arch are rarely found.

To process the data we used the special statistics packet SPSS version 13.0 was used. The critical level of significance of $\alpha = 0.05$ was used. The relevant zero hypotheses are rejected when P value is lower than α. The used Chi-square test or Fisher's exact test were used to analyze the relation between the categorical data. Independent Samples T-test were used when the distribution is normal for the variable researched. The one-Sample Kolmogorov-Smirnov test was used to check the frequency distribution.

3. Results.

The most common impacted teeth are the upper canines, namely 137 teeth (68 – 37.9% in the right and 69 – 37.4% in left) followed by the upper second premolars – 50 teeth (25 – 13.7% in right and 25 – 13.7% in left), then the lower second premolars 27 teeth (6 – 3.3% in the right and 21 – 11.5%), the lower canine 20 teeth (10 – 5.5% on the right and 10 - 5.5% on the left), the lower second molar – 11 teeth

(4 – 2.2% on the right and 7 – 3.8% on the left), the upper central incisor – 8 teeth (4 – 2.2% on the right and 4 – 2.2% on the left), the lower lateral incisor 3 - 1.6% cases on the left. We observed single cases of impacted upper lateral incisors, lower first molar and upper second molar. The impaction of a single tooth is observed in 117 (64.3%) of the patients. The impaction of two teeth we observed in 56 (30.8%), the impaction of three teeth in 5 (2.7%), the impaction of four teeth in 3 cases (1.6%), the impaction of 5 teeth in one case (0.5%).

The impaction of two teeth in the dentition is most often observed as a combination of the upper left and right canine , 24 cases (13.2%). The analysis showed 11 (6%) cases with impacted upper left and right premolars, four cases (2.2%) of impacted lower second premolars, three cases (1.6%) with both upper and lower canines impacted. The impaction of both of the lower canines is observed in 2 (1.1%) cases and impaction of the second premolars in 4 cases (2.2%). Four patients (2.2%) have one upper and one lower impacted canine. The following rare clinical cases were diagnosed and treated: unilateral impaction in the upper jaw of the canine and central incisor; canine and second premolar; canine and second molar in the lower jaw, two upper central incisors. An impaction of the upper teeth 132 (72.5%) is most likely to occur rather than of the lower teeth 36 (19.8%). The impaction in both jaws is observed in 14 (7.7%) patients. The distribution of the impacted teeth in the left part 72 (39.6%) and in the right part 55 (30.2%) is without any significant statistical difference as well as the mixed impaction on both sides 55 (30.2%) of the patients.

The statistical data show that the problem is observed most often in permanent (163 - 89.6%) rather than in the mixed dentition (19 -10.4%). If patients are classified in groups: out of the 9 -13 year olds (developing of the permanent dentition), there are 71 patients (39%) included. In the14 - 17 year old group (the age of bone growth), there are 82 (45.1%) patients included. In the 18 -21 years old group (the group of young adults), there are 26 (14.3%) patients included. In 21+ years old group there are 3 (1.6%) patients.

The hypothesis of the dependence between the impaction of teeth and other orthodontic phenomena and deformations was also studied. Fisher's exact test allowed the detection of a statistically significant relation between tooth agenesis and impaction for p=0.014. A relation between odonthoma collections and impaction has also been identified. Another orthodontic problem, which was related to impaction was tooth transposition for p=0.015. The results are shown in Table 1.

Another hypothesis studied is related to the management of the orthodontic treatment itself in patients with impacted teeth and then in the area with the freed up space for extrusion and arrangement of an impacted tooth in the dental arch. The study tried to see if there is a relationship when the treatment used the method of distalization of the upper molars with the Pendulum appliance and also released space in the arc by the extraction of permanent teeth (Table 2). What was also reviewed was the linkage between the numbers of extractions when treating patients with impacted and non - impacted teeth.

The link is statistically significant (p=0.035) in both groups of patients. With the patients without impacted teeth, the extraction percentage of treatments is 11.88%, while with those with impacted teeth 10 (98%). These are roughly similar values. The table clearly shows that most often symmetrical extractions of two or four teeth are conducted, which is a principle for maintaining good occlusal proportions and symmetry. A statistically significant

Table 2. Relationship between the treatment of impacted teeth and the treatment approach for distalization of the upper molars by the Pendulum appliance or by tooth extraction.

Extraction treatment: acc. to the number of the extracted teeth		Patients with non-impacted teeth	Patients with impacted teeth	Total	p
	N	1253	162	1415	
Without extraction	%	88.1%	89.0%	88.2%	
	N	14	2	16	
With extraction of 1	%	1.0%	1.1%	1.0%	
	N	53	13	66	
With extraction of 2	%	3.7%	7.1%	4.1%	
	N	12	1	13	
With extraction of 3	%	0.8%	0.5%	0.8%	
	N	90	4	94	
With extraction of 4	%	6.3%	2.2%	5.9%	
	N	1422	182	1604	
Total	%	100.0%	100.0%	100.0%	0.035
Patients non treated	N	1187	140	1327	
with Pendulum	%	83.5%	76.9%	82.7%	
Patients treated	N	235	42	277	
with Pendulum	%	16.5%	23.1%	17.3%	
	N	1422	182	1604	
Total	%	100.0%	100.0%	100.0%	0.028

Table 3. Relationship of the treatment of the impacted upper canines or second premolars and their dependence on the treatment plan with distalization of the upper molars using the Pendulum appliance.

		Treatment type			
Teeth	**Statistic**	**Non-tretated by Pendulum**	**Tretated by Pendulum**	**Total**	**p**
Impacted teeth without	N	61	13	74	
upper canines	%	43.6	31.0	40.7	
Uni- and by-lateraly	N	79	29	108	0.144
impacted upper canines	%	56.4	69.0	59.3	
	N	140	42	182	
Total	%	100.0	100.0	100.0	0.005
Impacted teeth without	N	118	27	145	
upper second molars	%	84.3	64.3	79.7	
Uni- and by-lateraly impacted	N	22	15	37	
upper second premolars	%	15.7	35.7	20.3	
	N	140	42	182	
Total	%	100.0	100.0	100.0	

relationship was found between the impacted teeth and the treatment by Pendulum. According to the findings, in 23.1% of the patients with impacted teeth we have used this method to achieve the necessary space in the upper jaw for the teeth alignment. In patients without impacted teeth the percentage is significantly lower - 16.5%.

Canines and second premolars are the most frequently impacted teeth in the upper jaw. That is why the analysis looked at which of them have been treated more often with the method of distalization of the upper molars (Table 3). The analysis was based on the use of the Chi-Square test which shows that in the upper jaw the unilateral and by-lateral form of retention of the upper canines are present in 79 patients and 29 of them are treated with the Pendulum appliance. The retention of the second premolars in the upper jaw was found in 22 patients. Fifteen of all patients were treated with Pendulum appliance.

The table presents statistically significant results. It creates the ground to say that distalization of the upper molars using the Pendulum appliance is a good and effective method to generate space in the arch and for the successful extrusion and introducing of the impacted or ectopic moved second premolars. There was no significant association found in the distalisation stage of the impacted upper canines during the treatment of the upper molars.

Reasonably, what could be raised is the question whether the age when the patient is diagnosed and treated is relevant to the choice of the treatment method. Therefore, we examined the hypothesis whether there is a correlation between the age when the treatment starts and the type of therapeutic approach used. The Independent Samples *t*-test used showed that the difference in age was statistically significant t (58)=2.64, p=0.011. (Table 4)

Patients in the early growth period have a better chance of Non-extraction treatment than those who have finished with the formation of the constant dentition and have passed the peak of their puberty growth. In the second category of patients the extraction therapeutic approach is applied more frequently.

There are greater opportunities in the distalization of the upper molars to include the second premolar tooth in an arc because of the open distal relocation site which coincides with the shortage of space in an impacted premolar. Such a therapeutic approach in an impacted canine is less successful because the location of the distal movement of the upper molars is opened in the area of the second premolars. To achieve space in the canines' zone what is necessary is the distal displacement of the two premolars, and this is associated with the loss of space in the bearing region and also at the molar area.

4. Discussion

Gisakis,[11] carried some research among the Greek in 2011 and found that in 82.7% of the patients with impaction there is related orthodontic deformation. All patients studied by us also have a concomitant orthodontic problem, most often its cause is impacted teeth. Gündüz[12] published a report on research carried out among the Turks in which he states that the prevalence of impacted teeth is 9.2% and the ratio male/female is 1:1.4. The upper canines are most likely to be impacted (71.5%) followed up by lower premolars (8.6%). Topkara et al.[13] researched orthodontic patients and found out that the canines are the most likely teeth to be affected by impaction (5.24%), followed by the lower second premolars (2.23%), the upper lower premolars (1.11%), lower canines (0.92%), molars (0.72%) and incisors (0.65%). Our findings show that the retention of the upper second premolar is second (27.4%) in frequency to the upper canines (75.3%). This result differs from the data of these authors, whose results show that second in frequency are the lower second premolars (our result – 14.8%). Clinically, this result can be explained by the higher frequency of the caries damage in the second temporary molars and the shorter time needed for medial movement of the upper first permanent molars. The Spee curve eases the medialization of the upper first permanent molar, while the more compact structure of the lower jaw slightly delays the medialization of the lower first permanent molar. That is why the second premolar

Table 4. Choice of the treatment approach and its relationship to the patient's age and growth period.

Treatment	N	Age				p
		Mean	SD	Min	Max	
Treated with Pendulum	42	13,4	3,6	9,0	29,0	
Treated with extractions	20	15,8	2,8	13,0	21,0	0.011

does not have enough space in the dental arch, which is a prerequisite for its retention. Celikoglu in 2010 reports prevalence of the impacted canines of 5.1% and transposition of canines of 0.3% which were impacted too. According to our findings 2.7% of the patients they had impaction teeth and transposition too. Gasymova[15] in 2014 found out prevalence of 12.53% of impacted teeth among the orthodontic treated patients. The treatment in these cases was done using low-frequency ultrasonic for their eruption stimulation. This is a treatment method that has not been used on our patients. Msgati et al.[16] found that the ratio among the male/female patients with impaction teeth is 1.2:1. Our study estimated that the male/female ratio is 1:2.

The hyperodontia and odonthoma collections are natural barriers in the path of the eruption of adjoining tooth germ and a prerequisite for the retention of teeth. Their detection is oftendone radiographically. Clinically, we often encounter the symptoms and signs suggestive of hyperodontia and odonthoma. They are the overdevelopment of the alveolar ridge in the area of the late tooth breakthrough tooth, diastemas or thremas, the dislocation of adjacent teeth, persistence of time teeth, and even the ectopic breakthrough of the tooth itself. These clinical findings are early signs to use the X-ray methods to diagnose problems and the transposition[17] of the hyperodontia.

Tooth impaction leads to disturbances in the harmony of the dental arch, occlusion and aesthetics. Often, the space for the impacted teeth in the dental arch is small and even missing. This is the reason why teeth move and what most often occurs is mesial movement of the posterior teeth. The incisive point is mismatched to the middle line. There are also tooth discrepancies in the opposite side of the impacted tooth.

5. Conclusion.

The early diagnosis of the problem is an important factor for the success of the treatment. There are conditions for the selection of treatment using options and techniques to change the dental arch in the transversal and sagittal direction. The growth potential of the patient is the leading factor that supports the processes, which makes this method not sufficiently effective in the treatment of the impacted upper canines, unlike the cases of impacted upper second premolars. One should not underestimate this treatment option that could be combined with other therapeutic methods and devices (protrusion, stripping) so that to achieve the necessary space for downloading and leveling of an impacted canine in the arch. These clinical techniques are preferable before extraction therapy in cases of patients with impacted teeth or without them.

Author contributions

Equal contribution to the paper.

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Questions

Which methods are used for the diagnostic of impacted teeth?

❑a. Clinical tests;
❑b. CBCT;
❑c. Anamnesis (Medical history);
❑d. Lab tests.

Which teeth are the most often impacted excluding the third molars?

❑a. Lower central incisors;
❑b. Upper first molars;
❑c. Lower first molars;
❑d. Upper canines.

Which other orthodontic problems accompanied the impaction of the upper canines?

❑a. Laterognatia;
❑b. Hypodontia of the upper incisor;
❑c. Progenia;
❑d. Diastema.

Using Pendulum appliance we achieve:

❑a. Provide support at extrusion of the impacted teeth;
❑b. Alignment of the dental arch;
❑c. Increasing the saggital size of the upper dental arch;
❑d. Retention after orthodontic treatment.

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PARTIAL CERAMIC CROWNS. ESTHETIC AND TISSUE CONSERVATIVE RESTORATIONS – PART I: POSTERIOR TEETH

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Background: Partial ceramic crowns (PCCs) are more tooth conservative and potentially less stressful for the periodontium than full coverage crowns and meet the esthetic demands of patients.
Objective: evidence shall be provided, if PCCs are a reliable treatment option, and under which conditions.
Data sources: this review is based on own published data and experiences and on a review of the literature.
Results: Longevity of PCCs is in the range of partial crowns from gold alloys. Failures due to chip fractures, bulk fractures, or debonding can be avoided/reduced by proper technique. Most clinical experience exists with leucite reinforced silicate or lithium disilicate ceramics, either pressed or CAD/CAM processed. Tooth preparation must respect the need for sufficient ceramic thickness of at least 1.5 mm. Residual buccal or oral cusps of less than 2 mm thickness should be included in the preparation. Cavity preparation should be defect oriented with few parallel walls as guidance for placement. Dual curing luting composites together with etch and rinse (E&R) adhesives are standard. Self-adhesive materials can be used but are sensitive to tooth desiccation before luting. Clinical experience with new universal adhesives is limited, but available results are promising. Light curing should be performed by applying 32 J/cm^2 from oral, buccal and occlusal aspects (silicate based ceramics).
Conclusions: PCCs are a reliable treatment option for extended defects in posterior teeth. Special guidelines must be followed including sufficient ceramic thickness and proper adhesive technique to avoid failures.
Keywords: partial crowns, ceramic, light curing, luting composite.

1. Introduction

Modern dentistry offers a large variety of different treatment modalities for large cavities in posterior teeth which need replacement of one or more cusps. Direct restorative techniques employing amalgam as well as resin-based composites in combination with the adhesive technique are increasingly being used in such cases on the one hand. However, on the other hand, the insertion of full crowns is still a well-recognized and widely-used procedure. Such full crowns are mainly fabricated either from gold alloys, non-precious metals, ceramics or combinations (metal ceramic crowns). Beside this, so-called partial crowns made from gold alloys have a long tradition as tooth tissue conservative alternative to full crowns, which also imply less stress on the adjacent periodontium.

Obviously, the esthetic properties of metallic partial crowns are not meeting our patients' high expectations in terms of virtually invisible (i.e. tooth colored) restorations. Therefore, it has been proposed to adopt the tissue conservative technique of metallic partial crowns to tooth colored materials, especially to ceramics, encouraging the fabrication of partial ceramic crowns (PCCs). PCCs would allow for a defect-oriented preparation and a tooth-colored restoration.

Fig. 1 shows a clinical case, where this technique was applied in a posterior tooth. Undoubtedly, the esthetics are pleasing. The question however is, if this is a reliable method, which can be recommended to the patients and what features have to be addressed in order to end up with a predictable treatment outcome. Here we describe our own experiences covering the recent 20 years and data from the literature adressing partial ceramic crowns in posterior teeth. In part II we concentrate on laminate veneers.

2. Definitions

A partial crown is defined as a restoration with partial

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Figure 1. Restoration of a molar with an insufficient amalgam restoration using a partial ceramic crown: a tooth conservative and esthetically pleasing restoration.

