ROMANIAN ACADEMY

STOMATOLOGY EDU JOURNAL

2017 VOLUME 4 ISSUE 1

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1
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CE PROGRAM FAQs

HOFIGAL®

Hofident Q10

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 aetion, 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).

2 Intrarea Serelor Str., Sector 4,
042124, Bucharest, ROMANIA

Tel./Fax: +4021-334.59.05;
+4021-334.74.86;
+4021-492.00.69.
e-mail: office@hofigal.eu,
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stomaeduj

2017 Volume 4 Issue 1
Pages 1-78

EDITOR OFFICE:
Stomatology Edu Journal
102-104 Mihai Eminescu st., 2nd District
RO-20082 Bucharest, ROMANIA
Tel/Fax: +40314 327 930
e-mail: stomatology.edu@gmail.com
www.stomaeduj.com
EDITORS:
Jean-François ROULET
Rolf EWERS
Marian-Vladimir CONSTANTINESCU
MANAGING EDITOR:
Florin-Eugen CONSTANTINESCU
ROPOSTURO
Romanian Association of Oral Rehabilitation and Posturotherapy
10, Ionel Perlea St., 1st District
RO-010209 Bucharest, Romania
Tel: +4021 314 1062
Fax: +4021 312 1357
e-mail: roposturo@gmail.com
www.roposturo.stomaeduj.com
PROJECT EDITOR:
Irina-Adriana BEURAN
DESIGN EDITOR:
Dragoș Georgian GUȚOI
COVER BY:
Arch. Florin ADAMESCU

PUBLISHER OFFICE:
Romanian Academy Publishing House
13, Calea 13 Septembrie, 5th District
RO-050711 Bucharest, Romania
Tel: +4021 318 81 46, 4021 318 81 06
Fax: +4021 318 24 44
e-mail: edacad@ear.ro
www.ear.ro
TECHNICAL EDITOR:
Doina ARGEȘANU
EDITORIAL ASSISTANT:
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SUBSCRIPTIONS
S.C. MANPRES DISTRIBUTION S.R.L.
1, Piața Presei Libere, Corp B
3rd floor, room 301–302, 1st District
RO-013701 Bucharest, Romania
Tel/Fax: +4021 314 63 39
e-mail: abonamente@manpres.ro
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ISSN 2360 – 2406 (Print)
ISSN 2502 – 0285 (Online)
ISSN – L 2360 – 2406

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Teamwork

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

Dear readers,

When I was a dental student one colleague told me: "Let's do teamwork". I asked back: "What does this mean?" and got the answer "You work, I team!". Of course I declined, because this was a total misinterpretation, or in other words the abuse of the team idea. During my whole life I have seen the team idea working perfectly towards success. In a team there is a group of highly motivated individuals who have different knowledge and skills and are working together towards a common objective. To be successful, communication is key! Open mind, open architecture or at least open office doors help a lot to develop the team function, which must be complemented by trust and openness. Say what you think and do what you say is the mantra. I will quote a few examples below.

When I moved to Berlin to become chair of a new department in a new institution, we had to define the teaching philosophy, to create teaching materials and robust structures to run the department, in order to fulfill the task of the three basic duties of an academic department: research, teaching and service (patient treatment). This task was impossible for a single individual (me). Therefore I was able to create a team approach by having a group of very motivated young dentists who wanted to change things towards a modern and effective dentistry being taught to our students. The tasks and responsibilities were shared as well as the credit for positive accomplishments. After a relatively short two years the Dental Clinic North of the Free University of Berlin was known as an excellent institution.

When I moved to the industry to become a manager, by definition the whole product development was performed by teams, where the best people for the task were selected from the different departments and assembled into a development team. With the high level of discipline and structure which is common for a well-functioning enterprise, we were successful year after year.

Some years ago I had the pleasure to listen to Bertrand Piccard who in March 1999 together with Brian Jones was the first to surround the globe in a balloon. Both spent 21 days in the 5 m long and 2 m wide carbon composite capsule, suspended from a gigantic hot air/helium balloon. It was all about team work. The two in the balloon depended on a control center which helped them make the right technical decisions as well on two meteorologists that gave them directions for which altitude to get the best winds. I remember that he told us the following story when asked how foolish he could be to hire two meteorologists (since no two meteorologists have the same opinion) he rerouted the question to the meteorologists that responded "It is the wrong question since we are 3!". Baffled, the person who had asked the question wanted to know who the third one was then. The answer was, "We together are the third one!"

Finally just a few weeks ago I was impressed by another great team which is very successful. Greg Sawyer, an engineer who suffers from a melanoma has joined the University of Florida cancer researchers.

Merging their knowledge and his, they came up with printing soft scaffolds which can harbor real tumors in vitro. Using this system they can observe how cells of the immune system interact with the tumor in order to

destroy it and how the tumor reacts to this attempt. Using the team approach they can test, in vitro, proposed cancer drugs and therapies very efficiently and closer to reality. This team is so successful that national grant money will flow in to fund their operations and they will build here in Gainesville a center for soft matter printing and cancer research.

Finally I want to remind you of the successful team that is producing the Stomatology Edu Journal. Many people with different skill sets are involved to create a semi-annual journal in print as well as on the internet. From finances to acquiring manuscripts to running the peer review process in order to create an appealing layout, a team of experts is at work for you readers to guarantee a high quality outcome! It is my task as Editor-in-Chief to thank them all!

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

DOI: 10.25241/stomaeduj.2017.4(1).edit.1

Promoting a fair quality control mechanism in specialized publications

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

Dear readers,

As a member of the editorial board of a young scientific journal pertaining to the global academia I have noticed that the fundamental principles of research are abandoned in the specialized literature in favour of "publications aimed at shopping around" (Dr Mutlu Özcan, 2009)[1] able to attract considerable funds and flatter some colleagues' professional vanity.

There are 17,000 higher education institutions in the academic world (according to Rauhvargers, 2011)[2], and over 1.8 million dentists working around the world (as declared by Worldmapper in 2004)[3], as well as an unknown number of dental researchers, while there are just over 6,000 dental journals[4] out of which only 91 are rated (Web of Science, 2017)[5]. This situation makes it difficult to publish an article, proof to that being my own personal experience alongside the Italian colleagues with respect to an original article that was printed about four years after its "conception".

To prevent similar situations from happening to Central and Eastern European researchers, in 2013, we launched the Stomatology Edu Journal, together with Professor Jean-François Roulet (University of Florida) and Professor Rolf Ewers (Medical University of Vienna), alongside an enthusiastic group of prestigious editors. The journal has been self-financing since 2016 and is included in the portfolio of the Romanian Academy publications.

The academia is clearly interested in publishing and the competitive spirit of researchers worldwide is being stimulated, but there are increasingly more frequent situations when ethical standards and professional deontology are violated in the "rush" for sponsorship and personal visibility.

The "open review" method allows referees to know the author's name, which could cause the premature rejection of the manuscript when the referees compete with the authors for the same grants, which distorts their right judgment, causing them to make decisions influenced by institutional or individual rivalry.

In order to promote the referees' impartiality we have chosen the commonly accepted practice implemented by renowned journals, namely the "double-blind review", which so far has proven to be the only way to ensure a fair quality control mechanism in specialized publications. As of this year, also as a common working practice of renowned journals, out of respect for your dear readers, besides the two referees unknown by the authors who evaluate each article, before the article you will read reaches the final evaluation by Professor Jean-François Roulet, it will be also assessed by an Academic Editor.

As part of the international collaboration of the journal I contacted Professor Michael L. Glick, Professor and Dean Emeritus, School of Dental Medicine, University at Buffalo, State University of New York, Editor of JADA, the Journal of the American Dental Association which has more than 100 years of tradition and is published monthly in over 170,000 copies.

During the First International Congress in Bucharest, Professor Michael Glick was the guest of honour of the Dean of the Faculty of Dental Medicine, Assoc Prof Dr Paula Perlea; it was an opportunity I used to present to

him the latest issue of the journal.
While acting with the courtesy and professionalism characteristic of a great Editor, Professor Glick made an exacting analysis of the content of the journal. He was appreciative of the fact that the articles published are accompanied by an evaluation form and the journal is also published online, with a monthly average of 5,000 unique visitors, topping over 94,000 readers, including more than 23,000 in the US.
Professor Glick suggested that we should maintain a constant number of online readers; that we should go from two to four annual issues; that we should use the structure of BDJ, JADA, JPD and other major publications, and that each issue should be co-ordinated by two editors whose responsibility would be to avoid unwanted mistakes.
As there is nothing accidental about globalization, we had another good friend of ours in Bucharest, namely Professor Adi A. Garfunkel, Dean Emeritus in Jerusalem and Professor Glick's master. For years on end, while he was in Bucharest, Professor Adi A. Garfunkel was so thoughtful that he provided me with a lot of helpful advice during my term as director of the "Professor Dan Theodorescu" OMF Surgery Hospital. With a lot of enthusiasm and generosity, so typical of him, he asked Professor Michael Glick to get involved in promoting the visibility our journal and for each issue to offer 3 items with JADA CE Credits to the US readers.
We are now waiting to see the result of Professor Michael Glick's request addressed to Mr Michael Springer, JADA Publisher, to get the 3 JADA CE Credits articles for the first issue of the Stomatology Edu Journal.
May the forthcoming Easter holiday bring light to the Stomatology Edu Journal readers, members and non-members of the American Dental Association (ADA).
So help us God!

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

References
1. Ozcan M. Peer review revisited--a note about publication-shopping scientists. J Adhes Dent. 2009;11(2):87.
2. Rauhvargers A. Global university rankings and their impact. Brussels: European University Association; 2011.
3. http://www.worldmapper.org/display.php?selected=218
4. Tijssen RJ, Yegros-Yegros A, Winnink JJ. University-industry R&D linkage metrics: validity and applicability in world university rankings. Scientometrics. 2016;109(2):677-696.
5. https://lib.hku.hk/sites/all/files/files/denlib/impact%20factor%202015.pdf

DOI: 10.25241/stomaeduj.2017.4(1).edit.2

A SIGNIFICANT SCIENTIFIC EVENT

The Faculty of Dental Medicine of the "Carol Davila" University of Medicine and Pharmacy in Bucharest organized the First International Congress of this institution for the last 28 years on 16-19 March 2017.
The event was held at the National Military Club Palace in Bucharest, which is an iconic building in the Romanian Capital City. It was built in 1912 using the plans of Dimitrie Maimaroiu, Romanian architect, in order to become the venue dedicated to catering for the social, cultural and educational needs of the Romanian Army.
The First International Congress organized by The Faculty of Dental Medicine of the "Carol Davila" University of Medicine and Pharmacy in Bucharest was meant to help dentists update their theoretical and practical knowledge, with its prestigious Romanian and foreign guests.
The topic of the Congress was "Dental medicine: a patient-tailored calling" and it focused on presentations made by important representatives of various areas of dental medicine, while highlighting methods and techniques which can be implemented in the dentist's office. Various workshops were also organized as part of the Congress, which covered various areas of dental medicine such as oral implantology, dental digital impressions, rubber dam isolation, supra-dental prosthesis on dental implants, major emergency situations in a dentist's office and

Assoc Prof Dr Paula Perlea and Professor Michael L Glick

Professor Michael L Glick,
Assoc Prof Dr Paula Perlea,
Professor Anda Kfir,
Professor Aaron Palmon and
Professor Jean-François Roulet

malpractice-related issues.
Dean Assoc Prof Dr Paula Perlea personally invited a number of prestigious foreign dentists, who accepted her invitation: Professor Michael L Glick, Dean Emeritus of the School of Dental Medicine of the New York University at Buffalo and JADA editor, Professor Jean-François Roulet from the University of Florida and former editor of the Journal of Adhesive Dentistry, and Oral Health & Preventive Dentistry, and editor of the Prophylaxe Impuls, Dean Emeritus of the Berlin School of Dental Medicine, Professor Aaron Palmon, Dean of the School of Dental Medicine of the Hebrew University of Jerusalem, Professor Adi A Garfunkel, Dean Emeritus of the Hebrew University of Jerusalem, Professor Gottfried Schmalz from the University of Regensburg, member of the German National Academy of Sciences - Leopoldina, Professor Kasturi (Saman) Warnakulasuryia from King's College London, Professor Iannis Iatrou, head of the bucco-maxillo-facial surgery clinic in Athens, Professor Anda Kfir, head of the endodontics clinic of the Tel Aviv School of Dental Medicine, Professor Stelianos Dalampiras from Thessaloniki, Dr Domenico Ricucci, opinion leader in endodontics in Italy, Professor Itzak Abramovitz, head of the endodontics clinic at the Hebrew University of Jerusalem as well as many others.
Following a proposal made by Dean Assoc Prof Dr Paula Perlea, and the unanimous vote given by the Senate of the "Carol Davila" University of Medicine and Pharmacy in Bucharest, on Friday, March, 17, 2017, Ioanel Sinescu, Rector of the University and Member of the Romanian Academy, awarded the title of Doctor Honoris Causa of the "Carol Davila" University to Professor Michael L Glick and Professor Jean-François Roulet for all their activity and merits dedicated to the development of dentistry.
During the Congress an exhibition was also organized which presented products, dental instruments and materials meant to guide dentists with respect to the current offer.
We can consider the Congress a real success, as it was attended by significant national and foreign dentists, it enjoyed a large audience, comprising dental students, dental residents as well as dentists.

Assoc Prof Dr Paula Perlea and
Professor Jean-François Roulet

Marina Meleșcanu Imre
DMD, PhD
Associate Professor
Vice-Dean of the Faculty of Dental Medicine
of the "Carol Davila" University of Medicine and
Pharmacy in Bucharest

DOI: 10.25241/stomaeduj.2017.4(1).news

20th Annual World Dental Summit
Date: 20 - 22 March 2017
Location: Rome, Italy
Event types: Conference, Exhibition
Visit event website: http://worlddental.conferenceseries.com/scientific-program

Congress BREDENT GROUP DAYS - 2017
Date: 05 - 09 April 2017
Location: Bansko, Bulgaria
Event types: Conference, Exhibition, Hands-on
Visit event website: http://bgdbansko.strikingly.com/

24th National Congress of the Collegio dei Docenti Universitari di Discipline Odontostomatologiche
Date: 06 - 08 April 2017
Location: Milan, Italy
Event types: Conference, Exhibition
Visit event website: http://www.congressicduo.it/international-symposium.html

New Orleans Dental Conference & LDA Annual Session
Date: 06 - 08 April 2017
Location: New Orleans, USA
Event types: Conference, Exhibition
Visit event website: http://www.nodc.org/conference

Digital Transformation in Dentistry Congress
Date: 07 - 08 April 2017
Location: Istanbul, Turkey
Event types: Conference, Exhibition
Visit event website: http://3dcongress.com/scientific-program/

IMAGINA DENTAL
Date: 13 - 15 April 2017
Location: Monaco, Monaco
Event types: Conference, Exhibition, Workshops
Visit event website: http://www.imaginadental.org/index.php?page=567

24th International Conference on Dentistry & Oral Care
Date: 17 - 19 April 2017
Location: Dubai, UAE
Event types: Conference, Exhibition
Visit event website: http://dentistry.conferenceseries.com/scientific-program

41st International Dental Forum & Exhibition
Date: 17 - 20 April 2017
Location: Moscow, Russia
Event types: Conference, Exhibition
Visit event website: http://www.dental-expo.com/dental-salon/eng/

33rd Annual American Academy of Cosmetic Dentistry Scientific Session
Date: 18 - 21 April 2017
Location: Las Vegas, USA
Event types: Conference, Exhibition
Visit event website: https://www.aacdconference.com/

2017 AMSMB Dental Medicine Symposium
Date: 21 - 22 April 2017
Location: Bucharest, Romania
Event types: Conference, Exhibition
Visit event website: http://www.unas.ro/unas/content/view/1938/1/

The 2nd International Quintessence Symposium on Oral Health: The Oral-Systemic Health Connection
Date: 21 - 22 April 2017
Location: Charlotte, USA
Event types: Conference, Exhibition
Visit event website: http://www.quintpub.com/iqsoh/program.pdf

International Dental Congress 2017
Date: 25 April 2017
Location: Kyiv, Ukraine
Event types: Conference, Exhibition
Visit event website: http://medforum.in.ua/?page_id=3438&lang=en

IAP 2017 - 16th International Congress of Periodontology of the International Academy of Periodontology
Date: 27 - 29 April 2017
Location: Brasov, Romania
Event types: Conference, Exhibition
Visit event website: http://www.atemedical.ro/ShowPage/?Name=Program-EN

1st African Regional Dental Congress
Date: 27 - 29 April 2017
Location: Marrakes, Morocco
Event types: Conference, Exhibition
Visit event website: http://www.african-dental-congress.org/programme/

3rd International Dental Implantology Conference
Date: 27 - 30 April 2017
Location: Cartagena, Colombia
Event types: Conference, Exhibition, Hands-on Courses
Visit event website: http://www.cortexdentalevents.com/#schedule

2nd International Conference and Expo on Dentistry & Prosthodontics
Date: 04 - 05 May 2017
Location: Toronto, Canada
Event types: Conference, Exhibition
Visit event website: http://prosthodontics.conferenceseries.com/scientific-program

147th Annual Session of the Texas Dental Association
Date: 04 - 06 May 2017
Location: San Antonio, USA
Event types: Conference, Exhibition
Visit event website: http://www.tda.org/Events/News-Home/ArtMID/646/ArticleID/237/The-TDA-Meeting

8th ConsEuro / AIC 19th International Congress
Date: 11 - 13 May 2017
Location: Bologna, Italy
Event types: Conference, Exhibition
Visit event website: http:// http://accademiaitalianadiconservativa.it/en/programma-aic-19th-international-congress-and-conseuro/

International Conference on Oral Biology and Restorative Dentistry
Date: 18 - 19 May 2017
Location: Toronto, Canada
Event types: Conference, Exhibition
Visit event website: http://oralbiology.dentalcongress.com/scientific-program

14th International Congress of Esthetic Dentistry
Date: 18 - 20 May 2017
Location: Bucharest, Romania
Event types: Conference, Exhibition, Hands-on
Visit event website: http://www.sser.ro/en/congress

30th International Conference on Dental Science & Advanced Dentistry
Date: 22 - 23 May 2017
Location: Las Vegas, USA
Event types: Conference, Exhibition
Visit event website: http://advancedentistry.dentalcongress.com/scientific-program

RDS 2017 - Congress of Romanian Dental Society
Date: 25 - 27 May 2017
Location: Bucharest, Romania
Event types: Conference, Exhibition
Visit event website: http://sdr.info.ro/

EAED 2017 Spring Meeting
Date: 25 - 27 May 2017
Location: Milan, Italy
Event types: Conference, Exhibition
Visit event website: http://milan.eaed.org/scientific-program/

The 25th International Symposium on Ceramics
Date: 02 - 04 June 2017
Location: San Diego, USA
Event types: Conference, Exhibition
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EOS Congress 2017 - European Orthodontic Society - 93rd Edition
Date: 05 - 10 June 2017
Location: Montreux, Switzerland
Event types: Conference, Exhibition
Visit event website: http://www.eos2017.ch/preliminary-programme-at-a-glance.html

ICOI European Congress / PSI 2017
Date: 08 - 10 June 2017
Location: Krakow, Poland
Event types: Conference, Exhibition
Visit event website: http://www.icoi.org/wp-content/uploads/2017/03/KONGRES_EN_marzec_2017.pdf

24th World Congress on Dentistry and Oral Health
Date: 12 - 13 June 2017
Location: London, UK
Event types: Conference, Exhibition
Visit event website: http://dentalevent.conferenceseries.com/registration.php

9th AIO International Congress
Date: 15 - 17 June 2017
Location: Chia Laguna (Cagliari), Italy
Event types: Conference, Exhibition, Hands On
Visit event website: http://congress.aio.it/programma.php

12th International Symposium on Periodontics & Restorative Dentistry
Date: 16 - 19 June 2017
Location: Boston, SUA
Event types: Conference, Exhibition
Visit event website: http://www.quintpub.com/isprd/2016_ISPRD_Final_Program.pdf

28th Asia Pacific Congress on Dental and Oral Health
Date: 10 - 12 July 2017
Location: Kuala Lumpur, Malaysia
Event types: Conference, Exhibition, Workshops
Visit event website: http://www.dentalcongress.com/asia-pacific/registration.php

AGD 2017 - Academy of General Dentistry
Date: 13 - 15 July 2017
Location: Las Vegas, USA
Event types: Conference, Exhibition, Workshops
Visit event website: http://www.agd2017.org/attendees/registration.aspx

23rd Global Dentists and Pediatric Dentistry Annual Meeting
Date: 17 - 18 July 2017
Location: Munich, Germany
Event types: Conference, Exhibition
Visit event website: http://annualmeeting.conferenceseries.com/dentists/registration.php

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March 2017

Estrich CG, Gruninger SE, Lipman RD.
Rates and predictors of exposure to Legionella pneumophila in the United States among dental practitioners: 2002 through 2012. J Am Dent Assoc. 2017 Mar;148(3):164-171. doi: 10.1016/j.adaj.2016.11.032. Epub 2017 Jan 23.

http://jada.ada.org/article/S0002-8177(16)30962-X/fulltext

CHITOSAN MODIFIED POLY(LACTIC-CO-GLYCOLIC) ACID NANOPARTICLES INTERACTION WITH NORMAL, PRECANCEROUS KERATINOCYTES AND DENTAL PULP CELLS

Maria Justina Roxana Virlan[1a], Bogdan Calenic[1b], Cimpan Mihaela Roxana[2c], Daniela Elena Costea[3d], Maria Greabu[1e*]

[1]Department of Biochemistry, Faculty of Dentistry, University of Medicine and Pharmacy Carol Davila, Bucharest, Romania
[2]Department of Clinical Dentistry - Biomaterials, Faculty of Medicine and Dentistry, University of Bergen, Bergen, Norway
[3]The Gade Laboratory of Pathology, Department of Clinical Medicine, University of Bergen, Bergen, Norway

[a]DDS, MSc, PhD Student
[b]DDS, PhD, Lecturer
[c]DDS, PhD, Associate Professor
[d]DDS, PhD, Professor
[e]PhD, Professor, Head of Department

Received: February 28, 2017
Revised: March 22, 2017
Accepted: April 02, 2017
Published: April 03, 2017

Academic Editor: David Wray, MD (Honours), BDS, MB ChB, FDS, RCPS (Glasgow), FDS RCS (Edinburgh) F Med Sci, Professor Em., Professor, University of Glasgow, Glasgow, UK

Cite this article:
Virlan MJR, Calenic B, Cimpan MR, Costea DE, Greabu M. Chitosan modified poly(lactic-co-glycolic) acid nanoparticles interaction with normal, precancerous keratinocytes and dental pulp cells. Stoma Edu J. 2017;4(1):14-24.

ABSTRACT

DOI: 10.25241/stomaeduj.2017.4(1).art.1

Introduction: Nanoparticles (NPs) can carry molecules to different body tissues. Due to their controlled delivery properties, chitosan covered poly-lacto-co-glycolic NPs (PLGAChi NPs) could be used to deliver drugs to oral tissues for the treatment of dental diseases or in anticancer therapy. The aim of this study was to determine the uptake and cytotoxicity of PLGAChi NPs on different types of cells found in the oral cavity.
Methodology: Normal oral keratinocytes (NOKs), precancerous keratinocytes (POE9i) and dental pulp cells (DPCs) were exposed for 12h and 24h to 20 g/mL and 200 g/mL PLGAChi NPs covalently tagged with fluorescein. 3D organotypic tissues of oral mucosa were grown in vitro and exposed to 200g/mL PLGAChi NPs for 24h.
Results: Both normal and premalignant oral mucosa cells (NOKs and POE9i) displayed uptake of PLGAChiNPs in a time and concentration-dependent manner, both in 2D and 3D models. A higher and more rapid uptake of PLGAChi NPs by precancerous cell line POE9i was observed when compared to NOKs. Interestingly, DPCs did not display internalized PLGAChi NPs, even at the highest concentration of 200 g/mL.
Conclusion: Chitosan-coated PLGAChi NPs proved to be able to cross the cellular membrane of oral keratinocytes, in 2D as well as in 3D cultures. The polymeric NPs used in the present study seem not to be suitable for applications that require NPs uptake by DPCs, as no evidence of uptake in these cells was found in this study. The finding that PLGAChi NPs showed significant internalization by human keratinocytes indicate that they could be used for drug delivery purposes to oral mucosa.
Keywords: chitosan, PLGAChi, nanoparticles, oral keratinocytes, dental pulp.