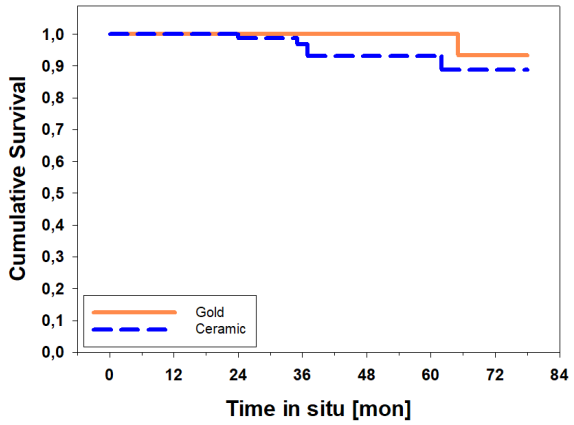

Figure 2. Survival rate (Kaplan Meier) of partial crowns from Vita Mark II feldspatic ceramic and from gold alloy after up to 5.5 years: no statistically significant difference (Federlin M, et al. Controlled, prospective clinical split-mouth study of cast gold vs. ceramic partial crowns: 5.5 year results. Am J Dent. 2010;23(3):161-167).

replacement of the clinical crown including part of the occlusal surface (at least one cusp) in posterior teeth. Other terms frequently used are "onlays", or "overlays". For the sake of simplicity, in this review we use the terms partial ceramic crowns, onlays and overlays synonymously. The term "table tops" is used for the singular replacement of occlusal surfaces; e.g. in teeth with extensive wear.[1] This method is not covered in this article.

3. Longevity

Ample experience mainly from retrospective studies exists with inlays from gold alloys with an excellent longevity of over 90% in situ after up to or longer than 10 years[2,3] and with metallic partial crowns (e.g. 76% to more than 86% survival) after up to 10 years.[4,5] Also, for ceramic inlays, available data show up to 98 % success after up to 8 years[6,7] coming close to gold alloy inlays. Less favorable results were reported for inlays from castable ceramics (76 % after 6 years), a material, which is no longer available.[8]

In analogy to the results for ceramic inlays, partial ceramic crowns fabricated from a castable glass ceramic (Dicor) only showed a 56% success rate of the restorations after 7 years in a retrospective study.[6] However, using a leucite reinforced glass ceramic (Empress), 81% of the restorations were still in situ after 7 years.[9] In a prospective, split mouth study comparing the longevity of gold alloy partial crowns to that of ceramic partial crowns (leucite reinforced glass ceramic), 89% of the initially inserted PCCs were still in situ after 5.5 years (Fig. 2) being statistically not different from gold alloy partial crowns.[10]

Another prospective clinical split-mouth study compared PCCs made from leucite reinforced ceramic (CAD/CAM) with lithium disilicate ceramic (pressed) PCCs in vital first or second molars. The 7-year Kaplan-Meier survival rate was 100% for pressed PCCs and 97% for CAD/ CAM PCCs.[11] These results are in the same order of magnitude as for all ceramic full coverage crowns, e.g. for leucite reinforced glass-ceramic crowns: (93.7%)[12] or 94.8% of the crowns (and more) in situ after up to 10 years (Lithium-disilicate).[13,14]

In conclusion, we estimate that ceramic partial crowns have the potential for being a reliable treatment method with survival rates which are in the same order of magnitude as those for full metal crowns.

4. Failure analysis

Chip fractures were observed (Fig. 3), probably due to incorrect occlusal adjustment or bruxism. This stresses the importance of correct occlusal adjustment. Furthermore, bulk fractures of the ceramic partial crowns were seen especially when the ceramic thickness was insufficient (less than 1.5 mm) (Fig. 4). This stresses the importance of a correct tooth preparation, respecting the material characteristics of the ceramic used, like a minimal thickness of 1.5 mm (see also preparation below).[11,15] Fractures may also occur due to a so-called "crack propagation" (Fig. 5); i.e. that small cracks increase over time due to mechanical stress, fatigue and eventually hydrolysis. Crack propagation may start from flaws at the base of the restoration (e.g. during fabrication process) or from flaws at the surface of the restoration (e.g. wear or unfinished surface following adjustments). A further reason for initiating small cracks is the incorrect (= heat producing) grinding and polishing during occlusal and approximal adjustment of the ceramics.[16]

Discoloration and wear of the luting material are also reported. Here, a small primary marginal gap between the ceramic restoration and the cavity wall, which has to be filled with the luting material, is beneficial. Furthermore, the correct choice and use of the luting material seems to be an important factor. By e.g. repolishing discolorations can be reduced to some extent. In this article, we describe techniques, which shall help to keep failures with PCCs at a minimum.

Figure 3. Chipping fracture of a partial ceramic crown.

Figure 4. Bulk fracture of a partial ceramic crown due to too little thickness of the ceramic.

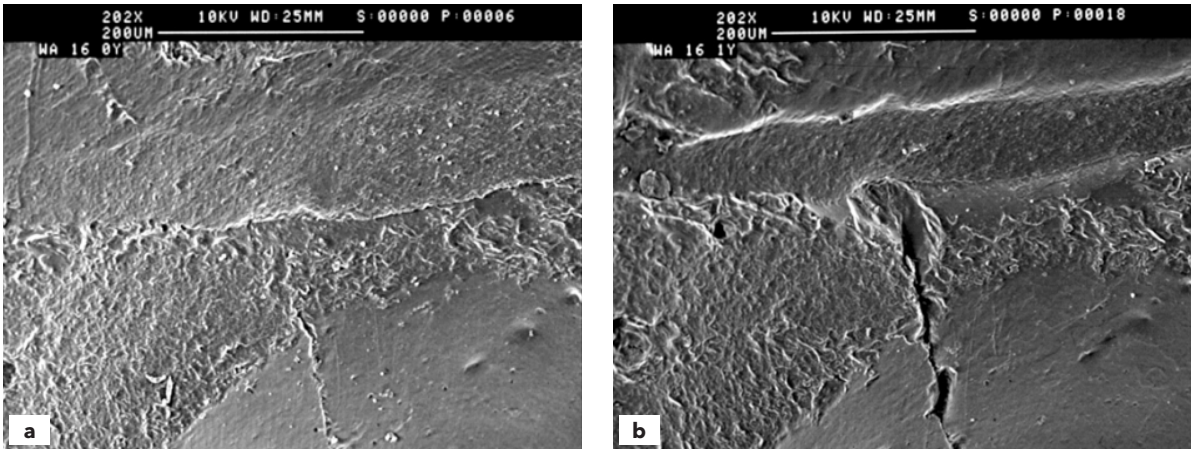

Figure 5. Scanning electron picture of a crack propagation in a ceramic restoration: (a) at baseliine (b) after 4 years (Friedl KH, et al. Clinical and quantitative marginal analysis of feldspathic ceramic inlays at 4 years. Clin Oral Investig. 1997;1(4):163-168).

5. Which Ceramic?

A large variety of different ceramic materials for partial crowns are available. They can be classified according to their composition or to the way they are processed. A survey of ceramics based on the composition is presented in Fig. 6.

Material

Ceramic materials differ e.g. in their mechanical and esthetic properties. In comparison to metals/alloys, which undergo some plastic deformation after the application of load, ceramics are considered to be brittle with no/very little plastic deformation, which can absorb energy.[17,18] The strength of ceramics is usually assessed by means of classic flexural strength tests using bar- or disk-shaped specimens[19] reflecting sudden application of a heavy load. Additionally, fracture toughness is a measure of resistance to crack propagation.[19] Esthetic properties are mainly related to the translucency of ceramics,[18] the higher the translucency, the better the esthetics.

Dental ceramics materials can be subdivided into three groups:[18]

a. primarily glass containing (feldspatic) ceramics based on silicate (also termed silica, SiO_2)
b. leucite reinforced silicate ceramics, lithium disilicate ceramics, or zirconium oxide reinforced lithiumsilicate ceramics
c. Mainly crystalline oxide ceramics (aluminum oxide, zirconium oxide) (Table 1).

Feltspatic ceramics in general show very good esthetics, but comparatively low mechanical strength (Table 1). Therefore, these materials were either reinforced with leucite, or are based on lithium disilicate; additionally, zirconium oxide reinforced lithiumsilicate ceramics have been introduced. All silicate based ceramic materials need to be adhesively luted to the tooth substrate. Examples for materials with long clinical experiences are leucite reinforced silicate ceramic (e.g. Empress I, formerly named Empress) or lithium disilicate ceramic, which contains 70% needlelike Lithium disilicate crystals (3-6 µm long) in a glass matrix (IPS e.max Press for labside fabrication and IPS.max CAD for chairside, CAD/CAM fabrication). This material shows better mechanical properties than leucite reinforced ceramics but still adhesive luting is recommended. At least 1.5 mm thickness is recommended for restorations made from these ceramics (see also preparation).[18] Recently, zircon oxide reinforced lithium silicate ceramics containing 10 wt.% 0,5 µm

Table 1. Flexural strength and Fracture toughness of different ceramics; modified according to (Raigrodski AJ. Contemporary materials and technologies for all-ceramic fixed partial dentures: a review of the literature. J Prosthet Dent. 2004;92(6):557-562; Aurelio IL, et al. Extended glaze firing improves flexural strength of a glass ceramic. Dent Mater. 2015;31(12):e316-324; Drummond JL, et al. Fracture surface examination of dental ceramics using fractal analysis. Dent Mater. 2005;21(6):586-589).

Material	Flexural strength (MPa)	Fracture toughness KIC(MPa/m1/2)
Leucite reinforced	140-210	1.2-2.0
Lithium disilicate reinforced	300-400	2.8-3.5
Zirconia oxide (Y-TZP)	900-1200	9-10

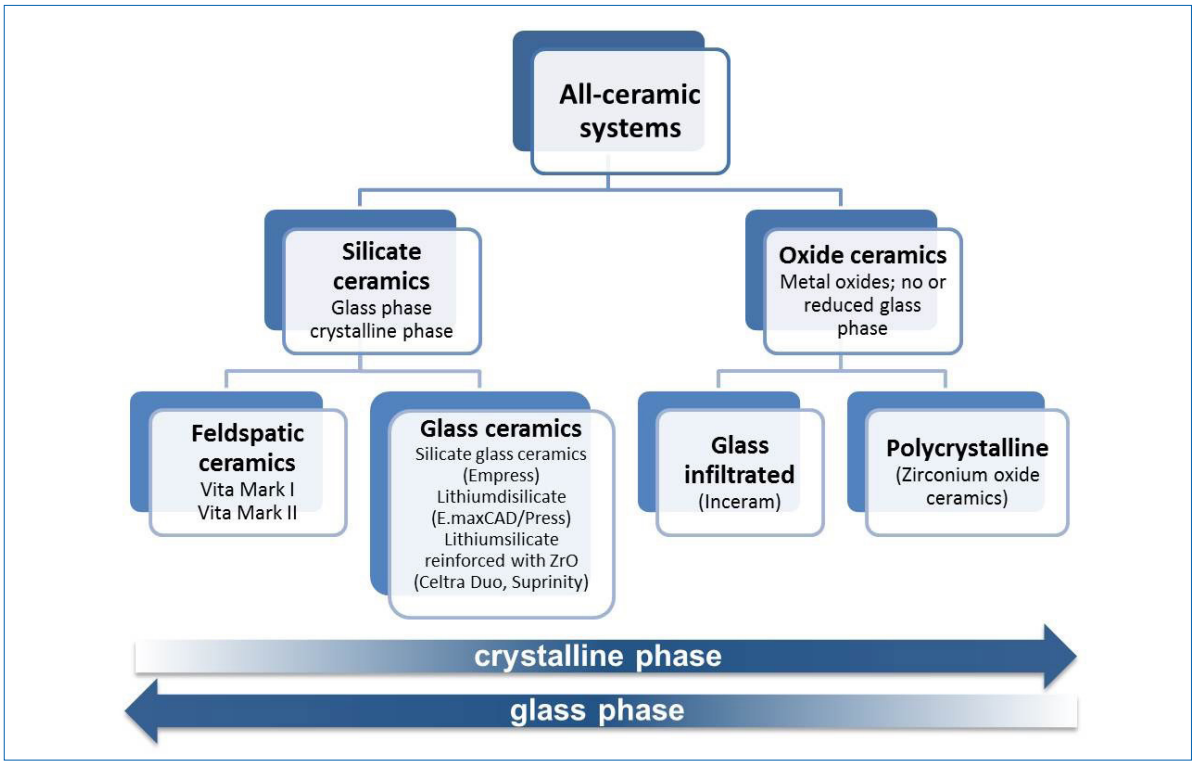

Figure 6. Overview of dental ceramic materials.

ZrO_2 have been introduced as an alternative material for the fabrication of single unit ceramic restorations which have to be adhesively luted. Restorations can be fabricated either labside (Celtra, Celtra Press; Suprinity) or CAD/CAM chairside (Celtra Duo, with an optional sintering step). Zircon oxide reinforced lithium silicate ceramics exhibit good mechanical properties and are translucent. Little clinical experience, however, exists with this ceramic for PCCs yet, and therefore this class of ceramics is not further covered in this review.

Oxide ceramics show low translucency compared to silicate ceramics but much better mechanical properties, which is due to the high amount of crystals.[18] Both, adhesive and conventional luting is possible. Adhesive luting, however, needs special ceramic pretreatment.[18] Today, monolithic restorations can be fabricated from zircon dioxide ceramics, but the range of indication rather covers crowns, bridges and more complex restorations than partial ceramic crowns. Therefore, this class of ceramics will not be addressed in this review.

Recently, materials named "Hybrid ceramics" have been marketed. These are, however, basically resin-based composites and/or contain methacrylate monomers. Therefore, the term "hybrid ceramic" may be misleading. These materials are industrially manufactured and must be processed by CAD/CAM techniques. They include heavily particle filled resins (i.e. resin based composites) cured at high temperature/pressure (e.g. Lava Ultimate, 3M or Cerasmart, GC) or a resin interpenetrating network (IPN) in a porous ceramic structure (e.g. Enamic, Vita). The latter material contains 86 wt.% feldspatic ceramic, which is infiltrated with resins (14 wt.% polymers). It has a strength of 144,4 MPa,[20] like glass ceramic (Mark II) but lower than lithium disilicate and a lower elastic modulus compared to other ceramics ranging between enamel and dentin.[20] Adhesive luting is required for these materials. Other similar materials are being marketed. For this group of materials little clinical experience for PCCs exists for the time being.

Processing methods

Initially, (feldspatic) ceramics were processed by sintering or - in the 80s of last century - by casting (e.g. Dicor). The method was based on impression taking and further processing in a dental laboratory. However, mechanical properties of the resulting restorations were limited and especially for the

castable ceramics failure rates for partial crowns were high.[6]

Pressing of ceramic was introduced using leucite reinforced ceramic (Empress I) in the 90s of last century with better clinical results. Further improvements were achieved using lithium disilicate (IPS e.maxPress) ceramics for the pressing process. However, again the restorations were fabricated in a dental laboratory after impression taking.

A basic change in the processing of ceramics occurred with the introduction of CAD/CAM techniques, which employed an optical impression (or scan), and the restorations were constructed by means of a computer program (CAD – Computer Aided Design). The restorations were then fabricated by 3-D-milling (CAM – Computer Aided Manufacturing) of an industrially prefabricated bloc. Restorations could be fabricated chairside, but also in a dental laboratory. This method has gained more and more importance recently.

Which ceramic to select?

Selection of the suitable ceramic materials/ceramic processing methods should be based on scientific data. Here, results from clinical studies over at least 3-5 years are of special relevance. For leucite enhanced glass ceramics and for lithium-disilicate ceramics such studies are available (see above: longevity). Regarding the aspect of processing of ceramics, broad and positive clinical experience exists with pressing techniques and with CAD/CAM. If the restorations are produced in a dental laboratory, an experienced technician and a close communication between dentist and technician are essential. In our clinic, we have extensive and positive experience over more than 20 years with leucite reinforced and lithium disilicate ceramics using the pressing technique or the CAD/CAM approach.

Fabrication of a ceramic partial crown

In the following series of figures, the fabrication of a lithium disilicate CAD/CAM partial crown is shown (Fig. 7a to 7f). After the optical "impression" the partial crown is constructed with the help of a computer program. In our clinic we are using the CEREC 3 system (Cerec Bluecam and Cerec Omnicam, Software Version SW 4.4.4.139706). Then, a suitable ceramic bloc is selected matching best in tooth color. Milling is performed on the blue bloc with partially crystallized 40% plate-like lithium-metasilicate crystals (0.2-1.0 µm) in a glass matrix (ca. 130–150 MPa). After try in, the restoration has to be heat treated to receive its final color, individualization,

Table 2. Results from an in vitro study comparing the fracture rate of ceramic (Vita Mark II) with 0.5 to 1 and 1.5 to 2 mm thickness; modified according to (Federlin M, et al. Partial ceramic crowns: influence of ceramic thickness, preparation design and luting material on fracture resistance and marginal integrity in vitro. Oper Dent. 2007;32(3):251-260).