1. Introduction

Polymeric nanoparticles (NPs) have been considered as the most efficient vehicles for drug delivery due to their excellent pharmacokinetic properties such as particle size, surface charge, surface chemistry, hydrophobicity, degree of rigidity and degradation speed.[1-3] Specifically, poly-lacto-co-glycolic NPs (PLGA NPs) can transport molecules to different tissues in the body, facilitating intracellular uptake of various drugs.[4]
However, the overall negative charge of PLGA NPs has been reported to diminish their interaction with the negatively charged cell membrane.[5-6] PLGA NPs can be surface modified to carry a positive charge by the addition of a chitosan shell. PLGA-chitosan NPs combine the positive charge of chitosan and PLGA's ability to efficiently entrap hydrophobic and hydrophilic drugs.[7-8] Chitosan, the deacetylated derivative of chitin, is used as the coating polymer, because it is cationic, biocompatible and biodegradable.[28] Chitosan-modified NPs were develloped for the transport of active molecules through nasal, ocular, vaginal or intestinal mucosa.[6]

***Corresponding author:**

Prof. Dr. Maria Greabu, PhD, Professor, Department of Biochemistry, Faculty of Dentistry, „Carol Davila" University of Medicine and Pharmacy of Bucharest, Bucharest, Romania
8 Blvd. Eroii Sanitari, Sector 5, RO-050474 Bucharest, Romania
Tel/Fax: +40.721.274.932 / +40.213.110.984, e-mail: mariagreabu@yahoo.com

Chitosan nanocarriers could be used in future dental applications[9] such as in dentin pulp regeneration procedures,[10-11] in bone regeneration techniques,[12] in endodontics[13-15] or in periodontal therapy.[12, 16] Moreover, chitosan containing NPs were able to transport antitumour substances to different cancer cell lines,[17-19] including oral cancer cells.[18-19]

Despite numerous scientific reports regarding organic nanomaterials in medicine, more experiments are needed in order to asses the effects of organic NPs on the oral mucosa. It has been shown that the interactions between NPs and cells depends on the cell type, as well as on the size and surface charge of NPs.[20] NPs behave completely differently depending on their surface coverings and size, while the concentration and the exposure time to such NPs makes them cytotoxic or biocompatible. Moreover, the oral mucosa is composed of a variety of cells with different properties which may react differently to the same NPs. The pathologic conditions can also modify the response of human oral cells to NPs, due to changes in cell physiological status.

The aim of our study is to determine the uptake and effect of chitosan covered poly-lacto-co-glycolic NPs (PLGAChi NPs) on the cells found in the oral cavity, in normal and pathological conditions. NPs were tested on normal human oral keratinocytes (NOKs) and human dental pulp cells (DPCs), harvested from healthy human donors, as well as on POE9i cell line used as a model for precancerous oral keratinocytes. In the attempt to create a stronger resemblance to the natural 3D structure of the oral mucosal tissue, the PLGAChi NPs were also exposed to 3D organotypic (OT) oral mucosa tissues grown in vitro. The PLGAChi NPs tested in our study were previously fabricated and characterized by Navarro et al.[21- 22]

2. Materials and methods

2.1. Cell culture

NOKs, DPCs and normal oral fibroblasts (NOFs) were primary cells isolated from clinically healthy adult volunteers (n=5). Samples of gingival mucosa showing no sign of clinical inflammation at collection time were used to generate NOKs and NOFs. The protocol for the isolation of NOKs has previously been described by Costea et al.[23] DPCs were isolated following a protocol adapted from from Ishkitiev et al.[24] and Lee et al.[25]

POE9i cells are dysplastic, premalignant human immortalized oral keratinocytes. NOKs and POE9i keratinocytes were grown in Keratinocyte Serum-Free Growth Medium (KSFM) (from Sigma-Aldrich, St. Louis, MO) medium supplemented with 1 ng/mL epithelial growth factor, 25 µg/mL bovine pituitary extract, 20 µg/mL l-glutamine, 100 U/mL penicillin, 100 µg/mL streptomycin and 0.25 µg/mL amphotericin B (all supplements were aquired from InVitrogen, Massachusetts, USA).

DPCs and NOFs were grown in DMEM medium (Sigma St Louis, Missouri) containing 10 % fetal bovine serum, 20 µg/mL l-glutamine, 100 U/mL penicillin, 100 µg/mL streptomycin, and 0.25 µg/mL amphotericin B (all supplements were aquired from InVitrogen, Massachusetts, USA). The protocol for growing normal human organotypics (OTs) was previously described by Costea et al.[23] The multilayered epithelium was elaborated using NOKs grown on top of collagen matrices populated with NOFs.

2.2. Viability Test

NOKs and POE9i cells were cultured in 6 well plates (150.000 cells/well) with 3.5 mL of culture medium. Cells were allowed to set for 24h into the incubator at 37°C and supplemented with 5% CO_2. Afterwards, the media was removed and the cells were washed with PBS. Then 3.5 mL media containing PLGAChi NPs at the tested concentrations was added in each well: 5 µg/mL, 20 µg/mL and 200 µg/mL. The viability was counted with trypan blue and an automatic cell counter (Sigma-Aldrich, St. Louis, MO). The counting was done in triplicates for every cell culture well.

2.3. Exposure of cells to PLGAChi NPs

The cells were seeded in two-well glass chambers (Thermo Fisher Scientific; Nunc™ Lab-Tek™) at a density of 75.000 cells/well. Every cell type was incubated with 1.5 mL of their own culture medium. The cells were kept for 48 h at 37°C till they became 70 % – 80 % confluent. Afterwards, the media were removed and washed twice with PBS. NOKs, DPCs and POE9i cells were exposed for 12h and 24h at the following concentrations of fluorescein marked PLGAChi NPs: 20 µg/mL and 200 µg/mL. 1.5 mL of media containing PLGAChi NPs at the mentioned concentrations was placed in every chamber slide: 20 µg/mL and 200 µg/mL. The solutions thus prepared were rotated for 30 minutes before exposure. The glass chambers were placed in the incubator in a humidified atmosphere at 37°C and supplemented with 5 % CO2 for 12 h or 24 h. At the end of the exposure time, the cells were washed three times with PBS in order to remove unattached particles, followed by fixation and staining. The controls were run in duplicate in each experiment and were placed into the incubator for one day.

The organotypic cultures were exposed to NPs after a total period of 10 days of coculture. The OTs were exposed to 200 µg/mL PLGAChi NP and let into the incubator for 24h. At the end of the exposure time, the OTs were washed three times with PBS in order to remove unattached particles, followed by fixation and staining.

Imaging and image analysis was performed using an optical microscope.

The fluorescent NPs uptaken by the cells were visualized by flourescence microscopy (AxioImager.M2 with ApoTome.2). The cells were mounted in Vectashield mounting medium with DAPI for nuclear staining and were visualized at a Zeiss up-right Axio Imager microscope with ApoTome slider module, using the 403 or 603 oil immersion objective lens.

Images were captured with Axi-oVision Rel 4.8 software controlled by AxioCam MRm camera (Carl-Zeiss, Germany). All images were representative of at least two independent experiments.
The quantification of NPs uptake was obtained with the help of the Icy software, using two plugins (HK-MEANS) : one developed by Dufour A.[26] and another one created by De Chaumont F.[27]

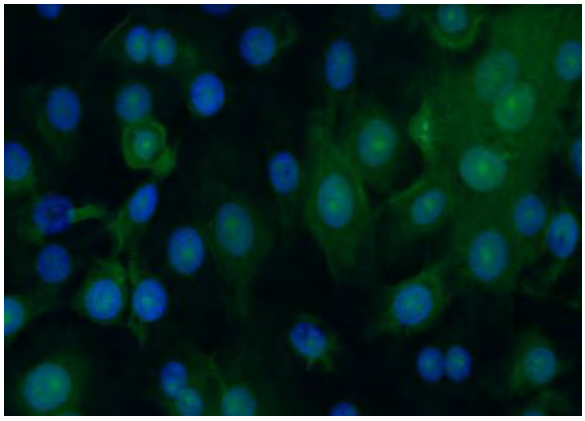
2.4. Statistical analysis

NPs uptake and cytotoxicity data were compared using Student's t-test. A p value < 0.05 was considered statistically significant.

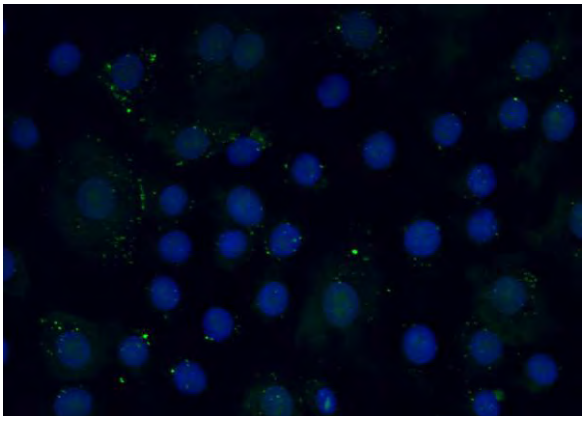
3. Results

3.1. PLGAChiNPs uptake by NOK, POE9 and DPC cells

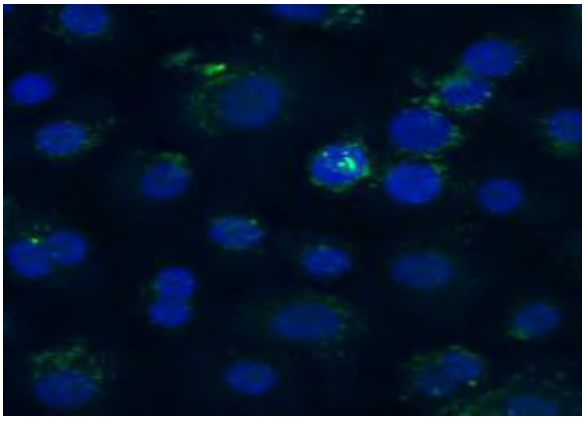
The PLGAChi NPs uptake by NOKs and POE9i cells was determined by fluorescence microscopy (Fig. 1, Fig. 2), as well as by confocal imaging (Fig. 4, Fig. 5). The quantification of NPs uptake revealed a significant amount of NPs inside the cells, both in normal human oral keratinocytes NOKs, as well as in premalignant oral keratinocytes POE9i (Fig. 6). Interestingly, the data obtained revealed a penetration of PLGAChi NPs in almost all the keratinocytes exposed to the NPs at the tested concentrations and time points (Fig. 6). The uptake of NPs inside NOKs varied from 91,83 % +/- 7,37 to 100 % for NOKs, meaning that a significant amount of keratinocytes incorporated the PLGAChi NPs. In NOKs the percentage of cells which showed incorporation of PLGAChi NPs was 91,83% +/- 7,37 after 12h exposure at a concentration of 20 µg/mL PLGAChi NPs. 92,39+/- 1,34 of the exposed NOKs showed NPs uptake after 24h exposure to 20 µg/mL PLGAChi NPs. PLGAChi NPs entered 98,55% +/-1,95 of the tested NOKs after incubation for 24h with 200 µg/mL PLGAChi NPs.
The total uptake inside NOKs was observed after one day of incubation with 200 µg/mL PLGAChi NPs. In POE9i cell line, all tested samples showed a 100% uptake of PLGAChi NPs at all the tested concentrations (20 µg/mL PLGAChi NPs and 200 µg/mL PLGAChi NPs) and exposure times (12h and 24h) (Fig. 6) .
The fluorescence microscopic images showing DPCs presented no relevant differences between control images and images of DPCs exposed to PLGAChi NPs (Fig. 3). No NPs were observed inside the cells exposed to PLGAChi NPs, even at the highest concentration 200 µg/mL and at the longest exposure time, 24h.



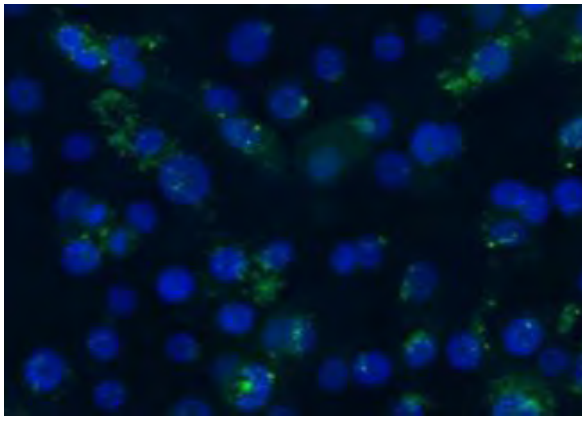
A. NOKs control.



B. NOKs 20 µg/mL PLGAChi NPs12h.



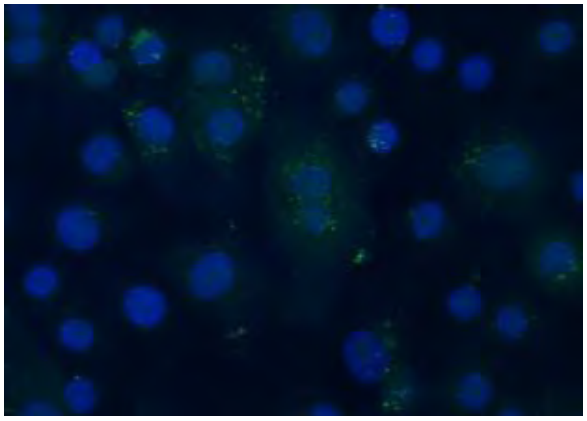
C. NOKs 20 µg/mL PLGAChi NPs 24h.



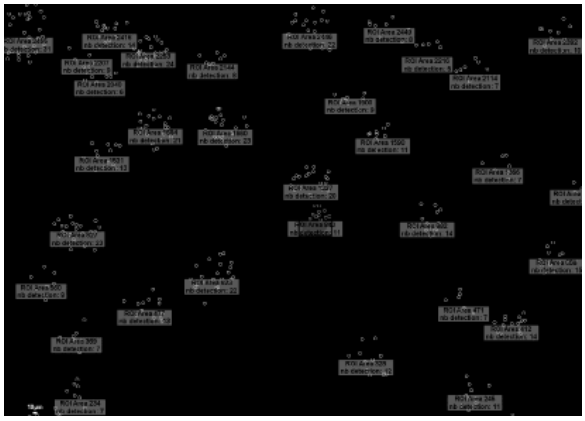
D. NOKs 200 µg/mL PLGAChiNPs12h.

3.2. PLGAChi NPs uptake in 3D organotypic cell cultures of normal human mucosa in 3D cell cultures

Intracellular uptake of the PLGAChi NPs was visible in the epithelial compartment of the reconstituted human oral mucosa grown in vitro. The images obtained by fluorescence microscopy revealed that PLGAChi NPs were able to penetrate the superficial layers of the reconstituted epithelial mucosa after 24h exposure at a concentration of 200 µg/mL.

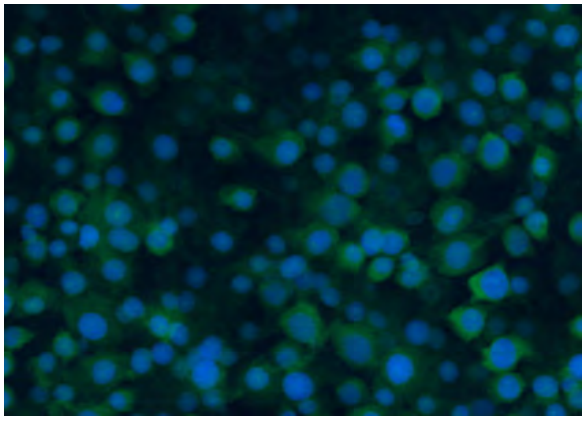


E. NOKs 200 µg/mL PLGAChi NPs 24h.

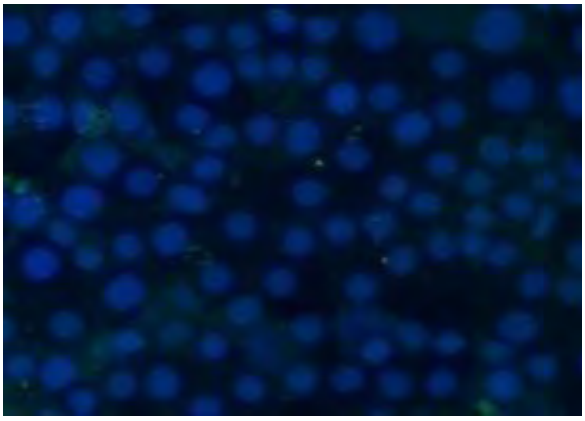


F. PLGAChi NPs detection (NOKs 200 µg/mL PLGAChi NPs 24h).

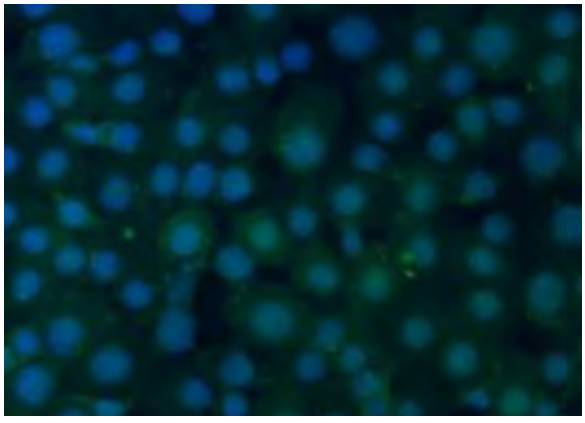
Figure 1. Fluorescence images showing uptake of PLGAChi NPs byNOKs.



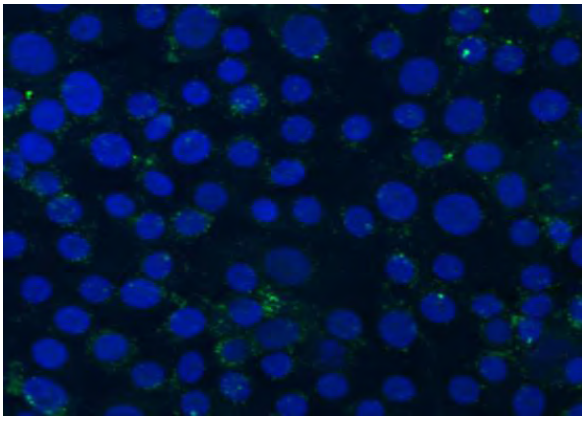
A. POE9i Control.



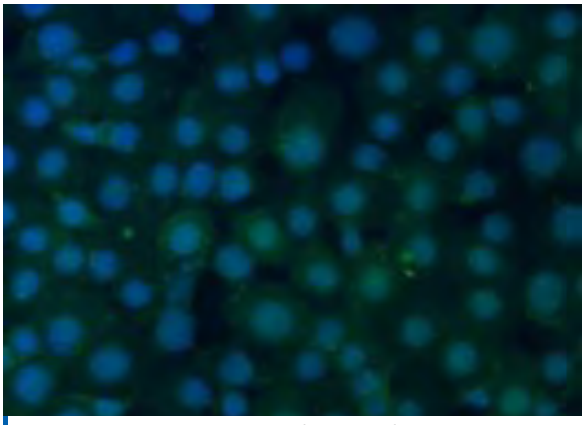
B. POE9i 20 µg/mL PLGAChi NPs12h.



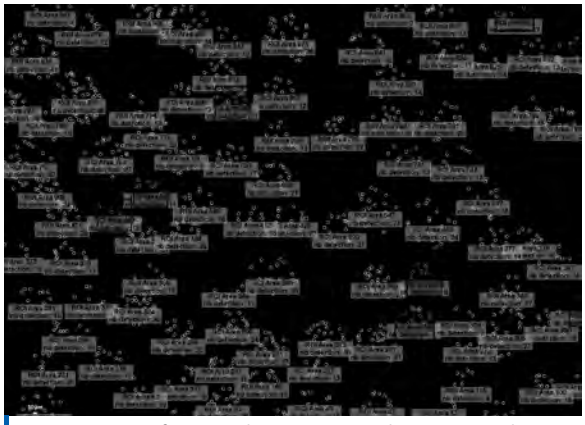
C. POE9i 20 µg/mL PLGAChi NPs 24h.



D. POE9i 200 µg/mL PLGAChi NPs 12h.

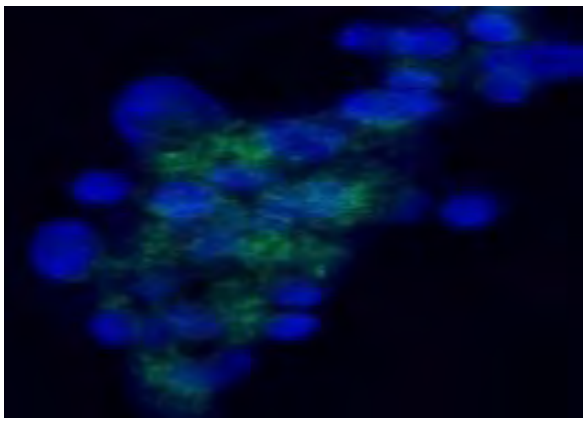


E. POE9i 200 µg/mL PLGAChiNPs 24h.

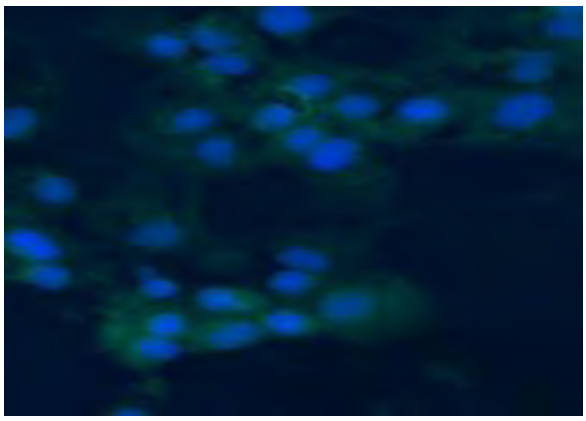


F. Detection of PLGAChi NPs internalization inside POE9i (image of POE9i 200 µg/mL PLGAChi NPs 12h).

Figure 2. Fluorescence images showing uptake of PLGAChi NPs inside POE9i. The fluorescent green dots are the internalized PLGAChi NPs.



A. DPCs Control.



B. DPCs 200 µg/mL PLGAChi NPs 24h.

Figure 3. Fluorescence microscopy images showing no signs of PLGAChi NPs uptake by DPCs cells.

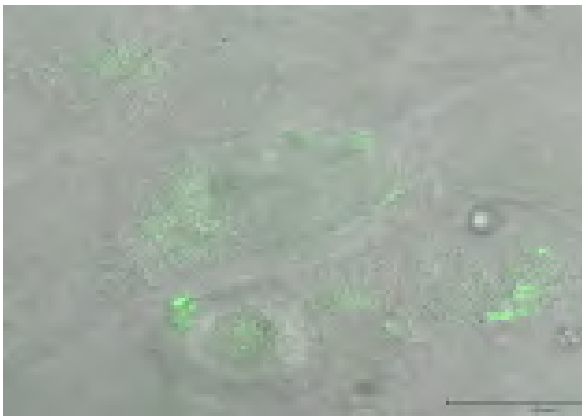


Figure 4. Confocal microscopy image demonstrating PLGAChi NPs uptake inside NOKs. The green fluorescent PLGAChi NPs are observed inside cells.

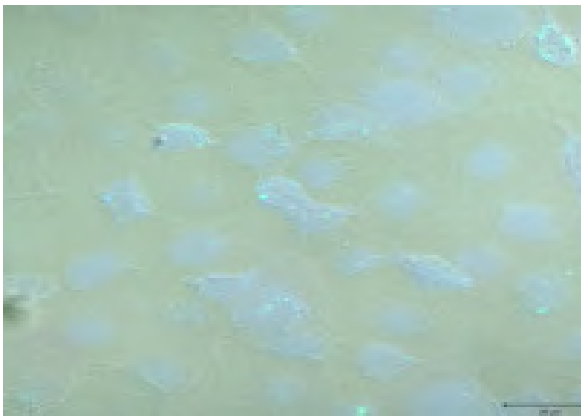


Figure 5. Confoccal Images of POE9i exposed to 200 µg / mL PLGAChi NPs for 12H. The fluorescent PLGAChi NPs green NPs are observed inside the cells.

3.3. Cytotoxicity evaluation of PLGAChi NPs in NOKs and POE9i cells

After 24h exposure to PLGAChi NPs, NOKs demonstrated no significant difference in the viability values at all tested concentrations: 5µg/mL, 20 µg/mL and 200 µg/mL PLGAChi NPs. A slight decrease in viability was observed inthe POE9i cell line exposed to 20 µg/mL PLGAChi NPs. However, the POE9i samples exposed to 20 µg/mL PLGAChi NPs showed 81% percentage of viable cells, as compared to 88 % live cells, in the control sample.

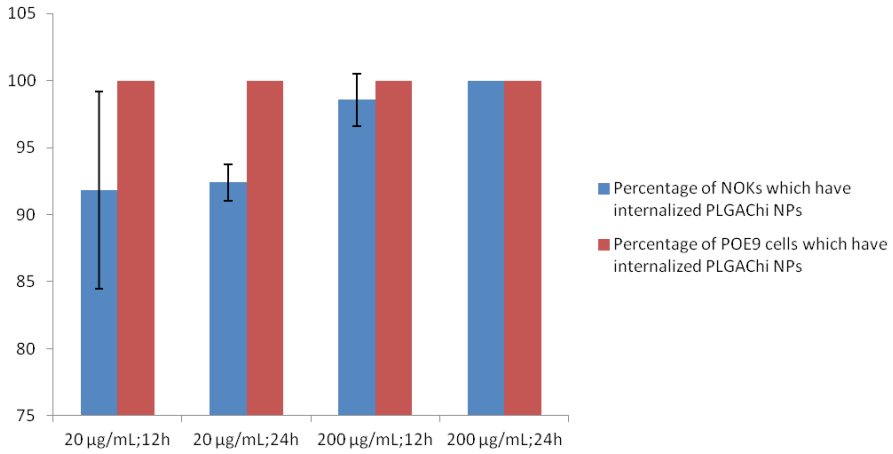


Figure 6. Percentage of cells which have internalized PLGAChi NPs from the total amount of exposed cells. NOKs and POE9i cells (average values).