	Ceramic Thickness	Fractures (n)
Rely X Unicem	Group 1 (0.5-1 mm)	7
	Group 2 (0.5-1 mm)	1
Variolink II	Group 1 (0.5-1 mm)	8
	Group 2 (0.5-1 mm)	1

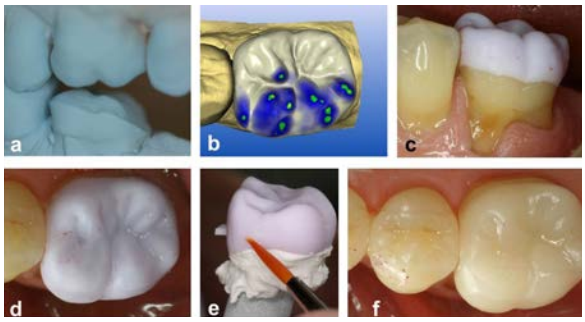

Figure 7. Fabrication of a lithium disilicate partial crown using a CAD/CAM approach: (a) preparation, (b) CAD of the restoration, (c) try-in of the metasilicate restoration, (d) occlusal adjustment, (e) preparation for final firing, (f) luted partial crown.

Figure 8. Crack formations on the buccal wall of a tooth with a PCC without coverage of the functional, buccal cusp.

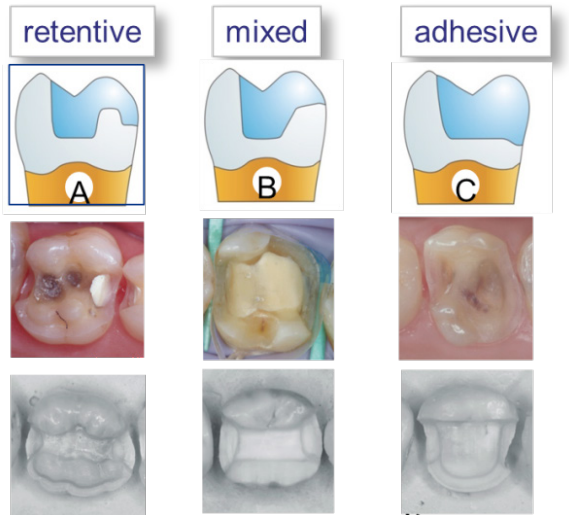

Figure 9. Retentive, semi-retentive and non-retentive cavity designs for the in vitro study on marginal quality (Federlin M, et al. Partial ceramic crowns. Influence of preparation design and luting material on margin integrity--a scanning electron microscopic study. Clin Oral Investig. 2005;9(1):8-17).

a b c d

Figure 10. Preparation and polishing instruments for ceramic partial crowns: (a) cylindrical diamond burs (course and fine grit) with rounded edges, (b) conical instruments with rounded edges and a stop at the frontal part, in order to keep the cavity depth, (c) ultrasound preparations tips for finishing approximal boxes, (d) silicone or rubber based instrument for polishing ceramic surfaces after occlusal/approximal adjustments.

glaze and strength. In this step the lithium-metasilicate is converted to lithium disilicate, then having its final mechanical strength (360-400 MPa).

6. Which Preparation?

Problems of ceramic fractures related to its mechanical properties and the resulting failures have been outlined above. Rules for a suitable preparation must first of all take care of these material properties.

Ceramic thickness

The necessary thickness of the ceramic to avoid crack propagation or fracture on loading was investigated in an in vitro study simulating repeated subcritical loading and thermocycling.[21] PCCs (Vita Mark II, Cerec3 System) were fabricated with 0.5-1.0 mm and 1.5-2.0 mm ceramic thickness. PCCs were adhesively luted to the cavities with either Excite/Variolink II or RelyX Unicem. After thermo-mechanical loading 15 PCCs of group 1 (0.5-1.0 mm) and two PCCs of group 2 (1.5-2.0 mm) fractured. The difference was statistically significant. Although the test material (Vita Mark II) is a feldspatic glass ceramic with less strength than the current lithium disilicate or zircon oxide reinforced lithium silicate ceramics, we still recommend – being on the safe side – a minimum thickness of the ceramic of 1.5 to 2.0 mm (Table 2).

Inlay or Partial Crown

The decision, whether the preparation design should include the cusps (partial crown) or not (inlay), should be based on both, the size of the defect and the luting technique (adhesive/non-adhesive). Tooth fractures or crack formation as a possible precursor of fractures may occur if the remaining tooth structure is too weak (Fig. 8). For non-adhesively luted/placed dental restorations, the generally accepted rule was that if the occlusal cavity is larger than 1/3 of the oral vestibular distance of the tooth, the cusp had to be covered. However, information concerning adhesively luted ceramic restorations was lacking.

Therefore, in an in vitro study,[22] cavities were prepared for PCCs with the non-functional cusps not covered and adjusted to wall thicknesses of 1.0 mm and 2.0 mm. Ceramic restorations were fabricated and adhesively luted to the cavities with Excite/Variolink II. After thermo-mechanical loading the specimens with 1.0 mm of remaining wall thickness revealed statistically significant more cracks after TCML than the group with 2.0 mm of remaining cusp wall thickness. (Table 3). In another study,[23] restorations with 1 mm thin cuspal wall with and without coverage were compared using the same method as described above. Horizontal reduction of thin non-functional cusp walls showed a tendency of less enamel crack formation and better marginal sealing than thin (= 1 mm) non-functional cusp walls without coverage.

Although the clinical relevance of cracks for the functioning of teeth was questioned, it was shown that enamel cracks may progress toward a complete loss of the whole tooth wall, which would require a new restoration or even tooth extraction.[24,25]

From these studies it can be concluded that – to be on the safe side – a remaining cusp wall thickness of less than 2 mm should be protected by coverage with an at least 1.5 to 2 mm thick ceramic layer to avoid/reduce enamel cracks and marginal deficiencies.

Preparation design

Traditionally, the preparation design for partial crowns using metal alloys was "retentive" with artificially created rather parallel box walls in order to support the retention of the metal restoration by friction. However, ceramic partial crowns are adhesively luted, by which bond strength between restoration and tooth is significantly improved. Therefore, the question was, if PCCs still require a retentive preparation. In an in vitro study, the

Table 3. In vitro increase of crack formation in enamel for 1 mm and 2 mm residual dental wall thicknesses after luting and after thermo-mechanical loading; numbers of samples (teeth); modified according to (Krifka S, et al. Ceramic inlays and partial ceramic crowns: influence of remaining cusp wall thickness on the marginal integrity and enamel crack formation in vitro. Oper Dent. 2009;34(1):32-42).

	BL vs. luting		Thermo/mech loading vs. BL		Natural teeth
	1 mm	2mm	1 mm	2 mm	
No changes	6	8	0	5	11
Increase of cracks	7	4	13	7	1

Figure 11. Different preparation designs, from a prospective clinical study.

influence of retentive, partially retentive and non-retentive preparation designs on marginal quality was investigated (Fig. 9) after thermo-mechanical loading.[26]

In general, no significant differences of the marginal quality could be found between the three preparations. However, few parallel walls facilitate the placement of the PCCs, because such walls are used for guidance to secure proper seating during luting. However, no sharp edges are allowed, which impair proper seating and correct fit of the restorations. Furthermore, increased shear forces may arise and compromise the strength and longevity of the entire restoration.

The retention rate of PCCs using a defect-oriented preparation design as described above was studied in a number of clinical investigations, and loss of retention was found to be low and mainly dependent upon the luting material and its correct handling (see below).[10,27]

It can be concluded that retentive cavity designs with rather parallel walls are not needed for ceramic partial crowns and a more defect oriented preparation design with only few parallel walls is recommended.

Approximal box depth

The approximal cavity floor with a margin located in dentin has long been considered to be a problem for adhesive restorations in general. Insufficient bonding to dentin and insufficient cavity access with the consequence that the proper technique could not be correctly performed were reasons for bond failure resulting e.g. in secondary caries. However, new bonding systems (see below) have improved the bond to dentin dramatically. Anyhow, it is important that the required steps for good adhesive bonding can properly be executed; thus excellent accessibility also to approximal cavity floors is necessary, especially during luting. Recently, the "proximal box elevation technique" has been introduced as an alternative method to restore large cavities with proximal margins below the cement-enamel junction by sealing the dentin margin with an adhesive/direct composite prior to placement of a direct or indirect restoration in a second step (28). The use of self-adhesive resin cements may not be suitable in this case. Little clinical experience exists with PCCs and the proximal box elevation technique.

Preparation/polishing Instruments

Cavity preparation is usually performed using diamond burs (Fig. 10) with a cylindrical or conical shape and a flat head and rounded edges. Fine grit instruments are recommended for finishing the cavity margins, which – by the way – may also improve bonding of SE adhesives (see below), because the created thin smear-layer allows for better permeation for these substances. Ultrasound preparation instruments can also be used for finishing approximal boxes. Fine grit diamond instruments can also be employed for occlusal and approximal adjustments of ceramic partial crowns. Important is that this adjustment must be performed avoiding heat and crack initiation; water coolant is recommended. Furthermore, ceramic surfaces must be polished following adjustments, in order to prevent/reduce plaque adhesion, increased abrasion of opposing teeth and crack propagation.[18,29] Achieving smooth surfaces depends on a sequential application of all polishing steps.[30] Examples for ceramic partial crown preparations in posterior teeth are shown in Fig. 11.

7. Which adhesive luting material?

Main problems of these materials are the washing out and wear of the luting materials in the luting space, the discoloration and eventually debonding of the restoration. Generally, PCCs fabricated from different silicate based ceramics must be adhesively luted. Suitable materials are composite resins (only light or dual curing materials) in combination with dental adhesives (E&R), self-adhesive cements or compomers (Fig. 12). Resin modified glass ionomer cements (RMGIC) have been marketed for this purpose, but in vitro we have observed problems with one of these materials, leading to fractures of the PCCs after thermo-mechanical loading. This

occurred most probably due to expansion after water uptake by the hydrophilic material.[26]

Extensive experience exists with the use of so-called dual cured luting composite materials together with the etch and rinse (E&R) adhesive technique followed by the use of self-adhesive luting materials.

Luting composites

Dye penetration studies with different luting materials have shown superior results in the critical areas (approximal cavity floor in dentin) with the use of a dual curing luting material and an E&R adhesive and of a self-adhesive material[21,31] as compared to compomers. The tested self-adhesive materials initially showed a white line along the luting space, which, however, disappeared after water storage. As ceramic thickness for partial crowns is mainly 1.5 mm or higher, dual curing luting composites are recommended. These materials contain a chemical initiating system, which is sensitive to protons[32] and thus dual curing luting composites should not be used with acidic monomers of self-etch (SE) adhesives. Exemptions are new universal adhesives (see below) or cases in which a separate dual cure activator is used.

Luting composites used together with an E&R adhesive are the standard, showing good esthetics, high bond values both to dentin and to enamel and they provide greatest retention.[33]

Self-adhesive luting materials

These luting materials have been developed and marketed in order to facilitate luting by avoiding a separate pretreatment of dentin or enamel. Laboratory tests had shown that bonding of self-adhesive luting materials to dentin was as good as that with E&R and SE adhesives in combination with a composite luting material, whereas bonding to enamel was compromised.[34-36] Therefore, selective enamel etching was proposed to be used with self-adhesive cements. In a prospective, clinical split mouth study with 34 patients we compared the use of additional enamel etching to that with no separate etching for luting partial ceramic crowns with a self-adhesive luting material. After 6.5 years observation period, additional selective etching of enamel did not offer advantages concerning marginal staining, but revealed better retention rates.[37] However, etching of dentin should be avoided, because bond strength of self-adhesive cements to etched dentin is reduced.[38]

Self-adhesive luting materials are comparatively simple to use and they enjoy a great popularity. A practical advantage is that so-called flash curing is possible: the material is cured for 2-3 seconds, then the surplus material can easily be removed and the final light curing is performed. However, appropriate ceramic pretreatment (etching and silanization) is still necessary and - as was outlined above – the bond strength to enamel is comparatively low (selective enamel etch recommended). Furthermore, desiccation of the dentin before luting should be avoided, because bond establishment and stability are impaired.[27]

Universal adhesives

Recently, a new group of adhesives has been introduced into the market, which can be used with resin-based composites in an E&R or in a SE mode (with and without selective enamel etching), and thus were named "Universal Adhesives". These adhesives are also interesting for luting ceramic to tooth substances as some of the preparations also contain silane substances. The idea is that no separate silane application after ceramic etching is necessary.

Universal adhesives contain acidic monomers. These normally interfere with dual cure luting composites (see above). However, one product (Universal Bond, 3M) was claimed to be compatible if used together with the respective dual cure luting composite from the same company (RelyX Ultimate, 3M), because this luting composite contains a proton scavenger. If other luting composites are used, a separate proton scavenger (dual cure activator) can be purchased and added.

In a prospective clinical split-mouth study with 50 patients we tested the clinical outcome when using this universal adhesive with and without selective enamel etching compared to a self-adhesive luting material.[27] Forty-eight patients were evaluated clinically according to FDI criteria at baseline and 6, 12 and 18 months. After 18 months, retention rates for the group with selective etching were slightly higher (97.6%) than without (95.8%). For both groups retention rates were significantly higher than for a self-adhesive luting material. From these – relatively short term – data it can be concluded that the new adhesives seem to work properly, especially together with the selective enamel etch technique. For all restorations in situ no difference in the clinical behavior (e.g. marginal discoloration) could be observed. The incorporation of a silane into the adhesive and the abandoning of a separate silanization procedure is discussed critically in the literature. Currently, a separate silanization procedure is advocated for.

Resin coating technique/Ceramic Pretreatment

Coating the cavity floors with a thin layer of a flowable resin-based composites prior to impression taking[31] as well as IDS – immediate dentin sealing – are advocated for to protect the freshly cut dentin

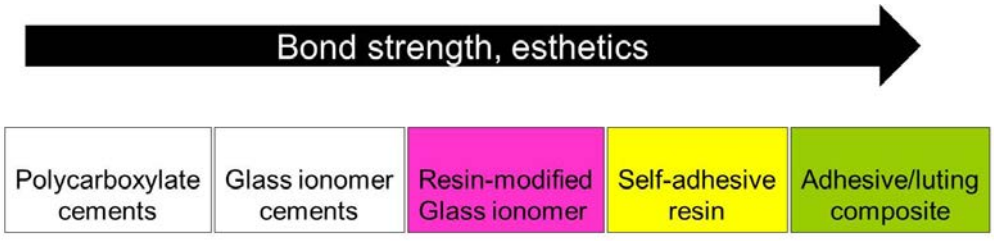

Figure 12. Overview over luting materials partial ceramic crowns. Polycarboxylate cements and glass ionomer cements must not be used for luting PCCs from silicate/disilicate ceramics.

Table 4. Etching and silanization regimens for different ceramic and luting materials.

Ceramic	Self-adhesive resin	Adhesive/luting composite
Feldspatic ceramic, leucit reinforced glass ceramic	60s HF, silane treatment	60s HF, silane treatment, Adhesive
Lithium disilicate ceramic	20s HF, silane treatment	20s HF, silane treatment, Adhesive
ZrO_2 reinforced Lithiumsilicate-ceramic	30s HF, silane treatment	30s HF, silane treatment, Adhesive
Resin containing materials	60s HF, silane treatment	60s HF, silane treatment, Adhesive

following preparation. Furthermore, contamination of the tooth structure during impression taking and temporization is reduced, thus enhancing the establishment of the adhesive bond. Indeed, marginal seal could be improved compared to conventional luting[31] but this technique has not become very popular as it is rather technique sensitive and complex. When using the resin coating technique, final luting must be executed with a luting composite (and not with a self-adhesive material).

Before luting leucite reinforced and lithium disilicate ceramics, they need to be etched and then a silane couple agent has to be applied. The details differ with the ceramic and the luting material (Table 4) These procedures are important, because they significantly improve the bond of the luting composite to the ceramic.

Biocompatiblity

Ceramics are generally considered to be biocompatible and no adverse effects like allergies have been reported. However, luting materials (often resin-based) are needed, and for resin-based materials cases of allergic reactions have been reported. Therefore, care should be exercised to not use luting materials in patients who have a history of allergic reactions to components of this material.[39] Furthermore, luting materials come into close and prolonged contact with dentin and – in deep cavities – potentially with the exposed pulp. Postoperative sensitivity has been observed in few cases in our clinical studies, which abated with time.[10,40] However, in deep cavities with the possibility of pulp exposure, a protective layer of calcium hydroxide cement or a hydraulic tricalcium silicate cement is strongly recommended.[39,41]

8. Light curing: irradiance, time?

Light curing is facing two problems: too little light applied, which may result in insufficient curing, less retention, wash-out and marginal discoloration or too much light applied, which may lead – especially when applied in a short time – to overheating. Insufficient light output may be due to insufficient instruments[42] or due to an insufficient technique;[43] e.g. when the tip of the light guide is not directed correctly to the restoration. Secondary caries has been associated with insufficient curing of resin-based composites but also increased release of substances from the materials and thus increased cytotoxicity.[44,45] Too much energy delivered by the light curing units may result in heat damage adding to the heat produced by the exothermic setting reaction of the luting composite. High energy light curing units have recently been marketed with an irradiance of > 6000 mW/cm^2.

Dentin has a low thermal conductivity.[46] As a rule of thumb, 16 J/cm^2 are needed for optimal curing of a resin-based composite (e.g. 800 mW/cm^2 for 20 seconds, or 1600 mW/cm^2 for 10 seconds. However, this rule (increasing irradiance while reducing irradiating time) cannot be extrapolated to very high energy levels and very short times like few seconds.[47] Compressed air reduced temperature increase.[48]

Polymerization rate is dependent on the light energy which reaches the luting material. Thus color, translucency and thickness of the ceramic and the distance between the tip of the light guide and the ceramic surface play an essential role when choosing the right amount of energy.[49,50]

Ceramic thickness

In an in vitro study measuring the depth of cure and the Vickers hardness of a standard luting composite, Jung et al.[51] found that with a leucite reinforced silicate ceramic (IPS Empress) and 2 mm ceramic thickness, at 40 sec 800 mW/cm^2 dual curing leads to a significantly better polymerization than light curing only. For a leucite reinforced ceramic of a thickness of 1 mm, light curing alone resulted in the same cure as that with an additional chemical cure.[49,52]

Translucency

For leucite reinforced silicate ceramic and for lithium disilicate ceramic, which is less translucent than the leucite reinforced material, similar curing of a dual curing luting composite occured with a ceramic thickness of 1 mm. For a larger thickness, significant differences were observed.[49] Follow meticulously the information of the manufacturer: ceramics with little translucency or dark colors require extended irradiation times.

Recommendation

- Generally, eyes of the dental personnel should be protected, e.g. by a shield at the end of the light guide.
- For posterior teeth, the use of a dual curing luting composite is highly recommended. For a standard light curing unit with an irradiance of around 800 mW/cm^2, an irradiation time of 40 seconds from occlusal and additional from oral and vestibular are recommended.[49]
- Irradiance levels of 800 to 2000 mW/cm^2 are regarded as standard. With light curing units emitting higher radiances, little clinical experience exists, and heat effect on the pulp or burning of lips should be prevented; rubber dam provides no protection.[53]

9. Step by Step checklist

- Case selection/Prevention program: as luting resins may enhance bacterial growth and biofilm

vitality,[54,55] excellent oral hygiene and participation in a structured recall system for monitoring and controlling oral hygiene measures is a prerequisite for successful long term results.

- Indication: large cavities needing cusp replacement.
- Preparation: defect oriented, create enough space for at least 1.5 mm ceramic thickness; no classical retention but guidance for insertion.
- Temporization: chairside using an impression taken before preparation, filling it with a temporary resin-based composite, placing it onto the prepared teeth and removing after setting. Temporaries should be luted with a eugenol-free material although the influence of eugenol on the final curing of luting composites is subject to discussion. In any case, more important is the careful removal of temporary cementation materials from the cavity prior to luting[56] using e.g. air polishing with glycin; calcium carbonate air polishing generally caused significantly reduced dentin bond strengths.[57]
- Lab work can be performed in the dental office or in the dental laboratory
- Try in of the restoration and careful adjustment of approximal and occlusal surfaces avoiding high pressure (heat), which may lead to ceramic fractures or to crack initiation; try in paste can be used to check for esthetics but must be carefully removed prior to bonding.
- For certain materials like lithium disilicate ceramic for CAD/CAM chairside application, further lab work (final painting, glazing, improving strength) is necessary.
- Pretreatment of the ceramic: Etching of the ceramic (silicate glass ceramic), silanization (see Table 4)
- Self-adhesive luting materials: ceramic pretreatment, additional selective enamel etching
- Luting composites with E&R adhesives: Separate curing of the adhesive improves bond strength.[58]
- Luting composites with universal adhesives: E&R is possible with all products; SE (with and without selective enamel etching) with certain products (see manufacturer information)
- light curing: e.g. 40 seconds/800 mW/cm^2 on three sides; be careful with high power light curing units (> 3000 mW/cm^2).
- Rough surfaces are abrasive to opposing enamel and reveal lower resistance to crack propagation,[18,29] polishing using e.g. silica, silicon carbide or diamond impregnated rubber polisher.[18]
- Ceramics and luting materials differ between manufacturers: it is essential that the specific recommendation of each manufacturer provided for the specific materials are followed meticulously.

Author Contributions

GS has drafted the manuscript. MF has added relevant information and a number of figures.

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Questions

What are the main reasons for PCCs failure?

❑a. Ceramic thickness less than 1 mm
❑b. Endodontic treatment
❑c. Subgingival location of approximal margin
❑d. Use of silicone polishers

What are the most important rules for a correct PCC cavity design?

❑a. Box preparation with as many as possible nearly parallel walls
❑b. No subgingival margin
❑c. Cavity oriented design with few parallel walls
❑d. Sharp edges inside the cavity to improve adhesion

What are the clinical advantages of reinforced silicate ceramics?

❑a. good esthetics
❑b. highest strength of all ceramics
❑c. most easily to handle
❑d. can be luted with glass ionomer cement

Which material is most suitable for luting reinforced silicate PCCs

❑a. Glass ionomer cements
❑b. Phosphate cement
❑c. dual curing resin-based composites
❑d. resin-modified glass ionomer cements

COMPLETE PROSTHESES TREATMENT – PRESENT AND FUTURE PERSPECTIVES

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Background: Background: Tooth loss is a public health problem across the globe, especially in low-income populations. Traditional complete denture treatment is time consuming, and less embraced by general practitioners.
Objective: The purpose of this paper is to review data on prevalence, future projections, and treatment modalities for edentulism. Most edentulous patients receiving care are treated with conventional, tissue-supported prostheses. Possible ways to improve efficiency in complete denture treatment, and ameliorate access to care are investigated.
Data Sources: Information was obtained mainly from PubMed, American College of Proshodontists databases, and non-indexed sources.
Study selection: Considering the scarcity of information on some topics (simplified complete denture fabrication methods, digital techniques), a wide range of papers were selected for analysis, from systematic reviews, randomized controlled trials, cross-sectional studies to case presentations, expert opinions, surveys, and dental organizations' reports.
Data extraction: The web search included the following key words: edentulism, demographic, implant, removable, denture, simplified, digital, denturist.
Data Synthesis: The future of traditional complete denture treatment remains questionable, considering the reduced appetite of general practitioners and patients for time consuming treatments. Simplified techniques deserve an increasing attention from practitioners and dental educators, as available data suggest that they produce similar outcomes, when compared to traditional methods. Digital technologies are expected to further improve treatment outcomes, within simplified protocols. As mid-level dental providers became a reality in some jurisdictions, denturism could be considered part of the solution, especially in underserved areas.
Keywords: edentulism, prosthesis, simplified, digital, curriculum.

1. Introduction

Despite significant advances in prevention and oral care, tooth loss remains a public health problem, especially in low income populations[1,2] and the elderly.[3,4] Access to care in the underserved segment of population is a long standing problem.[5] Overall, the prevalence of edentulism is still high, even in developed countries.[6,7,8]

While prevalence of edentulism is decreasing from decade to decade, the increase in senior population fuels the need/demand for complete prostheses for decades to come. The Dental practitioners are expected to face a serious task in providing care for a large number of edentulous patients, most of them seniors, with specific needs that have to be addressed accordingly.[9] Upgraded treatments with documented benefits,[3,10,11,12,13,14,15] including implant overdentures and implant-supported fixed prostheses are available, but are only address a fraction of the edentulous population, due mainly to increased costs. As such, the tissue-supported complete prostheses appear to be the mainstay in the treatment of edentulism,[3,6,12,13,16,17,18] despite the fact that they do not constitute optimal replacements for the lost function, with lower bite forces and altered masticatory muscle activity.[19]

Trends in the dental work force indicate that the ratio of dentists to the population in the U.S. will be in 2020 less than in was in 2010,[20] due to a faster increase in population, as compared to the increase in number of dental graduates. In addition to the shortage of dentists in the US,[21] a shortage of dental technicians[22] is expected to add to the already established issue of access to care.

Increased chair time expenditure for removable prosthodontics due to numerous steps makes denture treatment less attractive for practitioners,[23] as revenue per time unit is lower, compared to other

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common restorative procedures. Increased number of trips to see the dentist also adds to patient's expenses.
Reduced space for complete dentures in dental schools' curriculum[24,25,26] is likely to generate graduates less prepared for the treatment of edentulism.
Under these circumstances, it appears that the need/demand of complete dentures exceeds the offer of prosthodontic care within the limitations of existing dental care delivery systems, even in developed countries.
The purpose of this paper is to review data on prevalence and future projections on edentulism, also review treatment modalities for this condition. Possible ways to improve efficiency in complete denture treatment, and ameliorate access to care are also investigated.

2. Edentulism and demographics

The prevalence of edentulism in seniors observes a wide range internationally, from 11% in China, to 23% in Brazil, 24% in Indonesia, and 26% in the United States. In Europe, it varies from 15% to 78%.[16, 27]
In the U.S., the prevalence of edentulism registered a decline during past decades,[28] which can be approximated by a 10% decline for each decade.[29] Using Census data and projections from 1996 (indicating a significant increase in adult population, especially adults over 55), Douglass[30] estimated that the adult population in need for complete dentures will increase by 2020 to nearly 37.9 million, even considering a utilization rate of dentures of about 90%.[29,31] It was predicted that even if the estimated decrease in the prevalence of edentulism will follow previous trends, it will likely be offset by the 79% growth in the population over 55, triggering an increase of the need for complete dentures from 53.8 million (1991) to 61 million in 2020.[30] The fact that dentures need to be replaced periodically, in order to maintain reasonable function and the oral health related quality of life[32] is also to be considered.
Newer data indicate that during the past half century covered by surveys, the prevalence of edentulism in U.S. adults decreased from 18.9% to 4.9%.[33] As socioeconomic disparities increased during the same period, edentulism is currently concentrated in the low-income population.[33] The relative decrease in edentulism prevalence in the U.S. by 74% is comparable with data from other countries: 84% relative decrease in the U.K. over four decades.[34] A 57% relative reduction was noted in Finland,[35] 84% in Sweden,[36] and 61% in Australia,[37] during two-decade periods.[33]
In the U.S., the rate of decrease in edentulism is expected to slow to 2.6% by 2050. Such decline is predicted to be partially offset by population increase and aging, indicating that the number of edentulous individuals will actually decrease by 30%, from 12.2 million in 2010 to 8.6 million in 2050.[33]
In Europe, the prevalence of edentulism is also expected to decrease significantly during the next decades. The growth of the older segment of population is expected to counteract the trends in prevalence, but the effect is not expected to be as dramatic as in the U.S.[7]
Prevention of edentulism is work in progress worldwide, with significant disparities, related mostly to access to care and education. Overall, it is likely that the elderly will lose teeth later in life,[38] contributing to an anticipated decrease in the need for tooth replacement, at least in some populations of the developed world.

3. Treatment modalities for the edentulous patient

Despite consistent advances in organ and tissue engineering,[39,40] their current impact on the dental profession and practice is rather limited at best. Dentistry remains predominantly restorative nowadays, and the time when re-growing teeth will become mainstream is probably decades away.
The advent of dental implants more than half a century ago brought the hope to evade some of the shortcomings of conventional, tissue supported dentures. Constant development in materials and techniques enabled implant dentistry to become a predictable and lucrative enterprise. If cost were not a limiting factor, implant placement and restoration would be mainstream today, considering the excellent survival rates, even for implants being placed in predoctoral and residency programs.[41]
Most studies on implant treatment and oral function demonstrated an improvement of chewing function in the mandible.[13,14,42,43,44,45,46,47] The implant restorations are well received within the stomatognathic system, with electromyographical activity values comparable to those of dentate subjects.[48]
A systematic review by Fueki et al.[11] concluded that a mandibular implant-supported overdenture opposing a maxillary conventional complete denture provides significant improvement in the masticatory performance compared to the conventional upper and lower complete dentures for a limited population having persistent functional problems due to severely resorbed mandible.
After implant treatment, patients report high levels of satisfaction regarding various aspects
of their denture function and they are more satisfied than patients with similar problems who receive a conventional denture without implant support.[13,44,49]
Lindquist & Carlsson[50,51] found that treatment with implant-supported fixed prostheses, generated a significant improvement of the patients' assessment of their chewing ability, and of the results of chewing tests (particle size reduction and masticatory force).
While implant-supported/retained prostheses demonstrated superiority in terms of retention, stability and patient acceptance, especially with fixed restorations, their cost remains prohibitive for a large majority of edentulous patients. During the past decades, using a reduced number of implants was proposed in order to provide the most value for money in such cases, and possibly define a standard of care. The McGill consensus statement proposed a standard of care for edentulous patients, including a maxillary conventional complete denture opposing a 2 implant overdenture.[15] The said standard was

treated with circumspection later,[52,53,54,55,56] as there is no solid evidence to endorse a single standard of care for the treatment of the edentulous mandible pertaining to a specific treatment option. It was shown that patient choice has a greater influence on treatment outcome, as compared to the practitioner's bias towards a treatment option.[52] Fitzpatrick[52] emphasized that "the standard of care in the edentulous mandible is the intervention judged by the well-informed patient, in consultation with an appropriately trained and experienced dental health care provider, to best meet the needs and circumstances of the patient."

Efforts to reduce the costs and provide simplicity in implant overdenture treatment went even farther by investigating mandibular overdentures retained by a single implant.[57,58,59,60,61,62]

Well over half a century in the dental implant era, a large majority of edentulous individuals continue to wear conventional, tissue supported complete dentures, and the need for such prostheses will stay for years to come.[8,63,64]

4. Simplified denture fabrication protocols

Most U.S. dental schools teach a traditional protocol in complete denture fabrication, including a multi-step approach using preliminary and master cast impressions, semi-adjustable articulators, face-bow preservation, laboratory/clinical remount.[65,66] Despite the fact that the traditional multi-step method is preferred by prosthodontists and taught in a large majority of dental schools, most general dentists use simplified techniques in order to reduce the number of appointments and the cost.[8,16,63,64,67,68]

Shorter, less expensive but still acceptable treatment methods would benefit especially elderly patients with chronic pathology and less mobility.[1,17,69,70,71]

Simplified denture fabrication techniques make treatment more attractive for both practitioners and patients.