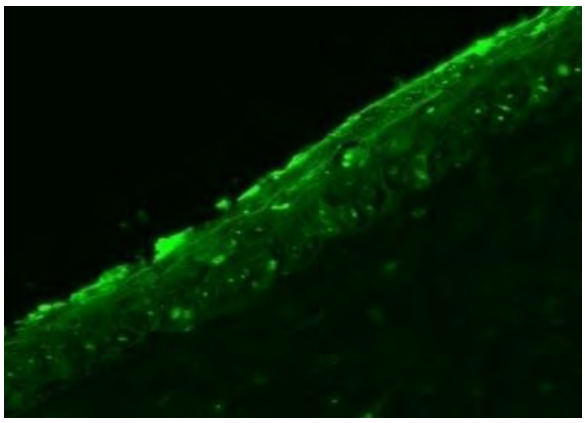


Figure 7. Penetration of PLGAChi NPs in the 3D organotypic models of human mucosa. The green fluorescent dots represent the PLGAChi NPs which were able to enter the reconstituted OT of normal human mucosa. The sample was exposed to 200µg/mL PLGAChi NPs for 24h.

In the NOKs and POE9i cell there was no statistical difference between the control and treated cells (Fig. 8).

4. Discussion

Polymeric NPs are still viewed as the first option for drug delivery and also widely used in the research of other diseases.[1-3] Recently, a wide variety of studies has been undertaken leading the way for possible future applications of PLGA NPs in a high number of dental fields, from periodontology and endodontics to tissue regeneration of skin, bone or cartilage.[28] Biocompatibility, biodegradability, flexibility, and minimal side effects are the main advantages when using PLGA for biomedical applications.[4] However, the overall negative charge of these NPs has been reported to diminish their interaction with the negatively charged cell membrane, while the rapid opsonization of hydrophobic PLGA NPs is a major limitation

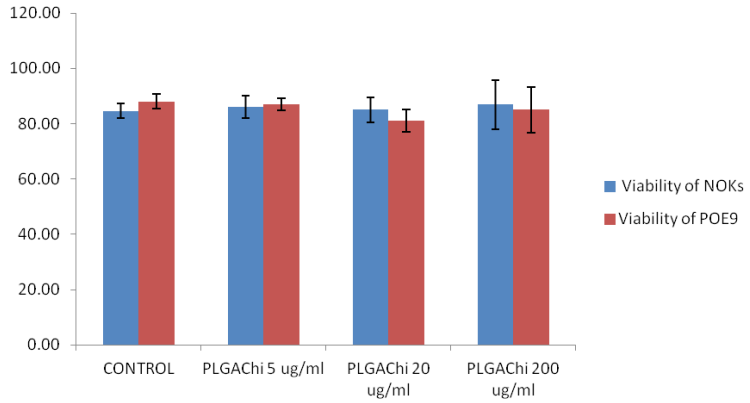


Figure 8. Viability of NOKs and POE9i after exposure to PLGAChi NPs.

that hinders their employment for biomedical applications.[5-6]

In order to improve PLGA NP proprieties, several research groups have tried to cover the polymers with a chitosan coating. Chitosan is obtained from chitin which is a positively charged polysaccahride found in crustaceans.[28] Chitosan contains many amino and hydroxyl groups, thus it can bind effectively to negatively charged substances (such as the cells membranes) via electrostatic interactions or hydrogen bonding, thus improving the intracellular uptake.[9] Chitosan by itself is known to strongly adhere to negatively charged surfaces due to its high charge density at pH< 6.5.[29] The advantages of modifying the surface of PLGA NPs with a mucoadhesive polymer, such as chitosan, may potentially include the inversion of zeta potential, the ability to promote cellular adhesion and retention of the delivery system at the target site.[30]

In order to fabricate polymeric NPs for future dental applications, we have tested the positive charged chitosan coated PLGA NPs (PLGAChi NPs) on oral cavity cells. NPs interaction with the oral epithelial cells was assessed by cytotoxicity measurements. After 24h of incubation with PLGAChi NPs (20 µg/mL NPs and 200 µg/mL NPs) no significant statistic differences were observed in the viability of samples and controls (Fig. 8). PLGA Chi NPs were biocompatible to all the tested cell lines: NOKs and POE9i cells. We found no association between the significant increase in the cell uptake of chitosan containing NPs and cell toxicity, at the tested concentrations. Due to PLGA and chitosan's well known biodegradability and biocompatibility, it was expected that NPs made of chitosan and PLGA would be well tolerated by the cells. Our results are in agreement with other comparable studies. Following a 2015 experiment, S. Alqahtani stated that chitosan covered PLGANPs did not affect the viability of Caco-2 cells.[31] Caco-2 cells displayed a viability above 95%, even after incubation for one day with a higher concentration of NPs than it was used in our study: 500 µg/mL PLGAChi NPs.[31] Moreover, chitosan covered NPs did not contribute additional toxicity to colorectal cancer cells after 3 days of exposure at a 75 µM solution of NPs.[32] The viability of the cells incubated with chitosan NPs remained at about 90 % relative to the untreated cells on day 1 and at about 89 % on day 3.[32] Another recent study also found that the surface modification of PLGA NPs with chitosan did not show any significant diffference in cytotoxicity of PLGA NPs.[6] The results indicated that A549 cell lung carcinoma cells exhibited around 80 % cell survival as compared to positive controls (10 % cytotoxic) for the following concentrations of PLGAChi NPs: 0.25, 0.5, 0.75, 1,1.25, 1.5, 1.75 and 2 mg/mL.[6] Other investigators have reported PLGAChi NPs to be safe even at much higher concentrations of 20 mg/mL.[33-35] In addition, other research groups revealed interesting cytotoxicity results of chitosan NPs effect on human skin keratinocytes HaCaT cells. Tretinoin containing chitosan solid lipid NPs were not cytotoxic to HaCaT cells even at the highest concentration 500 µg/mL used, which led to around 5 % less viability compared with the control.[36] Also lecithin/chitosan NPs can be applied to skin cells at concentrations up to 200 µg/mL without inducing plasma membrane damage or cell viability decrease.[37] Similarly, in a recent study, HaCaT cells exposed to melatonin containing lecithin/chitosan NPs in a concentration of chitosan of 1.25-20 µg/mL for 2 hours showed no relevant cytotoxicity.[38] However, a significant reduction in the cell viability of HaCaT cells was observed in the case of cells treated with NPs at a chitosan concentration of 20 µg/mL.[38] Chitosan-alginate NPs did not have a toxic effect on human monocytes but there was mild toxicity to skin keratinocytes at higher concentration of NPs.[29] Moreover, chitosan and PLGA NPs loaded with chlorexidine dihydrochloride in vitro toxicity evaluation on human gingival fibroblasts was between 20 % and 60 % in all experimental conditions.[9] Poly-γ-glutamic acid/glycol chitosan NPs incorporating p-phenylenediamine (PDA) showed lower cytotoxicity against HaCaT human skin keratinocyte cells than PDA alone.[39] Interestingly, PDA-incorporated NPs showed reduced apoptosis and necrosis reaction in HaCaT cells.[39]

A possible explanation for the chitosan NPs high biocompatibilty could be that chitosan is much more cytotoxic in a free soluble form than when it is incorporated into NPs, due to the fact that in the case of NPs, a significant portion of the positive amino groups of chitosan are engaged in electrostatic interractions.[38, 40]

To confirm PLGAChi NPs efficiency in intracellular penetration, the cellular internalization of PLGAChi NPs conjugated with fluorescein was investigated by fluorescence microscopy. The results indicated significant differences in NPs uptake between the different cell lines used in this study.

Fluorescence microscopy experiments conducted after 12h and 24h of incubation revealed a rate of inglobation influenced by the cell type. DPCs did not internalize PLGAChi NPs, even at the highest concentration (200 µg/mL PLGAChi NPs) and the longest incubation time (24h) (Fig. 3). But the microscopic results showed supporting evidence of incorporation of the tested NPs in oral keratinocytes, both in normal and in pathologic precancerous conditions (Fig. 1, Fig. 2, Fig. 4, Fig. 5).

The data obtained revealed a significant uptake of PLGAChi NPs into oral keratinocyte cells after 12h exposure with 20 µg/mL NPs: 91,83 % in NOKs and 100 % in POE9i cells (Fig. 6). The percentage of NOKs which have internalized the chitosan covered PLGA NPs increased gradually with the incubation time and concentration of the solution of polymeric NPs. The highest uptake of PLGAChi NPs inside both keratinocyte types was observed after 24h exposure to 200 µg/mL

PLGAChi NPs, when all cells were penetrated by the NPs (Fig. 6). What is mostly important is the fact that the PLGAChi NPs entered in a higher amount in the precancerous cells than in the normal oral keratinocytes. Chitosan covered NPs demonstrated a 100 % uptake at all tested concentrations and time points in POE9i precancerous cells. Moreover, the PLGAChi NPs were able to get internalized into the epithelial cells in reasonable amounts and in a time and concentration dependant manner. The percentage of keratinocyte cells with internalized NPs increased over incubation time, demonstrating a growing and highly efficient process of internalization of PLGAChi NPs by human NOKs and POE9i keratinocytes. The results obtained in 3D studies confirm the fact that PLGAChi NPs can enter the oral keratinocytes (Fig. 7).

Interestingly, what was observed was a higher and more rapid uptakeof PLGAChi NPs in precancerous keratinocytes compared to NOKs (Fig. 6). Based on these data, we hypothesise a preference of chitosan covered NPs for uptake byprecancerous keratinocytes over normal keratinocytes. This has been also hypothesised previously by[41] who showed that epithelial cell cultures forming tight junctions did not internalize NPs, while those lacking tight junctions, i.e., the cancer cells, did internalize. Although the NPs used in that study differ from our study, this could provide a possible molecular explanation. Interestingly, previous research articles have also found a preference of chitosan covered NPs for uptake by cancer stem cells. A doxorubicin-encapsulated polymeric nanoparticle surface-decorated with chitosan was able to target and eliminate tumor reinitiating cancer stem-like cells.[42] Moreover, hyaluronic acid-decorated dual responsive nanoparticles of Pluronic F127, PLGA, and chitosan were developed recently for targeted co-delivery of doxorubicin and irinotecan to eliminate cancer stem-like cells.[43] Also, chitosan-coated hyaluronic acid, docetaxel containing NPs were more effective against CD44+ cells than free docetaxel.[44] We have not investigated this aspect in our study, but this could be further investigated. The findings of this study provide evidence for the penetration of PLGAChi NPs not only in single cells, but also in oral mucosal cells assembled in 3D tissus, as shown by the results on the human 3D organotypic reconstructed human mucosa models grown in vitro (Fig. 7). Altough the 3D organotypic models replicate only to a certain extend the structure of the human tissue, in this case the human oral mucosa, they better resemble the oral microenvironment of the oral keratinocytes than the 2D models.

To our knowledge this is the first study that assesed the penetration of PLGAChi NPs in the reconstructed oral human mucosa. The NPs crossed the superficial epithelial layers, reaching the underlying conective tissue (Fig. 7).

Our results were in agreement with previous studies which showed a high uptake of polymeric NPs when fortified with chitosan, and that the uptake of chitosan coated NPs was much higher that that of uncoated NPs.[6, 30-31, 45-46] In a study from 2015, S.Alqahtani showed a significantly higher 3.5 fold cellular uptake of chitosan coated PLGAChi NPs compared to PLGA NPs in Caco-2 cells.[31]

In another study, positively charged chitosan covered PLGA NPs exhibited enhanced mucoadhesion, compared to negatively charged PLGA NPs and enhanced intracellular uptake in A549 cell line human lung carcinoma cells.[6] PLGAChi NPs managed to get internalized into Caco-2 cells with reasonable amounts after just 1h.[31] Another research group stated that PLGAChi NPs are internalized by hepatocytes 3A and fibroblasts 3T6 in a few minutes.[30]

Also, Chronopoulos reported that the uptake of PLGAChi NPs appears faster than with PLGA NPs, with major amounts of cytoplasmatic NPs found after only 5 minutes.[30]

Interestingly, uptake saturation is reached after 2-3h of incubation with PLGAChi NPs in human 3A hepatocytes and 3T6 fibroblasts although the uptake of PLGA NPs still appears less extensive than for PLAChi NPs.[30]

The performance of a delivery system depends on the polymeric composition, the size and surface charge.[38,47] Therefore, smaller sizes of NPs and a positive zeta potential lead to a better internalisation inside cells due to the attractive interaction with the negatively charged cell membranes.[48,49]

Hence, the size and zeta potential of the cureent NPs fabricated in our study are in favour of particle internalisation. Our data demonstrated that PLGAChi NPs exhibited a significant internalisation into the human oral keratinocytes .