Most simplified techniques will condense impression making in one appointment, which often includes jaw records also (without face bow registration), and sometimes anterior teeth selection/mock-up of anterior set-up. A critical review by Carlsson et al[72] established that "there was no support for the frequent textbook statement that the two-step procedure is necessary and superior to the one-step method". A try-in procedure is optional during most techniques, so the finished dentures can be delivered in as little as two appointments. In addition, such methods are likely to be integrated in a digital workflow.[73]

There were no significant differences noted in denture quality and patient satisfaction between dentures fabricated by using the traditional multi-step protocol and prostheses made by using simplified methods.[1,6,8,16,63,64,68,74,75,76,77] The goal of such methods would be to reduce the number of appointments while still observing the principles of complete denture treatment.[78,79,80] Such techniques are more cost effective,[64,67,69] and it was reported that by using a simplified technique, the clinical time can be reduced by as much as 34%, compared to conventional methods.[69] At the same time, patient satisfaction and prosthodontist rating of prosthesis quality were comparable between the two methods. Patients appreciated the reduced number of appointments.[69]

Overall, there is no compelling evidence to suggest that complete dentures fabricated following the traditional multi-step, complex protocol provide better outcomes than dentures made using simplified techniques.[81]

It is worth noting that the study by Regis et al.[68] employed relatively young dentists. Such young practitioners reached good results by using the simplified technique, which indicates that experience is not a factor under these conditions.[68] In addition, it was found that even predoctoral students can make adequate complete prostheses by using a simplified method.[82]

A one-step complete denture technique was also documented.[83] It employs prefabricated complete dentures templates with thermoplastic bases (which come in different sizes), which are adapted on casts, then relined chairside. While customization in tooth arrangements could be more like an afterthought, the one-step denture is regarded as a fast and cost-effective method for complete prosthesis fabrication.

5. Fabrication of complete prostheses using digital protocols

It took less than a decade for digital photography to reach mainstream and even take over professional photography at the beginning of the century. During the same period, CAD/CAM technologies soared in various industrial applications.

The digital methods in complete denture fabrication are not entirely new, as literature mentions such an approach as early as in 1994.[84] If we remember that it took more than three decades for digital protocols in fixed restorations to become mainstream, and considering that removable prosthodontics accounts for a significantly smaller portion of the dental business, it is likely that we will wait at least another decade for digital denture fabrication to become mainstream.

While the clinical steps remain essentially analogic, digital technologies in complete denture may address some of the disadvantages of conventional denture fabrication protocols, like increased number of treatment visits, and questionable adaptation of denture bases to the tissues due to polymerization shrinkage. Moreover, generating duplicate dentures appears simple and reliable with digital technologies. In the long run, digital technologies in complete denture fabrication are expected to help dealing with many other issues such as increased demand, access to care around the world, standardization in clinical research.[85]

On the flip side, the costs associated with complete denture fabrication by digital means are still high, as compared to fully analog methods. With widespread acceptance, however, these costs are expected to fall, and likely become lower than expenses associated to the traditional methods.[85] Moreover, due to the reversible feature of complete denture treatment,

in case of failure of a digital protocol, a traditional approach can always be instituted, or a combination of the two.[85]

A survey of U.S. post-doctoral program directors and predoctoral department chairs found that the use of digital technology in denture fabrication is incorporated in more than half of the graduate programs, while only 12% of the surveyed schools observe it in predoctoral education. It is estimated that up to 10% of complete dentures delivered in academic settings are processed by digital means.[86]

The use of digital technologies for complete denture fabrication in predoctoral education was found to be an effective and time saving method. The process was preferred and used effectively by students.[87]

6. Denturists and clinical dental technicians

Denturism was defined as the practice of fabrication and fitting of removable dentures by dental technicians, who perform both the clinical and laboratory stages of denture making.[88] In some countries, denturists are known as clinical dental technicians.

In the U.S. the practice of denturism is regulated in WA, OR, ID, MT, AZ, ME. Other states are seeking regulation (WY, TX, IL, IN, KY, TN, PA, VT, MA), with recent legislative action in CA, CO, OK, GA.[89]

Denturists practice legally also in Canada, New Zeeland, and Finland. There is an indication of illegal practice of denturism in Belgium, Greece, and the U.K.,[90] but it is probably much more widespread, especially in the developing world.

It was speculated that the development of denturism was mainly driven by dental technicians. Access to care was supposedly improved in the areas where denturists are allowed to practice.[90]

The literature on the practice of denturism is scarce; more data are needed before making informed recommendations on what role should such a category of dental professionals play in the modern prosthodontic care delivery.

7. Summary and conclusions

Although prevalence of edentulism is expected to further decrease in the future, as population is increasing and aging, many millions of people will still be edentulous during the next decades, especially within the lower socio-economic segment of population.

Implant-retained/supported restorations may remain rather a privilege, than a mainstream treatment.

The future of conventional complete denture treatment, as we know it from classic textbooks, remains questionable, considering the reduced appetite of general practitioners and patients for time consuming treatments.

In this climate, simplified techniques deserve an increasing attention from practitioners and dental educators, as it was shown that such methods enable similar results, as compared to traditional protocols. Digital technologies are expected to further improve treatment outcomes, within simplified protocols.

As mid-level dental providers became a reality in some jurisdictions, denturism could be considered part of the solution too, especially in underserved areas.

In the 21st century, no one should walk around toothless. Our patients deserve outcome driven, predictable, time- and cost-effective treatments, within dental care delivery systems that are able to absorb the consistent need for such therapies.

Author contributions

Study concept and preparation of manuscript - SUT. Revision of manuscript and literature search - MVC.

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Dr. Uram-Tuculescu lectures nationally on prosthodontic topics, patient management, ethics in dental profession.

Questions

Current trends in demographics and edentulism indicate that:

❑a. Prevalence of edentulism is increasing overall;
❑b. Prevalence of edentulism is decreasing overall;
❑c. The utilization rate of dentures is increasing overall;
❑d. The utilization rate of dentures is decreasing overall.

The standard of care for the edentulous mandible is:

❑a. Conventional complete denture;
❑b. Implant overdenture;
❑c. Implant supported fixed prosthesis;
❑d. Not pertaining to a specific treatment option.

Simplified complete denture treatment techniques:

❑a. Provide comparable outcomes, as compared to traditional techniques;
❑b. Are generally more expensive;
❑c. Require digital protocols;
❑d. Should be reserved to specialists in prosthodontics.

Fabrication of complete denture using digital protocols:

❑a. Is time consuming;
❑b. Requires an optic impression;
❑c. Follows simplified clinical protocols;
❑d. Is mainstream in the developed world.

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FACTORS INFLUENCING THE USE OF METHAMPHETAMINE BY DENTAL PATIENTS IN THE UNITED STATES

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ABSTRACT

Aim: This literature review explores the multiplicity of issues affecting the use of methamphetamine by dental patients in the United States. Current sources investigating trends in availability of methamphetamine from nontraditional (non-dental) resources are presented. Strategies for communicating with addicted patients are presented.
Summary: Issues of addiction and recovery from this highly addictive drug are explored, as well as its well-known destructive effects on the dentition.
Key Learning Points: The review draws from current literature in the fields of addiction, substance abuse and recovery, dentistry and psychology. Treatment recommendations are drawn from evidence in interprofessional fields.
Data Extraction, Data Synthesis: Not applicable in this article
Keywords: methamphetamine, caries, periodontal disease, addiction, substance abuse.

1. Introduction

To effectively address the methamphetamine issue in our health care settings, we must have a thorough understanding of the drug's historical progression, and its impact on the United States. Amphetamine was initially synthesized in Germany in the late 1880's. Several years later, Japanese pharmacologist Nagayoshi Nagai's advancements with ephedrine allowed for the production of substances containing amphetamines on a larger scale. Amphetamine-type stimulants (ATS) gained global prominence during WWII. Soldiers were administered ATS in order to increase alertness, reduce fatigue, and diminish appetite.[1] After the war had ended, Amphetamine use gained social prevalence in several countries, including the United States. During the 1960's, manufactured ATS pills were commonly used by young adults, college students, and truck drivers to increase mood and alertness. The widespread use of substances that contained amphetamines began to shed light on the damaging psychological and physiological impacts to the body. In response, the United States government attempted to halt the progression of ATS by implementing the Comprehensive Drug Abuse Prevention and Control Act of 1970, which regulated the use of drugs containing amphetamines to medical settings. This caused a sharp decline in use of the drug's most common form of methamphetamine; curtailing its presence of meth to the western regions of the United States. Unfortunately, the following decades witnessed the rise of Wild West of Meth, fueled by the triad of Mexican drug cartels, biker gangs, and high volume of the production of methamphetamine via rural "meth labs". Inevitably, methamphetamine use began to geographically spread and reached epidemical levels across the nation. Between 1992 and 2002, an alarming spike in treatment admissions for amphetamine-related instances rose by 920% in the Midwest, 560% in the South, 455% in the West, and 45% in the Northeast.[2,3] Social outcry and public health concerns caused the government to again attempt to stamp out the issue of methamphetamine use in America. The Combat Methamphetamine Epidemic Act of 2005 was incorporated into the Patriot Act, and signed into law by former President Bush in March 2006. The Combat Methamphetamine Epidemic Act regulates over the counter purchases of products containing ephedrine, pseudoephedrine, and phenylpropanolamine in hopes of deterring the production of methamphetamine in meth labs. While recent federal regulations have decreased methamphetamine production by individuals in the United States, the roles of producer and distributor have been aggressively seized by Mexican drug cartels. John Carnevale, an economist who formerly

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worked for the White House Office of National Drug Control explains that the impact of U.S. regulations has increased of drug flow from neighboring countries saying, "We've just created incentives for non-US producers to make more."[4] Gary Hill, a Drug Enforcement Administration assistant special agent in charge of the San Diego area reports similar findings. Hill describes the process by which the methamphetamine trade has evolved. He reports a recent shift of methamphetamine manufacturing to Mexico, Hill estimates that, "About 90 percent of meth now comes from outside of the US."[4] The drugs are then stashed in large California metropolitan areas such as Los Angeles and San Diego counties, before being distributed across the country. The Mexican Drug Cartel influence has undoubtedly changed the landscape of drug presence in the United States.

1.1. Background

Conventional wisdom would lead one to believe that the January 2016 re-capture of infamous drug lord Joaquín "El Chapo" Guzmán would disrupt the cartel's operations. However, research conducted by the U.S. Customs and Border Protection found that the arrests or death of key Drug Trafficking Organization (DTO) leadership shows no discernable impact on overall drug flow in the United States. The research report explains that DTO operations have created a built in redundancy, personnel, and protocol to mitigate the impact of the removal of any one person.[5] It is clear that the regulatory measures have done little to address the issue of methamphetamine abuse in the United States. Instead, preventative measures may be more effective than punitive responses. Discussing how to deal with the methamphetamine problem in the U.S., Carnevale stresses the need for a comprehensive approach to combat the issue stating, "We need to focus heavily on prevention and education efforts to teach people about long-term effects. Meth use needs to be brought back into the national dialogue."[4]

2. Prevalence

On a global scale, methamphetamine use trends have continued to climb in the past several years. According to the United Nations Office on Drugs and Crime, there are an estimated 25 million abusers of methamphetamines worldwide. These figures exceed both cocaine and heroin, which were estimated to be 14 million and 11 million respectively.[6] A possible explanation for the increase prevalence of methamphetamine is the ability to produce the drug with commonly accessible synthetic chemicals as compared to the natural derivatives of heroin and cocaine. Nationwide estimates show that number of persons aged 12 or older who were current nonmedical users of stimulants was 1.4 million, which was higher than estimates in 2012 (1.2 million) and 2011 (970,000). Methamphetamine abuse mirrored the upward trend of stimulant use for persons aged 12 or older. In 2013, estimates of methamphetamine were 595,000, which were higher then estimates for 2012 (440,000) and 2011 (439,00).[3] Furthermore, the number of methamphetamine initiates (first time users) among persons aged 12 or older was 133,000 in 2012, which was similar to estimates in 2011, and up from 2010 (107,000).[6]

3. Demographics

A variety of factors contribute to methamphetamines and stimulants use across multiple demographics. A 2004 study in New York's club scene found that significantly higher proportion of Caucasian individuals reported lifetime use of methamphetamine compared to African American and Hispanic individuals.[7] In a second study, several of the same authors found differences in other illicit drug use between ethnic groups in New York City, such as higher rates of injected drug and ecstasy use amongst Caucasians; along with increased rates of heroin use for Caucasians and Hispanics compared to African Americans.[8] While these findings were isolated to a specific region, they do point out that methamphetamine use rates vary depending on the setting and situation.

Methamphetamine use is prevalent across genders. Treatment samples indicate that nearly as many women enter treatment for methamphetamine abuse as men. Some women have reported using methamphetamine to cope with issues such as depression, and in attempt to lose weight.[9] Research of adolescent rates of methamphetamine use found that female youth were more likely to use than their male counterparts.[10] Data also suggests women methamphetamine users are more likely to report previous exposures to trauma, including physical and sexual abuse.[11] Messina et al. study revealed that women reported violence and sexual coercion in their relationships where methamphetamine use was present. Further research found that men engaged in more risky sexual behavior than women.[12]

Another group that has been shown to be deeply impacted by methamphetamine use has been the Men who have sex with men (MSM) population. Several studies have found that the MSM population is more likely to use methamphetamine, and to have increased rates of risky behaviors associated with methamphetamine use.[1,13,14] A study conducted in San Francisco in 2005 found that rates of HIV tripled for MSM population that used methamphetamine as compared to MSM population who did not use.[13] The increased rates of infectious disease transmission may be due to unsafe sexual practices in combination dangerous injection use amongst active users of methamphetamine.[15,16]

Like many illicit drug use patterns, methamphetamine use is consistently prevalent in areas where individuals of lower socio-economic status (SES) reside.[3,17,18,19] The SES measure refers to an individual's occupational status, income, wealth, and educational attainment relative to other members of their society.[17] Rather than applying methamphetamine use to a specific population, ethnic group, or race; SES may be the most accurate indicator of increased risk of drug use, and poorer health outcomes. In a study of socioeconomic disparities in health behaviors, Pampel et al. suggest that unhealthy behaviors are directly linked to distinct

differences related to an individual's social position and SES.[19] Methamphetamine users who belong to lower SES backgrounds may lack the resources and support to break their cycle of addiction.

3.1. Comorbidity

Methamphetamine use is often compounded by existing mental health disorders, and may induced psychiatric disorders. Salo et al. conducted a sample study of 189 individuals with a history of methamphetamine abuse. The study found that a substantial number of participants also met criteria for the Diagnostic and Statistical Manual for Mental Disorders, Fourth Edition (DSM-IV) diagnoses for psychotic disorders, mood disorders, and/or other substance abuse disorders. Of the sample population, 28.6% a psychotic disorder, about a fourth of the psychotic disorders were substance-induced. 13.2% had methamphetamine-induced delusional disorders, and 11.1% had methamphetamine-induced hallucinations.[20] Previous studies share similar findings, a 106 methamphetamine participant study found a correlation between methamphetamine abuse and reported lifetime history of hallucinations (38%) and paranoia (63%). Another 247 participant study of methamphetamine dependent individuals found that 45% of participants experienced their first episode of paranoia while using the drug.[21,22] Salo et al. study also found that participants reported a significant number of lifetime mood disorders (32.3%) such as depression and anxiety.[20] Moreover, previous research has highlighted the comorbid nature of methamphetamine and mood disorders. The National Epidemiologic Survey on Alcohol and Related Conditions (NESARC) conducted a 43,093 subject analysis finding that the prevalence of mood disorder among participants with amphetamine dependence was 64%.[23,24] In a 2012 study, Weber et al. highlighted the psycho-social impact that methamphetamine dependency and depression have on employment outcomes. The study consisted of 63 participants who had used methamphetamine, 15 who were employed, and 48 that were unemployed. Of the unemployed participants, 30 (62.5%) were either currently diagnosed, or had a lifetime diagnosis of Major Depressive Disorder.[25] Weber et al. study highlights the psycho-social and occupational impairment that methamphetamine use has on lives.