However, the experiment presents a series of limitations. As other studies showed the rapid internalisation of chitosan covered NPs in minutes or hours,[30,31] the exposure time used in our study (12h and 24h) might have been too long. Further investigations using a wider variety of concentrations and time points are needed in order to asses the differences in uptake of PLGAChi NPs between normal and patologic conditions. The use of organotypic models of reconstructed human mucosa in vitro resemble much more the natural conditions in vivo than the usual tests on monolayer cell cultures. But the organotypic models cannot substitute the in vivo experiments as they are composed only of a collagen biomatrix and epithelial cells, without other components of the natural mucosa, such as the imune cells and vascular components.[23,50] Moreover, saliva might interfere with NPs penetration in the oral mucosa and hinder the uptake inside the oral epithelium[50] As the reconstructed oral mucosa samples did not have a protective mucus layer, it is hard to predict the influence of saliva on the NPs penetration inside human mucosa in vivo. Future in vivo experiments should clarify and add significant data to the potential uses of PLGAChi NPs in oral medicine.

5. Conclusions

This study offers new insight on NPs uptake within human oral cells. PLGAChi NPs are not suitable in applications regarding DPCs, as they do not enter these cells. But, PLGAChi NPs are internalised by both human keratinocytes and fibroblasts. Chitosan-coated PLGA NPs have proved to be potent in crossing the cellular membrane of epithelial cells. Therefore, PLGAChi NPs are highly recommended for being used in drug delivery systems to the oral mucosa. This promising results suggest the need for further studies regarding PLGAChi NPs, and its uses in oral mucosa diseases or anticancer therapy. In conclusion, more research is needed to fully explore the underlying mechanisms of celllular uptake of PLGA with chitosan surface modification.

Author Contributions

MJRV contributed to the concept of the article, data gathering, data analysis and interpretation. BC's contribution was very important in the concept, interpretation and critical revision of the manuscript. DEC contributed to establishing of protocols, data gathering, interpretation of the results and critical revision of the manuscript. MRC critically revised the manuscript. MG contributed to all stages of the article from the concept of the article, protocols, interpretation and critical revision of the manuscript. All authors approved the final version of the article.

Acknowledgments

Bogdan Calenic acknowledges that this work was supported by a grant from the Romanian National Authority for Scientific Research and Innovation, CNCS – UEFISCDI, project number PN-II-RU-TE-2014-4-1879. We thank Professor Sabliov CM, Agricultural and Biological Engineering Department, Louisiana State University and LSU Ag Center, Baton Rouge, LA, USA for providing us with the PLGAChi nanoparticles used in this study.

We acknowledge Dr. G Negroiu, Institute of Biochemistry, Bucharest, Romania for assisting us in the acquisition of microscopy images. Many thanks to Macedon SE from Institute of Electrical and Electronics Engineers for the help in the quantification of the uptake of nanoparticles inside cells.

References

1. Li B, Li Q, Mo J, Dai H. Drug-loaded polymeric nanoparticles for cancer stem cell targeting. Front Pharmacol. 2017;8:51. doi: 10.3389/fphar.2017.00051. eCollection 2017. [Full text link] [Free PMC Article] [PubMed] Google Scholar (1) Scopus (0)
2. Fonseca AC, Ferreira P, Cordeiro RA, et al. Drug delivery systems for predictive medicine: polymers as tools for advanced applications. Mozaffari MS, editor. In: New Strategies to Advance Pre/Diabetes Care: Integrative Approach by PPPM, Advances in Predictive, Preventive and Personalised Medicine 3. Springer Science + Bussines Media Dordrecht; 2013.
3. Fonseca AC, Serra AC, Coelho JF. Bioabsorbable polymers in cancer therapy: latest developments. EPMA J. 2015;6:22. doi: 10.1186/s13167-015-0045-z. eCollection 2015. [Full text link] [Free PMC Article] [PubMed] Google Scholar (5) Scopus (4)
4. Virlan MJR, Miricescu D, Totan A, et al. Current uses of poly (lactic-co-glycolic acid) in the dental field: A comprehensive review. Journal of Chemistry, 2015, Article ID 525832, http://dx.doi.org/10.1155/2015/525832. [Full text link] Google Scholar(13)
5. Ravi Kumar MN, Bakowsky U, Lehr CM. Preparation and characterization of cationic PLGA nanospheres as DNA carriers. Biomaterials. 2004;25(10):1771-1777. [Full text link] [PubMed] Google Scholar(492) Scopus (367)
6. Dyawanapelly S, Koli U, Dharamdasani V, Jain R, Dandekar P. Improved mucoadhesion and cell uptake of chitosan and chitosan oligosaccharide surface-modified polymer nanoparticles for mucosal delivery of proteins. Drug Deliv Transl Res. 2016;6(4):365-379. doi:10.1007/s13346-016-0295-x. [Full text link] [PubMed] Google Scholar (11) Scopus (9)
7. Makita-Chingombe F, Kutscher HL, DiTursi SL, Morse GD, Maponga CC. Poly (lactic-co-glycolic) Acid-chitosan dual loaded nanoparticles for antiretroviral nanoformulations. J Drug Deliv. 2016;2016:3810175. doi: 10.1155/2016/3810175. [Full text link] [Free PMC Article] [PubMed] Google Scholar (8)
8. Kawashima Y, Yamamoto H, Takeuchi H, Kuno Y. Mucoadhesive DL-lactide/glycolide copolymer nanospheres coated with chitosan to improve oral delivery of elcatonin. Pharm Dev Technol. 2000;5(1):77-85. doi: 10.1081/PDT-100100522 [Full text link] [PubMed] Google Scholar (252) Scopus (177)
9. Chronopoulou L, Nocca G, Castagnola M, et al. Chitosan based nanoparticles functionalized with peptidomimetic derivatives for oral drug delivery. N Biotechnol. 2016;33(1):23-31. doi: 10.1016/j.nbt.2015.07.005. [Full text link] [PubMed] Google Scholar (9) Scopus (8)
10. Bellamy C, Shrestha S, Torneck C, Kishen A. Effects of a bioactive scaffold containing a sustained transforming growth factor-β1-releasing nanoparticle system on the migration and differentiation of stem cells from the apical papilla. J Endod. 2016;42(9):1385-1392. doi: 10.1016/j.joen.2016.06.017. [Full text link] [PubMed] Google Scholar (2)
11. Shrestha S, Torneck CD, Kishen A. Dentin conditioning with bioactive molecule releasing nanoparticle system enhances adherence, viability, and differentiation of stem cells from apical papilla. J Endod. 2016;42(5):717-723. doi: 10.1016/j.joen.2016.01.026. [Full text link] [PubMed] Google Scholar (3) Scopus (2)
12. Lee BS, Lee CC, Wang YP, et al. Controlled-release of tetracycline and lovastatin by poly (D, L-lactide-co-glycolide acid)-chitosan nanoparticles enhances periodontal regeneration in dogs. Int J Nanomedicine. 2016;11:285-297. doi: 10.2147/IJN.S94270. eCollection 2016. [Full text link] [Free PMC Article] [PubMed] Google Scholar (20)
13. Shrestha A, Kishen A. Antibacterial nanoparticles in endodontics: A review. J Endod. 2016;42(10):1417-1426. doi: 10.1016/j.joen.2016.05.021. [Full text link] [PubMed] Google Scholar (7)
14. Del Carpio-Perochena A, Kishen A, Shrestha A, Bramante CM. Antibacterial properties associated with chitosan nanoparticle treatment on root dentin and 2 types of endodontic sealers. J Endod. 2015;41(8):1353-1358. doi: 10.1016/j.joen.2015.03.020. [Full text link] [PubMed] Google Scholar (21) Scopus (13)
15. Del Carpio-Perochena A, Bramante CM, Duarte MA, et al. Chelating and antibacterial properties of chitosan nanoparticles on dentin. Restor Dent Endod. 2015;40(3):195-201. doi: 10.5395/rde.2015.40.3.195. [Full text link] [Free PMC Article] [PubMed] Google Scholar (18)
16. Mazzarino L, Borsali R, Lemos-Senna E. Mucoadhesive films containing chitosan-coated nanoparticles: a new strategy for buccal curcumin release. J Pharm Sci. 2014;103(11):3764-3771. doi: 10.1002/jps.24142. [Full text link] [PubMed] Google Scholar (35)
17. Nag M, Gajbhiye V, Kesharwani P, Jain NK. Transferrin functionalized chitosan-PEG nanoparticles for targeted delivery of paclitaxel to cancer cells. Colloids Surf B Biointerfaces. 2016;148:363-370. doi: 10.1016/j.colsurfb.2016.08.059. [Full text link] [PubMed] Google Scholar (10) Scopus (8)
18. Lin M, Wang D, Liu S, et al. Cupreous complex-loaded chitosan nanoparticles for photothermal therapy and chemotherapy of oral epithelial carcinoma. ACS Appl Mater Interfaces. 2015;7(37):20801-20812. doi: 10.1021/acsami.5b05866. [Full text link] [PubMed] Google Scholar (12) Scopus (12)