An overarching commonality for methamphetamine is the comorbid abuse of other substances. Referring back to Salo et al. study, 81% of the participants met the criteria for a second substance abuse disorder along with their methamphetamine use. The most common past comorbid drug dependence diagnoses were alcohol (33%), cocaine (27%), and cannabis (15%).[20] The research indicates that cigarette use very strongly linked to methamphetamine use. A 2009 review of the data regarding the prevalence of cigarette use amongst methamphetamine users found that users reported rates of smoking between 87% - 92%.[26]

3.2. Public Health Costs

The gripping comorbid nature of methamphetamine abuse has substantial public health costs in the United States. Publically funded substance abuse treatment programs where methamphetamine was the primary substance addiction being treated increased 255% from 1997 to 2007.[3,20] According to a national report compiled by the RAND Corporation, methamphetamine use cost the United States roughly $23.4 billion dollars in 2005.[27] An Oregon State University Hospital Emergency Department (ED) study tracked 15,038 ED visits in which 383 were methamphetamine related over a 20-week period. Of the methamphetamine related cases, patients presented with psychiatric conditions (18.6%), trauma (18.6%), skin infections (11.0%), and dental disorders (9.6%). Weekly costs for methamphetamine-related ED visits averaged $133,181 dollars, and an estimated annual total of $6.9 million dollars in hospital expenses.[28] The public costs for methamphetamine abuse extends beyond primary care settings. Law enforcement agencies across the country spend substantial amounts of resources to address methamphetamine related incidences of crime. In 2015, The National Drug Early Warning System (NDEWS) published community profiles of several regions areas across the United States. The NDEWS profiles collected drug seizure data provided by the National Forensic Laboratory Information System (NFLIS), and Drug Enforcement Administration (DEA). Methamphetamine related drug reports ranked first in the following major communities: Atlanta-Metro (30.2%), Los Angeles (38 %), Denver-Metro (27.7), and Seattle-King County (29.5%). While in San Francisco, methamphetamine (10.7%) related drug reports ranked second to cannabis (11.3%).[29] The interrelated nature of the methamphetamine abuse, mental health issues, and crime have detrimental systemic costs that burden individuals and communities across the nation.

3.3. Biopsychosocial/ Neurological Effects

Methamphetamine use has been linked to an array of physiological health issues. Once in the blood stream, methamphetamine induces an adverse concentration of monoamine neurotransmitters dopamine, norepinephrine, and serotonin that adversely impact the functioning of the central nervous system. These neurotransmitters are crucial to behaviors and cognition, and play a various roles on behavior such as motivation, attention, arousal, concentration, movement, memory, and learning. When taking the drug, methamphetamine users report feelings of euphoria, abundance of energy, increased motivation, alertness, increased self-confidence, and decreased appetite.[1,30,31] However, the prolonged toxicity of methamphetamine results in excessive stimulation of the sympathetic nervous system, resulting in physiological effects such as elevated heart rate, increase blood pressure, hypertension, hyperthermia, pupil dilatation, sweating, insomnia, and psychomotor agitation.[1,31] Excessive exposure to methamphetamine has also has been linked to chronic health risks such as coronary heart disease, cardiomyopathy, pulmonary edema, stroke, and seizures.[31,32,33] Other effects of methamphetamine use include, dermatological infections, skin ulcerations,

anorexia, and dental carries.[1,33]

3.4. Pharmacology

The lipid soluble nature of methamphetamine assists its rapid movement across the blood brain barrier initiating powerful neurocognitive reactions. Not only does methamphetamine cause an extreme rush of pleasure by releasing dopamine and norepinephrine into nerve terminals, it also inhibits the natural reuptake process, resulting lasting effects of the drug.[1,31,34] This process explains the lengthy half-life of methamphetamine which is 10 and 12 hours, which substantially longer than other stimulants such as cocaine (~90 minutes).[1,30,31] Rothman et al. conducted in-vitro studies finding that methamphetamine has the potential to release twice the amount of noradrenaline as dopamine, and 60 times the amount of noradrenaline release than serotonin.[35] The exponentially powerful effects of methamphetamine give insight to the extremely addictive nature of the drug.

Prolonged use of methamphetamine has been shown to cause chronic health issue. After repetitive drug use, nerve terminals experience neurotoxicity caused by oxidative stress and neuro-inflammation resulting from increased intra and extracellular concentration of dopamine.[31,34,36] The deterioration of these terminals and depleted supply of dopamine impairs the brain's ability to naturally feel pleasure, resulting anhedonia. As a result, risks for methamphetamine abuse greatly rises as individuals increase frequency of use, dosage, and alter routes of administration in attempts to reach previous highs. Once common routes of methamphetamine administration such as smoking and oral ingestion fail to yield desired effects, methamphetamine users often shift to intravenously injections because of the superior bioavailability of the drug in the body's system.[30,31] The elevated concentration and increased potency of intravenous administration accelerates the decline of dopomergenic synapsis while exasperating physiological effects.[30,33,37] Long-term recovery outcomes are adversely affected by intravenous use due to the invasive effects throughout the body. A 3-year follow up study of methamphetamine users in recovery found that individuals who injected the drug reported significantly more severe symptoms of depression than smokers and intranasal users.[38] While dosing characteristics vary between methamphetamine users, binge episodes consisting of persistent and excessive administration of the drug typically last for several days.[30] During binge episodes, individuals often suffer from anxiety, hyper-arousal, and insomnia.1. Methamphetamine users often engage in detrimental personal health practices by consuming sugary food/drinks, and neglecting personal hygiene particularly during binge episodes.[1,33,39]

Current research shows a strong connection between methamphetamine use and a litany of psychological issues that often stem from decrease neurological functioning. Methamphetamine damages neurological processes and is expressed via maladaptive mood, behavior and cognitions. Common psychological effects of methamphetamine include hallucinations, delusions, paranoia, psychomotor agitation, while mood disorders typically manifest as depression, anxiety, and in some cases, bipolar disorders.[1,20,34] Emerging research has been able to explain how the neurological effects of methamphetamine inform the psychological pathology associated with the drug. Scott et al. published an extensive meta-analysis of the neurological effects of methamphetamine use. The review incorporated 18 studies consisting of a total of 951 participants, including 487 participants with a history of methamphetamine use, and 464 normal comparison participants. The meta-analysis aimed to identify the regions of the brain, and neurological functioning that were altered due to methamphetamine use. Scott et al. found that significant deficits were associated to neurological processes related to frontostriatal and limbic circuits. The presence of methamphetamine to these regions of the brain cause cognitive deficits to episodic memory, and executive functioning.[33] Several studies within the meta-analysis highlight the harmful effects of methamphetamine use to episodic memory. Individuals who are dependent on the drug are unable to consciously recall experiences and negative symptoms associated with prior methamphetamine use. Diminished episodic memory may be a reason that the individual repeats past mistakes associated with their drug use.[31,33] Another finding of the meta-analysis was that executive dysfunction is closely related with methamphetamine use. Participants who were dependent on methamphetamine show impairments in executive functioning involving inhibition, decision making, delayed gratification, and attention.[31,33] Other neurological issues associated with methamphetamine addiction include psycho-motor delays and verbal-learning deficits.[37] Debilitated cognitive processes such as working memory and decision-making increase the likelihood for methamphetamine dependency, risky behaviors, and poorer overall health outcomes.

Methamphetamine use has disastrous effects on the brain and body, yet there is evidence to suggest that if an individual can work towards recovery, they have the potential to have positive health outcomes. Research shows that the brain is extremely resilient. Individuals who are recovering from methamphetamine addiction have shown significant decrease of psychological symptoms, and increase in cognitive functioning. In a study involving 34 methamphetamine participants in recovery, Bagheri et al. found that after a just three weeks of abstinence, participants reported a decrease in symptoms of depression, and increase in quality of life.[40] Research indicates that not only mood disorders may be alleviated, but also neuro-cognitive performance has been shown to increase when in recovery. Several studies on participants in recovery found that abstinent individuals were able to improve neurological functioning close to baseline standards.[37,41] Individuals who were in recovery, and/or had achieved abstinence from methamphetamine use displayed marked improvements in assessments

Table 1. Interventions for those patients in the extreme risk category.

RISK CATEGORY	RECARE EXAM	RADIOGRAPHS	SALIVA TESTING	FLUORIDE	XYLITOL	ANTIMICROBIALS, i.e., Chlorhexidine	CALCIUM PHOSPHATE	SEALANTS (Resin-based & Glass Ionomers)	pH Neutralizing
LOW	6+: Every 6-12 months <6: Annual	6+: BWX every 24-36 months <6: BWX every 12-24 months	6+ & <6: Optional at baseline exam	6+ Home: OTC toothpaste 2x daily 6+ In-office: F varnish optional <6 Home: OTC toothpaste; no in-office fluoride	6+ & <6: Optional	6+: If required <6: No	6+ & <6: If required Optional for foot sensitivity (adults)	6+: Optional on sound tooth surfaces <6: Optional on sound tooth surfaces	6+: If required <6: No
MODERATE	6+: Every 4-6 months <6: Every 3-6 months	6+: BWX every 18-24 months <6: BWX every 6-12 months	6+ & <6: Recommended at baseline and recafe exams	6+ Home: OTC toothpaste 2x day + OTC 0.05% NaF rinse daily 6+ In-office: Initially 1-3 applications F varnish & at recafe appt. <6 Home: OTC toothpaste 2x day <6 In-office: F varnish initial visit & recafe Caregiver: OTC NaF rinse	6+: 6-10 grams/day <6: Xylitol wipes & substitute for sweet treats or when unable to brush Caregiver: 2 sticks of gum or 2 mints 4x day (in total 6-10 grams of xylitol per day)	6+: If required <6: Recommend for caregiver	6+: If required Optional for foot sensitivity (adults) <6: Brush with smear (0-2 yrs) of pea size (3-6 yrs) 1x day, leave on at bedtime	6+: Optional on sound tooth surfaces <6: Fluoride-releasing sealants of glass ionomers on deep pits and fissures	6+: If required <6: No
HIGH 1 or more cavitated lesions is considered high risk	6+: Every 3-4 months <6: Every 1-3 months	6+: BWX every 6-18 months <6: Anterior PAX & BWX every 6-12 months	6+ & <6: Required at baseline and recafe exams	6+ Home: 1.1% NaF toothpaste 2x day 6+ In office: Initially 1-3 applications F varnish & at recafe appt. <6 Home: OTC toothpaste 2x day <6 In-office: F varnish initial visit & recafe Caregiver: OTC NaF rinse	6+: 6-10 grams/day <6: Xylitol wipes & substitute for sweet treats of when unable to brush Caregiver: 2 sticks of gum or 2 mints 4x day	6+: 0.12% CHX gluconate 10 ml rinse for 1 minute/day for one week each month Antimicrobial therapy should be done in conjunction with restorative treatment as needed <6: Recommend for caregiver	6+: If required <6: Brush with smear (0-2yrs) of pea size (3-6 yrs) 1x day, leave on at bedtime	6+: Recommended <6: Fluoride-releasing sealants of glass ionomers on deep pits and fissures	6+: If required <6: No
EXTREME (High risk plus dry mouth or special needs) 1 or more cavitated lesions plus hyposalivation is considered extreme risk	6+: Every 3 months <6: Every 1-3 months	6+: BWX every 6 months <6: Anterior PAX & BWX every 6-12 months	6+ & <6: Required at baseline and recafe exams	6+ Home: 1.1% NaF toothpaste 1-2x day & 0.05% NaF rinse when mouth feels dry & especially after eating or snacking 6+ In office: Initially 1-3 applications F varnish & at recafe appt. <6 Home: OTC toothpaste 2x day <6 In office: F varnish initial visit & recafe Caregiver: OTC NaF rinse	6+: 6-10 grams/day <6: Xylitol wipes & substitute for sweet treats of when unable to brush Caregiver: 2 sticks of gum or 2 mints 4x day	6+: 0.12% CHX gluconate 10 ml rinse for 1 minute/day for one week each month Antimicrobial therapy should be done in conjunction with restorative treatment <6: Recommend for caregiver	6+: Apply paste several times daily <6: Brush with smear (0-2yrs) of pea size (3-6 yrs) 1x day, leave on at bedtime	6+: Recommended <6: Fluoride-releasing sealants of glass ionomers on deep pits and fissures	6+: Acid neutralizing rinses/gum/mints if mouth feels dry, after breakfast, snacking, & at bedtime <6: No

Adapted from: Jenson L, Budenz AW, Featherstone JDB, Ramos-Gomez FJ, Spolsky VW, Young DA. Clinical protocols for caries management by risk assessment. J Calif Dent Assoc. 2007;35(10):714-723. Ramos-Gomez F, Crystal YO, Ng MW, Crall JJ, Featherstone JDB. Pediatric dental care: prevention and management protocols based on caries risk assessment. J Calif Dent Assoc. 2010;38(10):746-761.

of fine motor functioning, attention, processing speed, memory, mental flexibility, and verbal fluency.[32,37,41] Furthermore, longer-term abstinence has been associated with reports of discernable improvement in mood and reduction of emotional distress.[41] If abstinence from methamphetamine abuse is sustained, there is data to suggest that structural recovery of neurological composition may occur. Morales et al. found that methamphetamine dependent individuals who were able to attain abstinence for one month displayed an increase of gray matter in all of the cortical regions that were assessed.[42] Continued abstinence from methamphetamine use has been shown to correlate with increase gray matter density. A 2005 study found that participants who achieved long term abstinence (6 months or more) had greater prefrontal grey-matter density and less impairment of frontal executive functioning compared to participants who reported short-term abstinence (less than 6 months).[32] These findings provide strong evidence for individuals who suffer from methamphetamine addiction can recovery to become well-functioning both cognitively and physically.

4. Recommendations for dental treatment

As health care professionals, it is essential that we understand the powerful effects of methamphetamine abuse on the individual and on the community. An appreciation of the interrelated bio-psycho-social factors that contribute to the cycles of methamphetamine abuse is essential for comprehensive treatment. The harmful impact of methamphetamine use, such as neurological deficits in episodic memory, increase rates of psychological disorders, and serious physiological health concerns are interrelated. Moreover, health professionals should be aware of the comorbid nature of methamphetamine use with other psychological and substance abuse disorders.

When dealing with dental disease, it is valuable to know the adverse effects of methamphetamine on oral health. Contrary to common belief, research indicates that intravenous (injection) administration of methamphetamine has been linked with increased rates of dental disease as compared to smoking or inhaling.[39,43] Route of administration is pertinent information for dentists to gather when creating a treatment plan to combat dental disease with a person who is actively using methamphetamine. Thorough information gathering regarding daily activities, such as dietary habits, will also help lead to effective dental treatment. Methamphetamine users have reported increased consumption of sugary drinks, which has been known to cause to increased rates in dental carries with users.[39,43,44]

4.1. Empathetic communication throughout treatment enhances outcomes

This demographic also suffers from periodontal disease which may lead to tooth loss. All information received from a patient should be met with appreciation and empathy. In order to increase likelihood of consistent care, gather information

about the patient's experiences navigating through the health care system. Identify barriers to treatment along, with patient's strengths and concerns about their dental health. In a large urban sample of 571 methamphetamine users, Shetty et al. found that 40 percent of participants felt embarrassed about their dental appearance.[45] Promoting dental health and addressing aesthetic concerns can be a powerful tool to increase mood, confidence, and attitudes towards change. Collaboratively create a treatment plan that focuses on attainable goals centered on harm reduction.

The authors recommend the implementation of caries risk assessment protocols for "extreme risk" patients.[46] (Table 1)

Those patients who express the desire to recover from methamphetamine use are of course the individuals most likely to benefit from our interventions. It is helpful if the dental team can collaborate with the patient's physician to facilitate a referral to a drug treatment program/ facility. A letter tailored to high caries risk patients may be mailed to the patient as follow-up to the office visit. Additionally, the letter may be sent as a copy to the physician of record for the patient. These measures help to remind the patient as well as the physician of the interprofessional collaboration that is occurring on the patient's behalf, and to serve as reminders of the recommendations for home care.