19. Mazzarino L, Loch-Neckel G, Bubniak Ldos S, et al. Curcumin-loaded chitosan-coated nanoparticles as a new approach for the local treatment of oral cavity cancer. J Nanosci Nanotechnol. 2015;15(1):781-791. [PubMed] Google Scholar (20) Scopus (13)
20. Trif M, Florian PE, Roseanu A, et al. Cytotoxicity and intracellular fate of PLGA and chitosan-coated PLGA nanoparticles in Madin–Darby bovine kidney (MDBK) and human colorectal adenocarcinoma (Colo 205) cells. J Biomed Mater Res A. 2015;103(11):3599-3611. doi: 10.1002/jbm.a.35498. [Full text link] [PubMed] Google Scholar (8)
21. Navarro SM, Darensbourg C, Cross L, et al. Biodistribution of PLGA and PLGA/chitosan nanoparticles after repeat-dose oral delivery in F344 rats for 7 days. Ther Deliv. 2014;5(11):1191-1201. doi: 10.4155/tde.14.79. [Full text link] [Free PMC Article] [PubMed] Google Scholar (8) Scopus (8)
22. Navarro SM, Morgan TW, Astete CE, et al. Biodistribution and toxicity of orally administered poly (lactic-co-glycolic) acid nanoparticles to F344 rats for 21 days. Nanomedicine (Lond). 2016;11(13):1653-1669. doi: 10.2217/nnm-2016-0022. [Full text link] [PubMed] Google Scholar (3)
23. Costea DE, Loro LL, Dimba EA, Vintermyr OK, Johannessen AC. Crucial effects of fibroblasts and keratinocyte growth factor on morphogenesis of reconstituted human oral epithelium. J Invest Dermatol. 2003;121(6):1479-1486. doi: 10.1111/j.1523-1747.2003.12616.x [Full text link] [PubMed] Google Scholar (81) Scopus (59)
24. Ishkitiev N, Yaegaki K, Imai T, et al. High-purity hepatic lineage differentiated from dental pulp stem cells in serum-free medium. J Endod. 2012;38(4):475-480. doi: 10.1016/j.joen.2011.12.011. [Full text link] [PubMed] Google Scholar(60) Scopus (37)
25. Lee CP, Colombo JS, Ayre WN, Sloan AJ, Waddington RJ. Elucidating the cellular actions of demineralised dentine matrix extract on a clonal dental pulp stem cell population in orchestrating dental tissue repair. J Tissue Eng. 2015;6:2041731415586318. doi: 10.1177/2041731415586318. eCollection 2015. [Free PMC Article] [PubMed] Google Scholar(12)
26. Dufour A, Meas-Yedid V, Grassart A, Olivo-Marin JC. Automated quantification of cell endocytosis using active contours and wavelets. In: Pattern Recognition, 2008. ICPR 2008. 19th International Conference on (pp. 1-4). IEEE. USA: Tampa, FL; 2009 [Full text link] Google Scholar (21) Scopus (15)
27. de Chaumont F, Dallongeville S, Chenouard N, et al. Icy: an open bioimage informatics platform for extended reproducible research. Nat Methods. 2012;9(7):690-696. doi: 10.1038/nmeth.2075. [Full text link] [PubMed] Google Scholar (395) Scopus (294)
28. Virlan MJ, Miricescu D, Radulescu R, et al. Organic nanomaterials and their applications in the treatment of oral diseases. Molecules. 2016;21(2). pii: E207. doi: 10.3390/molecules21020207 [Full text link] [PubMed] Google Scholar (8) Scopus (6)
29. Friedman AJ, Phan J, Schairer DO, et al. Antimicrobial and anti-inflammatory activity of chitosan–alginate nanoparticles: A targeted therapy for cutaneous pathogens. J Invest Dermatol. 2013;133(5):1231-1239. doi: 10.1038/jid.2012.399. [Full text link] [Free PMC Article] [PubMed] Google Scholar(84) Scopus (70)
30. Chronopoulou L, Massimi M, Giardi MF, et al. Chitosan-coated PLGA nanoparticles: a sustained drug release strategy for cell cultures. Colloids Surf B Biointerfaces. 2013;103:310-317. doi: 10.1016/j.colsurfb.2012.10.063. [Full text link] [PubMed] Google Scholar (61) Scopus (48)
31. Alqahtani S, Simon L, Astete CE, et al. Cellular uptake, antioxidant and antiproliferative activity of entrapped α-tocopherol and γ-tocotrienol in poly (lactic-co-glycolic) acid (PLGA) and chitosan covered PLGA nanoparticles (PLGA-Chi). J Colloid Interface Sci. 2015;445:243-251. doi: 10.1016/j.jcis.2014.12.083. [Full text link] [PubMed] Google Scholar(19)
32. Chuah LH, Roberts CJ, Billa N, Abdullah S, Rosli R. Cellular uptake and anticancer effects of mucoadhesive curcumin-containing chitosan nanoparticles. Colloids Surf B Biointerfaces. 2014;116:228-236. doi: 10.1016/j.colsurfb.2014.01.007. [Full text link] [PubMed] Google Scholar (42) Scopus (39)
33. Pawar D, Mangal S, Goswami R, Jaganathan KS. Development and characterization of surface modified PLGA nanoparticles for nasal vaccine delivery: effect of mucoadhesive coating on antigen uptake and immune adjuvant activity. Eur J Pharm Biopharm. 2013;85(3 Pt A):550-559. doi: 10.1016/j.ejpb.2013.06.017. [Full text link] [PubMed] Google Scholar (54) Scopus (41)
34. Grabowski N, Hillaireau H, Vergnaud J, et al. Toxicity of surface-modified PLGA nanoparticles toward lung alveolar epithelial cells. Int J Pharm. 2013;454(2):686-694. doi: 10.1016/j.ijpharm.2013.05.025. [Full text link] [PubMed] Google Scholar (66) Scopus (55)
35. Tahara K, Sakai T, Yamamoto H, et al. Improved cellular uptake of chitosan-modified PLGA nanospheres by A549 cells. Int J Pharm. 2009;382(1-2):198-204. doi: 10.1016/j.ijpharm.2009.07.023. [Full text link] [PubMed] Google Scholar (139) Scopus (103)
36. Ridolfi DM, Marcato PD, Justo GZ, et al. Chitosan-solid lipid nanoparticles as carriers for topical delivery of tretinoin. Colloids Surf B Biointerfaces. 2012;93:36-40. doi: 10.1016/j.colsurfb.2011.11.051. [Full text link] [PubMed] Google Scholar (96) Scopus (66)
37. Hafner A, Lovrić J, Pepić I, Filipović-Grčić J. Lecithin/chitosan nanoparticles for transdermal delivery of melatonin. J Microencapsul. 2011;28(8):807-815. doi: 10.3109/02652048.2011.622053. [Full text link] [PubMed] Google Scholar (43) Scopus (27)
38. Blažević F, Milekić T, Romić MD, et al. Nanoparticle-mediated interplay of chitosan and melatonin for improved wound epithelialisation. Carbohydr Polym. 2016;146:445-454. doi: 10.1016/j.carbpol.2016.03.074. [Full text link] [PubMed] Google Scholar (7) Scopus (6)
39. Lee HY, Jeong YI, Choi KC. Hair dye-incorporated poly-γ-glutamic acid/glycol chitosan nanoparticles based on ion-complex formation. Int J Nanomedicine. 2011;6:2879-2888. doi: 10.2147/IJN.S26458. [Full text link] [Free PMC Article] [PubMed] Google Scholar (13) Scopus (13)
40. Sonvico F, Cagnani A, Rossi A, et al. Formation of self-organized nanoparticles by lecithin/chitosan ionic interaction. Int J Pharm. 2006;324(1):67-73. doi: 10.1016/j.ijpharm.2006.06.036 [Full text link] [PubMed] Google Scholar (131) Scopus (89)
41. Sahay G, Kim JO, Kabanov AV, Bronich TK. The exploitation of differential endocytic pathways in normal and tumor cells in the selective targeting of nanoparticulate chemotherapeutic agents. Biomaterials. 2010;31(5):923-933. doi: 10.1016/j.biomaterials.2009.09.101. [Full text link] [Free PMC Article] [PubMed] Google Scholar (120) Scopus (91)
42. Rao W, Wang H, Han J, et al. Chitosan-decorated doxorubicin-encapsulated nanoparticle targets and eliminates tumor reinitiating cancer stem-like cells. ACS Nano. 2015;9(6):5725-5740. doi: 10.1021/nn506928p. [Full text link] [PubMed] Google Scholar (65) Scopus (50)
43. Wang H, Agarwal P, Zhao S, et al. Hyaluronic acid-decorated dual responsive nanoparticles of Pluronic F127, PLGA, and chitosan for targeted co-delivery of doxorubicin and irinotecan to eliminate cancer stem-like cells. Biomaterials. 2015;72:74-89. doi: 10.1016/j.biomaterials.2015.08.048. [Full text link] [Free PMC Article] [PubMed] Google Scholar (51) Scopus (45)
44. Shabani Ravari N, Goodarzi N, Alvandifar F, et al. Fabrication and biological evaluation of chitosan coated hyaluronic acid-docetaxel conjugate nanoparticles in CD44(+) cancer cells. Daru. 2016;24(1):21. doi: 10.1186/s40199-016-0160-y. [Full text link] [Free PMC Article] [PubMed] Google Scholar (3)
45. Wang Y, Li P, Kong L. Chitosan-modified PLGA nanoparticles with versatile surface for improved drug delivery. AAPS PharmSciTech. 2013;14(2):585-592. doi: 10.1208/s12249-013-9943-3. [Full text link] [Free PMC Article] [PubMed] Google Scholar (70) Scopus (54)
46. Bakhru SH, Altiok E, Highley C, et al. Enhanced cellular uptake and long-term retention of chitosan-modified iron-oxide nanoparticles for MRI-based cell tracking. Int J Nanomedicine. 2012;7:4613-4623. doi: 10.2147/IJN.S28294. [Full text link] [Free PMC Article] [PubMed] Google Scholar (32) Scopus (33)
47. De Cicco F, Porta A, Sansone F, Aquino RP, Del Gaudio P. Nanospray technology for an in situ gelling nanoparticulate powder as a wound dressing. Int J Pharm. 2014;473(1-2):30-37. doi: 10.1016/j.ijpharm.2014.06.049. [Full text link] [PubMed] Google Scholar (25) Scopus (24)
48. Chuah LH, Roberts CJ, Billa N, Abdullah S, Rosli R. Cellular uptake and anticancer effects of mucoadhesive curcumin-containing chitosan nanoparticles. Colloids Surf B Biointerfaces. 2014;116:228-236. doi: 10.1016/j.colsurfb.2014.01.007. [Full text link] [PubMed] Google Scholar (42) Scopus (39)
49. Hillaireau H, Couvreur P. Nanocarriers' entry into the cell: relevance to drug delivery. Cell Mol Life Sci. 2009;66(17):2873-2896. doi: 10.1007/s00018-009-0053-z. [Full text link] [PubMed] Google Scholar (985) Scopus (734)
50. Konstantinova V, Ibrahim M, Lie SA, et al. Nano-TiO2 penetration of oral mucosa: in vitro analysis using 3D organotypic human buccal mucosa models. J Oral Pathol Med. 2017;46(3):214-222. doi: 10.1111/jop.12469. [Full text link] [Free PMC Article] [PubMed] Google Scholar (2)

Maria Justina Roxana VIRLAN
DDS, MSc, PhD Student
Department of Biochemistry
Faculty of Dental Medicine, U.M.F."Carol Davila "Bucharest, Romania

CV

Dr Justina Virlan graduated from the Faculty of Dental Medicine in 2012 and completed an Endodontics residency. In 2015 she finished a master programme at the Faculty of Medical Engineering. A laureate of the National Chemistry Competition and a PhD student at the Biochemistry Department of the Dental Medicine Faculty, she has a high interest in nanomaterials and their applications in dentistry.

Questions

Chitosan modified poly(lactic-co-glycolic) acid nanoparticles (PLGAChi NPs) could be used to deliver drugs:

- ❑ a. to the dental pulp cells;
- ❑ b. to the oral mucosa;
- ❑ c. to the dental pulp cells and oral mucosa;
- ❑ d. none of the above.

The PLGAChi NPs (used in this study) can enter :

- ❑ a. normal oral keratinocytes (NOKs);
- ❑ b. precancerous oral keratinocytes (POE9i);
- ❑ c. dental pulp cells (DPC);
- ❑ d. normal oral keratinocytes (NOKs) and precancerous oral keratinoctes (POE9i).

The multilayered epihelia of oral mucosa was grown in vitro using:

- ❑ a. collagen matrix;
- ❑ b. collagen matrix; normal oral fibroblasts (NOFs);
- ❑ c. collagen matrix; normal oral fibroblasts (NOFs); normal oral keratinocytes (NOKs);
- ❑ d. collagen and matrigel matrix; normal oral fibroblasts (NOFs); normal oral keratinocytes (NOKs).

In the cell lines that have internalized PLGAChi NPs, the maximum uptake of NPs was observed after exposure to:

- ❑ a. 200 g/mL PLGAChi NPs for 24 h;
- ❑ b. 200 g/mL PLGAChi NPs for 12 h;
- ❑ c. 20 g/mL PLGAChi NPs for 12 h;
- ❑ d. 20 g/mL PLGAChi NPs for 24 h.

CONTEMPORARY DENTAL CARIES MANAGEMENT CONCEPTS IN PAEDIATRIC DENTISTRY: A SURVEY OF AWARENESS AND PRACTICE OF A GROUP OF GULF COOPERATION COUNCIL DENTISTS

Iyad Hussein[1a*], Manal AlHalabi[1b], Mawlood Kowash[1c], Amar H Khamis[2d]

[1]Paediatric Dentistry Department, Hamdan Bin Mohammed College of Dental Medicine, Mohamed Bin Rashid University of Medicine and Health Sciences, Dubai, UAE
[2]Biostatistics & Genetic Epidemiology Department, Hamdan Bin Mohammed College of Dental Medicine, Mohamed Bin Rashid University of Medicine and Health Sciences, Dubai, UAE

[a]DDS (Dam), MDentSci (Leeds), GDC Stat.Exam (London), MFDSRCPS (Glasg), UK Certified Specialist in Paediatric Dentistry, Clinical Assistant Professor in Paediatric Dentistry
[b]BDS, MSc, Associate Professor and Programme Director of Master of Science in Paediatric Dentistry Programme
[c]BDS, MSc, DDSc, FRCD©, FDSRCPS(Glasg), Associate Professor in Paediatric Dentistry
[d]PhD, DEA, MSc, BSc, Associate Professor Biostatistics & Genetic Epidemiology

Received: January 04, 2017
Revised: February 28, 2017
Accepted: March 07, 2017
Published: March 08, 2017

Academic Editor: Rodica Luca, DDS, PhD, Professor, "Carol Davila" University of Medicine and Pharmacy Bucharest, Bucharest, Romania

Cite this article:
Hussein I, AlHalabi M, Kowash M, Khamis AH. Contemporary dental caries management concepts in paediatric dentistry: A survey of awareness and practice of a group of Gulf Cooperation Council Dentists. Stoma Edu J. 2017;4(1):25-36.