If methamphetamine use continues any treatment rendered by the dentist will not have the probability of success. There is promise in the use of silver diamine fluoride as an agent to halt the progression of caries disease for patients in recovery or for those individuals who have already recovered from their addiction to this substance.[47,48,49] Prior to treatment of carious surfaces with SDF, informed consent must include a discussion of staining and discoloration of affected surfaces, as discussed by the authors.[48,49]

The patterns and severity of dental disease associated with methamphetamine use have been studied. Brown et al, in a project published in the Journal of the California Dental Association, found

Dear (Patient Z),

Our assessment indicates that you are at extreme risk of new dental decay in the near future because you have (fill in the blank) and you have severe "dry mouth" due to (fill in the blank). We want you to move to a safer situation to avoid new decay if at all possible. Please do the following right away:

- Complete a caries bacterial test with us today (as a base line before antibacterial therapy). We will know the results of this test in three days.
- Complete a saliva flow measurement to confirm your extreme dry mouth. This is a very simple test that we will complete today as part of the bacterial assessment.
- Review your dietary and oral hygiene habits with us and receive instructions about how to improve them both. The most important thing is to reduce the number of between-meal sweet snacks that contain carbohydrates, especially sugar. Substitution by snacks rich in protein, such as cheese, will also help as well as the xylitol gum or candies recommended below.
- Brush twice daily with a new strong toothpaste, either Control RX or Prevident Plus toothpaste (5,000 parts per million fluoride). We will provide you with some today. This is to be used twice daily in place of your regular toothpaste.
- Rinse for one minute, once a day with a special antibacterial mouthrinse that we will provide you with today. It is called Peridex or Periogard and has an active ingredient called chlorhexidine gluconate at 0.12 percent. You will use this once daily just before going to bed at night (10 ml for one minute), but only for one week each month. You must use this at least one hour after brushing with the 5,000 ppm fluoride toothpaste.
- Get a fluoride varnish treatment for all of your teeth every three months at your caries recall exams.
- Receive the necessary restorative work such as fillings and crowns, as needed, in a minimally invasive fashion.
- Suck or chew xylitol candies or gum four times daily. You can obtain supplies from us today or we can help you buy these elsewhere.
- Use a special paste that contains calcium and phosphate (e.g., MI paste). Apply it several times daily to your teeth. We will teach you how to do this properly.
- Obtain a thorough professional cleaning during your current visit.
- Get a sealant treatment on all of the biting surfaces of your back teeth to keep them from being reinfected with the bacteria that cause dental decay.
- Use a baking soda rinse (or similar neutralizing product) four to six times daily during the day. You can make this yourself by shaking up two teaspoons of baking soda in an eight-ounce bottle of water.
- Please return when called for a re-evaluation in about one month.
- Please return when requested for a caries recall exam in three months.
- Get new bitewing radiographs (X-rays) about every six months until no cavitated lesions are evident.
- Come in for another caries bacterial test at the three-month visit or sooner to compare results with your first visit to check whether the chlorhexidine is working satisfactorily.
- Receive a review of your use of chlorhexidine and Control RX/Prevident and oral hygiene at that visit.
- Come in for a thorough professional cleaning as needed for your periodontal health.
- Get another fluoride varnish treatment of all teeth again at three-month caries recall visit and another set of bitewing X-rays at six months.

We will provide you with a timetable to help you to remember all of these procedures.

Although this sounds like a lot of things to do and to remember, this intensive therapy is necessary to stop the rapid destruction of your teeth. It can really work, and if you are willing to put in the time and effort, you can clear up your mouth, gums, and teeth and avoid costly restorative dental work in the future. Please help us to help you.

Practitioner signature _____ Date_____

Patient signature _____ Date_____

that methamphetamine users had higher decayed, missing, and filled teeth (DMFT), and that the duration of use significantly increased this score.[50] Recent analysis of this demographic corroborates this finding, and adds to the current knowledge base by establishing that methamphetamine users were twice as likely to have untreated caries as a control group (non-users), and four times as likely to have "caries experience". The data published by this group also found, counter to the popular perception that smoking methamphetamine causes the most severe manifestations of "meth mouth", that injection users of MA had significantly higher rates of tooth decay compared with noninjectors.[51] Periodontal disease was also found to be "unusually high" among meth users. "Whereas 37% of adults aged 35 to 49 years in the US general population have total periodontitis, more than 89% of the MA users showed total periodontitis".[45] Xerostomia and dehydration associated with meth use (mediated by alpha-2 receptors in the brain) causes users to crave sugar, and these individuals crave and typically drink "large quantities of soft drinks".[43] Additionally, oral hygiene may suffer significantly during periods of heavy drug use.[43] Bruxism is reported by 68% of meth users in a study of the effects of chronic meth use on oral health.[5]

Author contributions

Equal contribution to the paper.

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Questions

Methamphetamine may be categorized as one of the following:

❑a. Hallucinogen;
❑b. Stimulant;
❑c. Sedative;
❑d. Opioid.

Methamphetamine may be synthesized:

❑a. Only in large commercial laboratories;
❑b. By amateur chemists in homes, garages, and makeshift laboratories;
❑c. From expensive pharmaceutical grade ingredients purchased from chemical warehouses only;
❑d. Only from precursor amphetamine substrates.

Adverse dental effects of methamphetamine include the following:

❑a. Periodontal disease;
❑b. Craving for sugary drinks;
❑c. Xerostomia;
❑d. All of the above.

Recovery from methamphetamine can be achieved through

❑a. Relatively easy withdrawal methods;
❑b. Difficult long-term substance abuse recovery methods over a period of months or years;
❑c. The use of medically prescribed drugs such as diazepam;
❑d. Immediate full-time employment and reintegration into family and social networks.

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Case Reports

ENDODONTIC RETREATMENT USING MTA-BASED SEALANTS IN A TOOTH WITH PERFORATION AND PERIAPIAL LESION: A CLINICAL CASE REPORT

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ABSTRACT **DOI: 10.25241/stomaeduj.2017.4(4).art.7**

Introduction: To report an endodontic retreatment with a root perforation and use of reparative cement and filling sealant based on mineral trioxide aggregate (MTA).

Summary: Retreatment in teeth with root perforations can reduce the longevity of the treatment, because it depends on the rapid location and proper sealing, with biocompatible materials that promote tissue repair. A female patient came to the dental office complaining of pain in tooth 36, with an indication of retreatment on it. Radiographically, it presented thickening of the periodontal ligament and periapical lesion in the mesial and distal roots, leading to the diagnosis of chronic apical periodontitis. With the help of an operative microscope, it was possible to find a perforation in the most cervical portion in the furcation region of the mesio-vestibular root canal. To treat this perforation, it was filled with MTA HP Repair, to enable preparation of root canals and subsequent filling with MTA Fillapex, through the Schilder Plus technique and execution of a 12mm relief on distal root for placement of the intra-radicular retainer. Rehabilitation of teeth with root perforations can be performed with MTA-based filling sealants, presenting satisfactory results for repairs in cases of perforations and periapical lesions.

Key learning points:
- Root perforations are accidental unwanted complications that can occur in stages of the endodontic treatment;
- The prognosis for endodontic perforations depends on the size and location of the defect and how quickly the perforated area was sealed with biocompatible material.

Keywords: mineral trioxide aggregate, root canal filling materials, periapical periodontitis.

1. Introduction

Root perforations are accidental unwanted complications that can occur in stages of the Endodontic treatment, as preparation of the access cavity and preparation of the root canal, or as a result of the extension of resorption or iatrogenic procedures.[1] Of these, 53% of iatrogenic perforations occur during the insertion of intra radicular retainers and the remaining 47% are induced during routine endodontic treatment.[2]

One of the most important causes of failure in endodontic treatment is the dental perforation at different places, among which the perforations in the furcation region have the worst prognosis. Perforations lead to inflammatory response in the periodontal region, which can cause irreversible damage of the periodontal ligament or even dental loss.[3]

The prognosis for endodontic perforations depends on the size and location of the defect and how quickly the perforated area was sealed with biocompatible material. A variety of materials such as zinc-oxide eugenol, amalgam, Cavit, composite resin, glass ionomer and mineral trioxide aggregate (MTA) have been suggested to seal these perforations.[2,3,4]

The introduction of MTA by Torabinejad in 1993 had a great impact on the endodontic practice, increasing the treatment success rates. In addition to its superior sealing properties, studies have shown that MTA has excellent biocompatibility when placed in contact with the periradicular tissues.[2,5] It was initially recommended as filling material, but

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Figure 1. Initial Radiography.

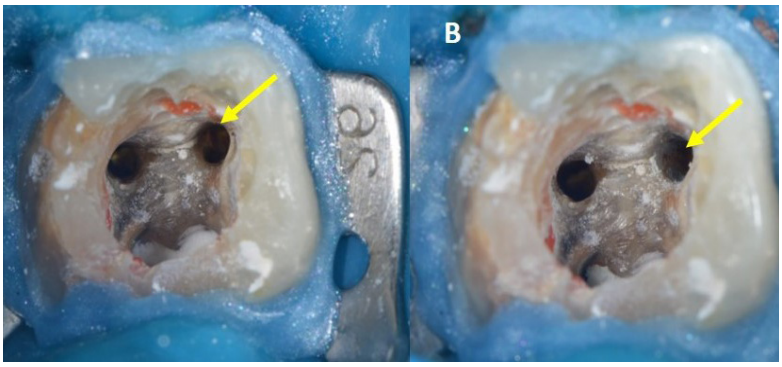

Figure 2. A. Initial aspect of the perforation; B. Aspect after placement of MTA HP Repair.

Figure 3. Radiographic aspect after the placement of MTA HP Repair in the perforation.

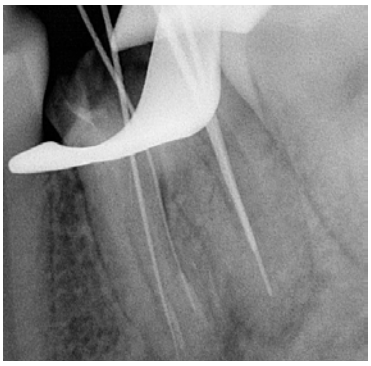

Figure 4. Odontometrics radiography.

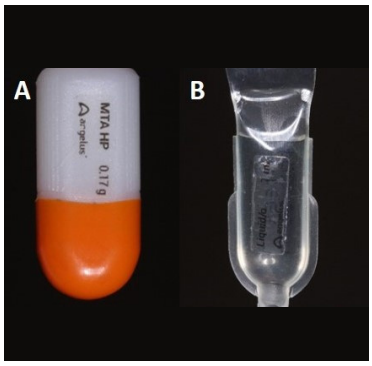

Figure 5. Product used for sealing the perforation - MTA HP Repair Sealant (Angelus Indústria de Produtos Odontológicos) A. Powder capsule; B. Liquid (distilled water).

Figure 6. Figure 6. Manipulation of MTA HP Repair reparative sealant. A. Powder; B. Liquid; C. Insertion with MTA instrument.

also features high success rates in pulp capping, pulpotomy, apical barrier formation in open apices and root perforation repair.[6]

The purpose of this clinical case report was to report an endodontic retreatment with presence of root perforation in the furcation region, in which reparative cement and filling sealant based on mineral trioxide aggregate (MTA) were used.

2. Clinical Case Report

A female patient came to the dental office complaining of pain, for retreatment of element 36. Radiographically, it presented thickening of the periodontal ligament and periapical lesion in the mesial and distal roots, leading to the diagnosis of chronic apical periodontitis (Fig. 1).

Through radiographies with angulation to mesial and distal it was possible to check the presence of 4 canals. In the first session, the following actions were performed: a crown opening, location of the canals and removal of the filling material with an ultrasound flat tip Irrisonic (Helse Dental Technology, São Paulo, Brazil). After 3 days, the patient returned and with an operative microscope it was possible to locate the perforation in the most cervical portion in the furcation region in the mesio vestibular root, which was covered by red resin (Fig. 2A). Intra canal medication based on calcium hydroxide (Biodinâmica Química e Farmacêutica, Paraná, Brazil) and a saline solution were used.

In the next session, the deviation in the mesio canal was filled with MTA HP Repair (Angelus Indústria de Produtos Odontológicos, Paraná, Brazil) and glass ionomer (S.S. White Duflex, Rio de Janeiro, Brazil) to enable performing the instrumentation of canals avoiding the expansion of the perforation (Fig. 3).

In the same session, the remaining gutta-percha present in the distal canal was removed, electronic odontometrics was performed, and the tooth received calcium hydroxide intra canal medication (Biodinâmica Quimica e Farmacêutica, Paraná, Brazil).

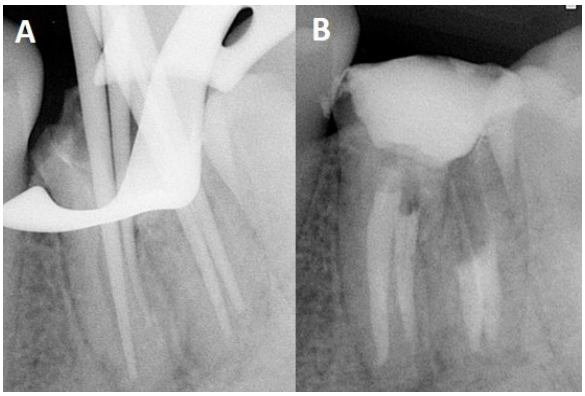

Figure 7. A. Try in of the gutta-percha points; B. Final radiographic aspect after filling.

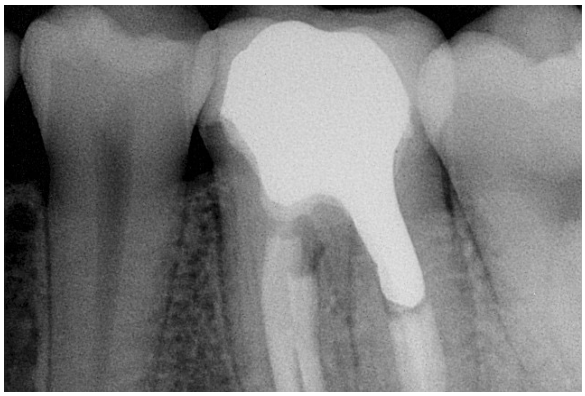

Figure 8. Follow-up radiography after 7 months.

Within 4 weeks, patient asymptomatic, the working length was confirmed via apical and radiographic locator (Fig. 4) and the perforation was filled again with MTA HP REPAIR (Angelus Indústria de Produtos Odontológicos, Paraná, Brazil) (Figs. 5 and 6) in order to increase the perforation protection (Fig. 2B). Medication was changed inside the canals.

After a month with medication, the total biomechanical preparation was performed, with the Oregon technique and intra canal medication was provided again. The patient returned after 15 days without pain, with the presence of periapical repair, and the canals were filled with gutta-percha and sealant (Fig. 7). MTA Fillapex (Angelus Indústria de Produtos Odontológicos, Paraná, Brazil) was applied using the Schilder Plus technique at the CDC adhesion level, and the distal canal was left with a 12mm relief for the placement of intra radicular retainer

After 7 months of follow-up, the patient does not present, clinically, pain symptoms and radiographically there was repair of the bone resorption in the mesial and distal roots (Fig. 8).

3. Discussion

The purpose of repairing a root perforation is to maintain a healthy periodontal, in juxtaposition with the perforation place, so that it is free of persistent inflammation and preventing or reestablishing the periodontal ligament insertion to nearby tissues. The success of the perforation repair depends on a good sealing of the perforated location with a biocompatible material and that it maintains the health conditions of the periodontal ligament.[7]

Some authors report that MTA can be used to repair root perforations with predictable results, since in examined cases, teeth did not present pathological changes after 12 to 45 months, and more than 82% of treated patients exhibited radiographic success with absence of pain.[8,9,10]

According to Siew 2015, in a revision conducted with a total of 188 perforations included in the analysis, a success rate of 72.5% was concluded, regardless of the materials used, and of 80.9% for the use of MTA. These results suggested that non-surgical repair using MTA material can result in a higher success rate compared to other materials.[7,11]

What differentiates MTA from other materials is its ability to promote the regeneration of the sealant, thereby facilitating the regeneration of the periodontal ligament. Therefore, it establishes an effective sealing of root perforations and can be considered a potential repair material that improves the prognosis of perforated teeth that otherwise would be compromised.[2,11]

Therefore, the choice of the material used in this clinical case both for the perforation repair and the filling sealant was based on the most recent literature. The radiographic follow-up shows that the success of the case represents what is found by other writers, with absence of pain, or periapical changes.

The ability to promote a proper sealing is a primary factor in the attempt to restore periodontal health,[2] and this must consider the technical skill and professional features and characteristics of the material used. The new formulations of the restorative sealant based on MTA facilitated the insertion of the material, mainly in small cavities or difficult access.

Burst perforations interfere in the dental element prognosis. The mesio vestibular root of the upper molars and the mesial root of the lower molars are highly susceptible to this type of perforation due to the thin root walls.[1] In addition to the limitation of sealing, the difficulty in determining the perforation location, its size and shape can be limiting for the case. Using microscope surgery is an effective tool in the detection and treatment of root perforations, and access to this technology was essential for the success of this case.[12]

4. Conclusion

The reparative and filling sealant based on MTA, in its composition, has effective and satisfactory results in the treatment of root perforations, mainly when associated with technologies such as the operating microscope.

Authors' Contributions

Elaboration of the article - NR; Prosthetic rehabilitation of the clinical case, Literature review - LN; Literature review, Photos of the clinical case - AM; Implementation of the clinical case - CM; Revision of article to the guidelines - GR; Implementation of the clinical case, Final revision of the article - MA.

Acknowledgments

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Dr Rodrigues Nascimento Oliveira Tavares has a Master's Degree in Integrated Clinic with emphasis on endodontics and restoration of endodontically treated teeth. She is a specialist in Endodontics certified by Centro Universitário do Triângulo (UNITRI). Since 2015 she has been volunteering in the extension project: Clinical care for patients in need of endodontic and restorative treatment in molar teeth. She has a college degree in Dentistry awarded by the School of Dentistry at Federal University of Uberlândia.

Questions

Which perforations have the worst prognosis?

❑a. Apical region;
❑b. Furcation region;
❑c. Cervical region;
❑d. Middle region.

Which materials have been suggested to seal perforation?

❑a. Amalgam, glass ionomer, MTA;
❑b. Coltosol;
❑c. Ceramic;
❑d. Zirconia.

In which area was the perforation identified?

❑a. Mesio buccal canal;
❑b. Distal canal;
❑c. Mesio lingual canal;
❑d. Mesial canal.

Which material was used in order to repair the perforation?

❑a. Amalgam;
❑b. MTA;
❑c. Glass ionomer;
❑d. Cavit.

How to reach the gold standard in prophylaxis: Guided Biofilm Therapy

Lately, more and more dental equipment companies have created associations to educate their users so as to increase the visibility of their products.

Thus, EMS - Electro Medical Systems S.A., a Swiss company, in an attempt to disseminate the unique Guided Biofilm Therapy (GBT) prophylaxis concept based on the scientific studies of Per Axelsson and Jan Lindhe1-3 from the Göteborg University, Sweden founded the Swiss Dental Academy. It provides practitioners with training courses for them to adopt a clinical protocol for the guided biofilm treatment and best patient care practices. Since its creation in 2005, it has trained over 35,000 practitioners from over 25 countries around the world. I have also been the recipient of such a guided biofilm management course.

During the IDS 2017, out of a multitude of dental prophylaxis devices, I noticed the the Ultra-Compact Prophylaxis Station+ at the EMS stand. The device is based on the Airflow® Prophylaxis Master developed by the EMS Research Center following over 100,000 hours of technical and clinical testing in collaboration with top dental professionals around the world. The device was designed to meet the highest standards of performance, safety and comfort, being built to meet the 3 basic treatments of the Guided Biofilm Therapy (GBT):

1. Removing supragingival biofilms, stains and young calculus from natural teeth, restorations and implants. It is performed in a single cleaning and polishing procedure with the Airflow Handpiece made of medical-grade resin bodies and new generation thermo-disinfectable materials;
2. Removing subgingival biofilms from periodontal and peri-implant pockets from 4 to 9 mm. It is carried out with the Perioflow® Handpiece and Plus powder which ensures effective elimination of the biofilm, sustained reduction in bacteria, prevention of tooth loss or loss of implants;
3. Removing the supra and subgingival residual calculus. It is done with the ergonomic Piezon® Led instrument based on the revolutionary No-Pain technology, ideal for conservative treatments and minimally invasive therapies. The instrument has an optimal diameter with a narrow tip for better visibility and accessibility, alongside a 5,0000 Kelvin built-in lamp that provides natural light. All the unique EMS Piezon tips are made of surgical stainless steel.

In addition to the qualities of Airflow® Prophylaxis Master, the Ultra-Compact Prophylaxis Station+ has the following advantages:

• Pressurization Tower
Automatic pressurization system pressurizing and depressurizing within seconds with a 360° integrated magnetic connection.
• Interactive Touch Panel
Simple and ergonomic touch panel comes with a 10 level responsive interface that regulates and manually adjusts temperature and volume control feature with operating sound notifications and maintenance reminder.
• New Cord
Durable and more efficient, the new EMS cord has a 'plug-and-play' system that is easily detachable and simple to service.
• Foot-Pedal Wireless
Wireless stainless steel foot-pedal with boost mode and 360° power activation access.
• External Filters
Transparent air & water filters allowing for an easy check at a glance.
• Purge System
Completely integrated Airflow® and Piezon® waterline purge system cleans fluid lines in under a minute.
• New No Pain Technology
Dynamic response feature automatically regulating the output power according to the required force to remove calculus.
• Seamless Design
Easy to clean and maintain. All cables are stored in the station to eliminate trip hazards.
• Ultra-compact
Efficient space management.
• Independent Bottled Water Supply
No need for an external water connection.
• Easy to Move and Store
360° movement.
• Extra Storage Space
For additional powder bottles.

The Ultra-Compact Prophylaxis Station+ is an effective alternative to reach the gold standard in prophylaxis: Guided Biofilm Therapy (GBT).

Florin - Eugen Constantinescu
DMD, PhD Student
Editorial Director, Product News

The Ultra-Compact Prophylaxis Station+
(EMS - Electro Medical Systems S.A., CH-1260 Nyon, Switzerland)
https://www.ems-dental.com/en/accessories/airflow-station-plus

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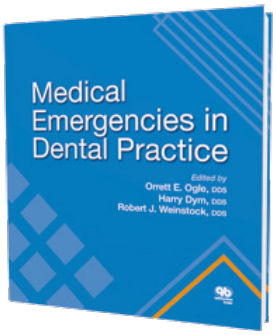
Medical Emergencies in Dental Practice



Authors: Orrett E. Ogle / Harry Dym / Robert J. Weinstock (Ed.)
Publisher: Quintessence Publishing
Language: English
ISBN: 978-0-86715-569-3
Edition: 1/e
Publish Year: 2016
Pages: 200, illustrated
Price: 69.00 €

Dental personnel must be trained to handle medical emergencies that occur during daily treatment. Yet, efficient management of medical emergencies should be thoroughly prepared in advance.
Drs Orrett E. Ogle, Harry Dym and Robert J. Weinstock's book entitled "Medical Emergencies in Dental Practice" develops a step-by-step treatment guide as well as decision-making algorithms for the immediate treatment of patients with medical emergencies. In distinct and clearly structured chapters the readers are familiarized with pretreatment evaluation of the dental patient, essentials of an emergency kit and basic life support techniques.
Having acquired this knowledge, the readers are prepared to handle the most common medical emergency situations encountered during dental treatment such as: respiratory emergencies, acute chest pain, syncope, allergy and anaphylaxis, seizures, epilepsy, and stroke, nausea and vomiting, hemorrhagic emergencies, emergencies in the pregnant patient, hypertension and hypotension emergencies, TMJ emergencies, diabetic emergencies, malignant hyperthermia, thyroid crisis, local anesthesia emergencies, and adrenal crisis. This book provides an essential practical guide that should not be missing from the library of any dental clinic.

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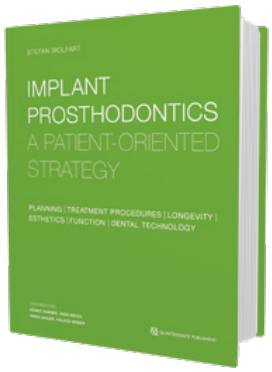
Implant Prosthodontics

A Patient-Oriented Strategy: Planning | Treatment Procedures | Longevity | Esthetics | Function | Dental Technology



Dental Technology
Authors: Stefan Wolfart
Publisher: Quintessence Publishing
Language: English
ISBN: 978-1-85097-282-2
Edition: 1/e
Publish Year: 2016
Pages: 728, illustrated
Price: 289.00 €

Specialized literature abounds in books about surgical aspects of oral implantology, but there is no comprehensive and systematized textbook on the implant-supported prosthodontic rehabilitation of the patient. This book entitled Implant Prosthodontics - A Patient-Oriented Strategy under the editorship of Professor Stefan Wolfart fills this gap in the literature giving a comprehensive, explanatory, and abundantly illustrated book including five parts and twenty-seven chapters.
The first part presents the Basic Principles of implant prosthodontics by analyzing patient profile, esthetic, dental prosthesis, emergencies, and implant-abutment profiles, timing of implant placement and loading protocols. Part two covers Treatment Concept and Treatment Planning starting from the medical and dental history, examination and diagnosis, establishing seven basic rules of implant prosthodontic planning for each individual clinical situation. Part three, Clinical Procedure, presents radiographic analysis, surgical guide, surgical procedures, provisional restorations, impression-taking technique, the maxillomandibular relationship record, fixed and removable restoration, occlusion concept, intraoral optical impression, prosthetic complications, and aftercare and recall. Part four, which deals with Restorations Concepts, analyzes one by one the single tooth gap within the esthetic zone, the multi-tooth gap or the free-end situation, severely reduced dentition and the edentulous arch. The final part is dedicated to Laboratory Procedures, fixed and removable prostheses on implants. The book ends with an Appendix of materials, instruments, equipment, and software.
Implant Prosthodontics - A Patient-Oriented Strategy is a fundamental guide for both implantologists and prosthodontists, but also for general dentists and dental technicians in which they will find a complete and systematic presentation on the implant-supported prosthodontic rehabilitation of the patient illustrated with over 2,000 figures and many flowcharts.

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The Books Review is drafted in the reviewer's sole wording and illustrates his opinions.

Occlusal Adjustments in Implants and Natural Dentition - 3D Occlusion

Author: Vicente Jiménez-López
Publisher: Quintessence Publishing
Language: English
ISBN: 978-1-85097-292-1
Edition: 1/e
Publish Year: 2016
Pages: 240, illustrated
Price: 148.00 €

Occlusion is a very important part of maintaining the health of the stomatognathic system. Over time there have been many books on this subject, but Dr Vicente Jiménez-López manages to make o very compelling demonstration of this topic in his book entitled "Occlusal Adjustments in Implants and Natural Dentition - 3D Occlusion".
Starting from the operating philosophy that the human body needs to be evaluated from a holistic perspective for its proper functioning, it must provide the structures with a perfect balance in correlation with functional dental occlusion. After defining and illustrating the occlusion related terminology, the book presents the basic principles of organic occlusion. For any rehabilitation case it is essential that the quality of anterior guidance is evaluated first, continuing with centric relation, bilateral posterior occlusal stability and vertical dimension. These aspects are eloquently presented and illustrated in different chapters. The description and explanation of the prematurities and interferences that are the cause of the occlusal dysfunction and TMJ pathology are the outstanding achievements of this book. Completion of any oral rehabilitation case in implants and natural dentition requires occlusal adjustment in a stomatognathic system with relaxed muscles through the splint therapy. This book comes with an illustrative DVD which includes more than 200 clinical animations.
Dr Vicente Jiménez-López' book is a comprehensive presentation starting from the principles of occlusion and addressed both beginner and advanced dentists and technicians in practicing oral rehabilitation.

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Beyond Lingual Orthodontics Vol. 1: Lingual Biomechanics

Author: Roberto Lapenta
Publisher: Quintessence Publishing
Language: English
ISBN: 978-84-89873-64-3
Edition: 1/e
Publish Year: 2016
Pages: 604, illustrated
Price: 180.00 €

An orthodontist in daily practice is very frequently required by patients to use lingual orthodontic treatment for aesthetic reasons. Dr Roberto Lapenta's book entitled "Beyond Lingual Orthodontics. Vol. 1: Lingual Biomechanics" gathers his experience of lingual therapy including mistakes and achievements, successes and failures and presents useful procedures for lingual orthodontics. The book has ten chapters and is written in Spanish and English (two-column format), and each chapter has a QR code that links to demonstration videos online.
The first two chapters tackle procedures and arguments that help us develop customized protocols for each case and patient. He believes that it is very important to understand the specific biomechanics of orthodontics and in the next two chapters he shows all lingual brackets used and different methods for positioning. In chapters five and six reveals the fundamental issue of bonding considering that 30% of the treatment success is based on the bonding of brackets including their positioning, the individualization of prescription and the optimization of bonding. Facilitating many treatments is due to the use microimplants and anchorage which are explained in chapters seven and eight. The last two chapters analyze the friction and the resolution of dental crowding with lingual orthodontics.
Dr Roberto Lapenta and his collaborators have been able to provide readers with a well-structured and photographic documented book that is a step-by-step guide for improving lingual orthodontic treatment.

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The Books Review is drafted in the reviewer's sole wording and illustrates his opinions.

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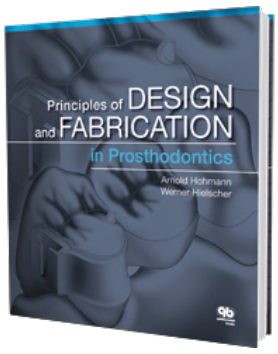
Principles of Design and Fabrication in Prosthodontics



Author: Arnold Hohmann / Werner Hielscher
Publisher: Quintessence Publishing
Language: English
ISBN: 978-0-86715-612-6
Edition: 1/e
Publish Year: 2016
Pages: 408, illustrated
Price: 128.00 €

"Principles of Design and Fabrication in Prosthodontics", a book written by Arnold Hohmann and Werner Hielscher covers the working steps in the design and fabrication of restoration and dentures. It is addressed to advanced dental students and technicians. The textbook has nine chapters and describes the philosophy behind prosthodontic design, being a genuine guide.
It presents the working principles and features of preprosthetics, coronal restoration, partial and removable partial dentures, telescopic and resilient anchoring and supporting elements, as well as the basic terms in the statics and dynamics of partial dentures. There is a complex chapter dealing with complete dentures which presents most techniques of design and fabrication, such as Gysi, Hiltebrandt, Schreinmakers, Gerber, Ludwig and APFNT System. The book approaches the topic of implantology describing the implants types, the component parts, the indications and prosthodontics in implantology. After reading this book, dental technicians have the ability to carry out successful prosthodontic work much better than those who have not read it yet.

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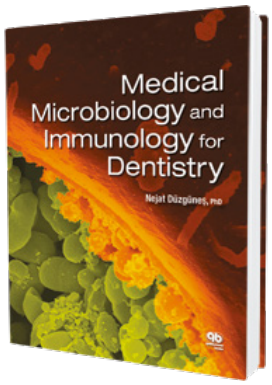
Medical Microbiology and Immunology for Dentistry



Author: Nejat Düzgünes
Publisher: Quintessence Publishing
Language: English
ISBN: 978-0-86715-647-8
Edition: 1/e
Publish Year: 2016
Pages: 306, illustrated
Price: 118.00 €

Nejat Düzgünes, PhD, currently Professor in the Department of Biomedical Sciences at the University of the Pacific Arthur A. Dugoni School of Dentistry decided to write this book entitled Medical Microbiology and Immunology for Dentistry specifically addressed to dentists, because all medical microbiology textbooks are generally much too detailed for training purposes. This textbook has five parts and 41 chapters. The first part is dedicated to Immunology and presents the immune system, antibodies and complement, immune response and vaccines. The second part is about Bacteria, and talks about bacterial structure, metabolism, and genetics, bacterial pathogenesis, antibacterial chemotherapy, sterilization, disinfection, and antisepsis, microbial identification and molecular diagnostics and illustrates a lot of bacterial types. Oral microbiology is covered in two major chapters: Oral Microflora and Caries, and Periodontal and Endodontic Infections. A discussion about Fungi, fungal structure, replication, and pathogenesis, fungal diseases and antifungal chemotherapy is the content of part three. The last two parts present Viruses, Prions and Parasites along fourteen chapters. Most of the conditions treated by dentists are the result of bacterial infection and understanding the microbiology of these diseases is essential for their treatment. Through complete information on microbiology and immunology, this book is a quintessence of specialty literature and a therapeutic guide useful in each dentist's daily practice.

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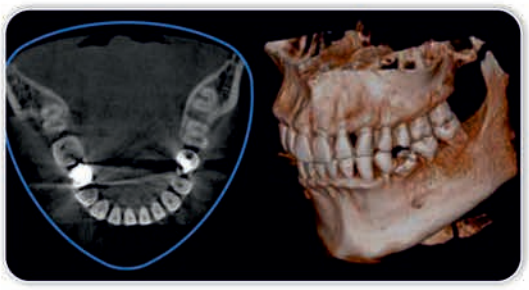

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