ABSTRACT

DOI: 10.25241/stomaeduj.2017.4(1).art.2

Introduction: Debatable clinically relevant child dental caries management concepts exist; restoring a carious primary molar (RCM), the choice of pulpotomy medicament (PM), the "Hall Technique" (HT), and sealing of dental caries (SDC). Our aim was to assess the knowledge and practice of dentists treating children in the Gulf Cooperation Council (GCC) region of the aforementioned contemporary concepts.
Methodology: Paediatric Dentists (PDs) and General Dental Practitioners (GDPs) who treated children completed a questionnaire (N=150) covering: RCM choices; choice of PM; knowledge and practice of HT and acceptance of SDC in primary and permanent teeth. Statistical analysis was conducted using Chi-Square test ($p<0.05$).
Results: For RCM: 76% of those surveyed would remove non-pulpal caries in an asymptomatic lower D and restore with composite (33%), glass ionomer or conventional stainless steel crown (SSC) (17.4%), amalgam (7.4%) and zirconia (0.7%). The remaining 24% would seal caries (HT SSC). For PM: 40.7% chose Ferric Sulphate, followed by Formocresol (36.7%), Mineral Trioxide Aggregate (14%) and Calcium hydroxide (8.7%); For HT: 60.6% had knowledge of HT but 81.5% never used it. For SDC: sealing caries in primary & permanent teeth was rejected by 56.6% & 53.1% respectively. GDPs and PDs choices differed significantly with RCM, HT (knowledge and practice) ($p=0.007$, 0.003 and 0.003 respectively).
Conclusion: Overall the surveyed dentists practicing in the GCC disagreed on RCM, PM with reluctance to accept new concepts like the HT and SDC. PDs choices of RCM differed from GDPs, and their awareness of HT and practice of HT were more favourable.
Keywords: Hall technique, pulpotomy medicaments, dental caries, sealing caries.

1. Introduction

The discipline of paediatric dentistry is an extensive field in a constant state of development and change. Several aspects of its clinical practice, related to the management of the caries, have shown new insights and practices challenging old concepts. With the drive to base both dental education and dental practice on sound platforms of evidence based dentistry and contemporary clinical guidelines, a plethora of new methods/concepts have emerged. This created a scientific debate, albeit a healthy one, that divided the paediatric dentistry community and created opposing schools of thought. Interestingly, the debate had an impact on undergraduate dental education and postgraduate dental practice.[1] In paediatric dentistry, how to restore a carious primary molar (RCM),[2, 3, 4] the choice of appropriate "pulpotomy medication" (PM) in primary teeth,[5] the "Hall technique" (HT),[6] and "sealing dental caries" (SDC) in primary and permanent teeth[7] were four areas where change and debate took place. These

***Corresponding author:**

Clinical Assistant Professor Iyad Hussein, DDS (Dam), MDentSci (Leeds), GDC Stat.Exam (London), MFDSRCPS (Glasg). Paediatric Dentistry Department, Hamdan Bin Mohammed College of Dental Medicine Mohamed Bin Rashid University of Medical and Health Sciences, Dubai, UAE
Tel/Fax: +971 43838907, e-mail: iyad.hussein@mbru.ac.ae

clinical issues have had direct impact upon clinical treatment of child patients and are of interest, not only to specialists in paediatric dentistry, but general dental practitioners alike. While the debate has been, and still is, ongoing in the dental literature,[8,9] the opinions of those treating children in the dental community in the Gulf Cooperation Council countries (GCC) had not been assessed. What were the opinions of dentists about these changing new concepts? As the United Arab Emirates (UAE) and the State of Kuwait (SoK) are representative nations in the GCC (along with Saudi Arabia, Oman, Qatar and Bahrain) which have dental practitioners from many different backgrounds, the aim of this paper was to survey- by means of a questionnaire- the dental awareness and practice of dentists in GCC countries of the above concepts. It was hypothesised that GCC dentists; a) agreed on treatment options for RCM when faced with a non-pulpally involved carious primary molar in a cooperative child, b) agreed on the PM used in a primary molar pulpotomy, c) were aware of the HT, d) had practiced the HT and e) agreed to the concept of SDC in primary and permanent teeth.

2. Materials and methods

2.1. Design

The study was designed as a cross-sectional survey. Data was collected by the authors and postgraduates (the surveyors) from Hamdan Bin Mohamed College of Dental Medicine (HBMCDM) in Dubai, UAE. The participants were dental professionals (General Dental Practitioners/ Interns [GDPs], and Paediatric Dentists [PDs]) attending paediatric dentistry postgraduate conferences held at various institutions in the UAE and SoK namely HBMCDM in Dubai (UAE) and Ras AlKhaima Dental College, Ras AlKhaima (UAE) and the Kuwait Health Ministry, Kuwait city, (SoK). The aim was to investigate their awareness and practice of RCM, HT, choice of PM and SDC concepts outlined above. The reason behind the choice of events was to capture the views of a cross section of dentists dealing with children from various areas in the GCC.

2.2. Sample selection

The sample was a convenience sample selected during the aforementioned dental activities during 2015. At registration time randomised participants were invited by the surveyors from HBMCDM, to participate in the survey by filling a questionnaire. In both countries a total of 315 attendees were invited to participate. Participants were allowed to complete the questionnaire once only, thus avoiding duplicate entries.

2.3. Ethical matters

All participants were informed of the objectives and confidential nature of the survey and that there would be no negative consequences for declining to participate even if they agreed initially. Hence, they freely consented to participate in the survey. Ethical approval of the work was obtained from the Ethics Committee of HBMCDM (approval ERC/ DCDM 11/14) and approval of the event organisers of the activities in both SoK and UAE.

2.4. Questionnaire

A size A4 sheet questionnaire was designed by the authors and was administered to all participants involved in the study. The questionnaire, was piloted and tested amongst the paediatric dentistry staff and postgraduates of HBMCDM (10 members) (Fig. 1 and Table 1) and was found to be reliable and consistent (Cronbach's alpha= 0.66). They were not included in the final sample. The questionnaire included:

- A section capturing demographic data (age, gender, specialty, country of practice, years in practice and country of qualification);
- Six questions items covered the previously highlighted topics RCM, HT, PM and SDC (Fig. 1 and Table 1).

2.5. Data analysis

The survey sheets were completed anonymously. The returned questionnaires were collected by the surveyors and incomplete questionnaires were excluded from the study. The data collected was uploaded into a Microsoft Office 2010 Excel© sheet and data analysis was carried out using SPSS© statistical software Statistical Package of Social Science (SPSS Inc.; Chicago, Illinois) version 21 was used for data management and analysis. Descriptive statistics including frequencies, means, median, and standard deviation were performed to give general descriptions of the data. Chi-square test was performed to test the dependency between variables. The level of statistical significance was set at 5%.

3. Results

Out of a total of 315 attendees invited to take part in the survey, 202 verbally expressed willingness to participate and were issued the questionnaire sheets. However only 159 actually participated, completed and returned the questionnaires to the surveyors. Nine surveys with incomplete fields were excluded; therefore, the total number of those surveyed was 150 dentists (a return rate of 74.2%). The demographic breakdown of those surveyed, was as follows: Out of the total number of those surveyed (N=150), the majority of them were GDPs (n=119, 79.3%) while 20.7% (n=31) were PDs. The majority were female dentists (70.7%, n=106) and the rest were males (n= 44, 29.3%).

The mean age was 30.5 (±6.5) years and the range was 23-60.

The dominant age group was between 20-30 years (n= 96, 64%). The countries of practice were UAE (n=79, 52.7%) followed by Kuwait (n=35, 23.4%), the remaining dentists were working out with these two countries but within the GCC [29 from Saudi Arabia (19.3%), 3 from Bahrain (2%), and 2 (1.3%) from each of Qatar and Oman]. The median of years of practice was 4 years and the range was1-30 years. Countries of qualification were various but were regrouped into Arab countries (50.6%,

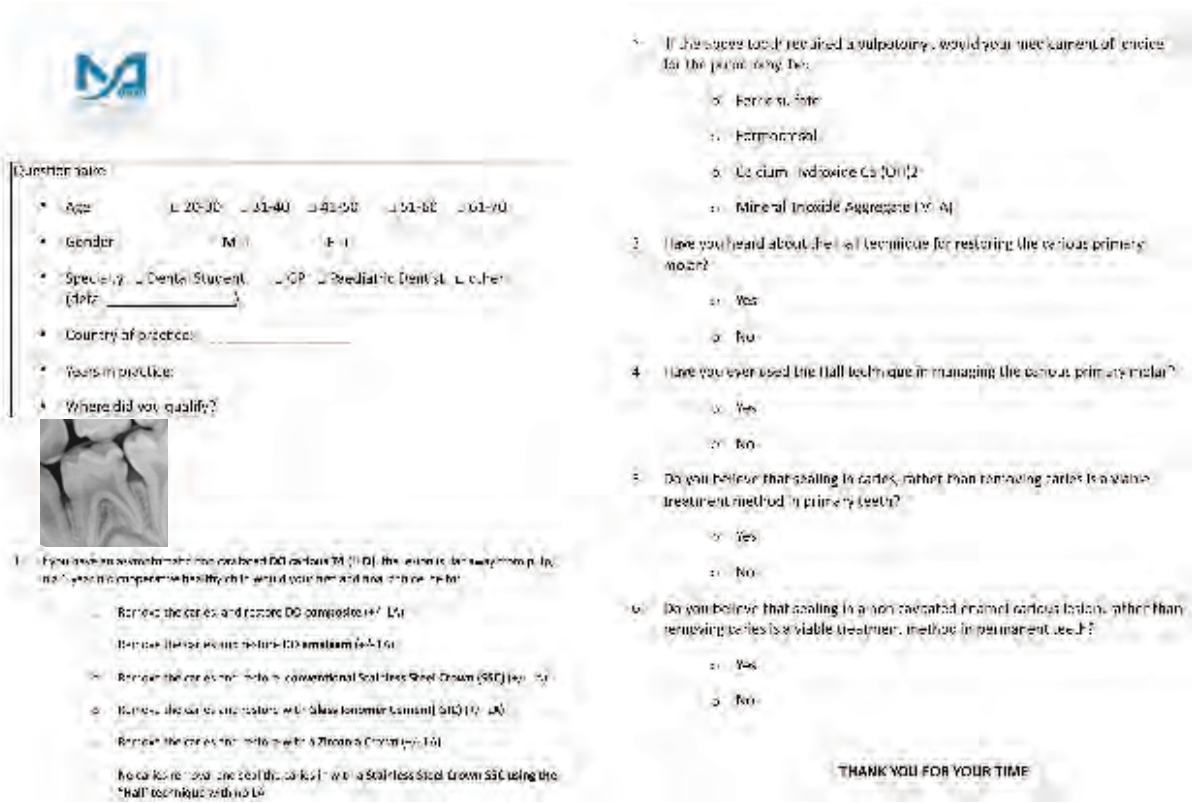


Figure 1. The Questionnaire: original format.

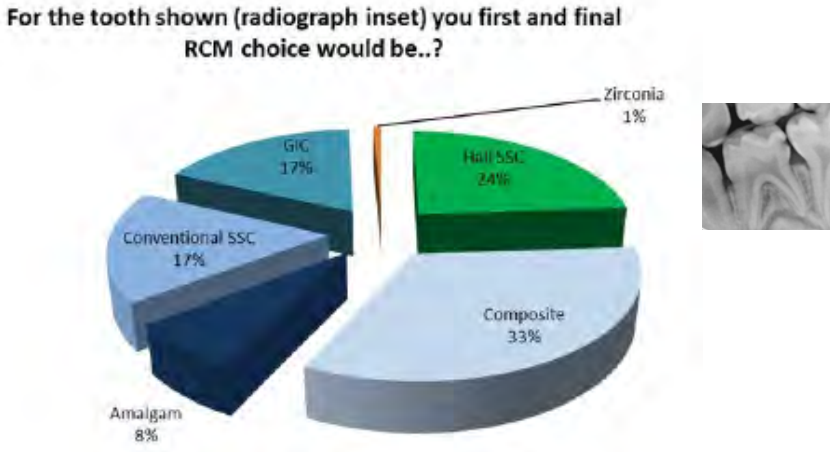


Figure 2. The management choices for treatment of tooth DO caries 74 set (see radiograph inset). SSC: Stainless Steel Crown; GIC: Glass Ionomer Cement.

n=76), East Asia (15.3%, n=23), Western Europe (11.3%, n=17), Eastern Europe (20.6%, n=31) and the United States of America (USA) (2%, n=3). The results of the survey showed the following (Fig. 1 and Table 1).

3.1. Results for the first question (RCM), *which asked about management options for caries in tooth #74 (class II ≤ caries shown in a radiograph) in a cooperative six year old child* (Fig. 2), the majority chose caries removal and restoration (n=114, 76%) compared to the HT (n=36, 24%, Fig 2). Within the group that chose to remove caries and restore, the choices were; composite (n=50, 33.3%), Glass Ionomer Cement (GIC) (n=26, 17.4%), conventional SSC (n=26, 17.4%), amalgam (n=11, 7.4%) and finally zirconia crowns (n=1, 0.7%).

While GDPs and PDs followed the same pattern (i.e., favour caries removal and restore rather than seal), cross tabulating the RCM choices in the above scenario and the specialty revealed statistically significant differences between their individual restorative choices (p=0.007) (Fig. 3). Most PDs (n=20, 64.5%) chose SSCs (either conventional SSC or HT SSC) compared to GDPs (n=42, 35.3%). GDPs first choice was to use composite (n=42, 35.3 %), while PDs first choice was conventional SSCs

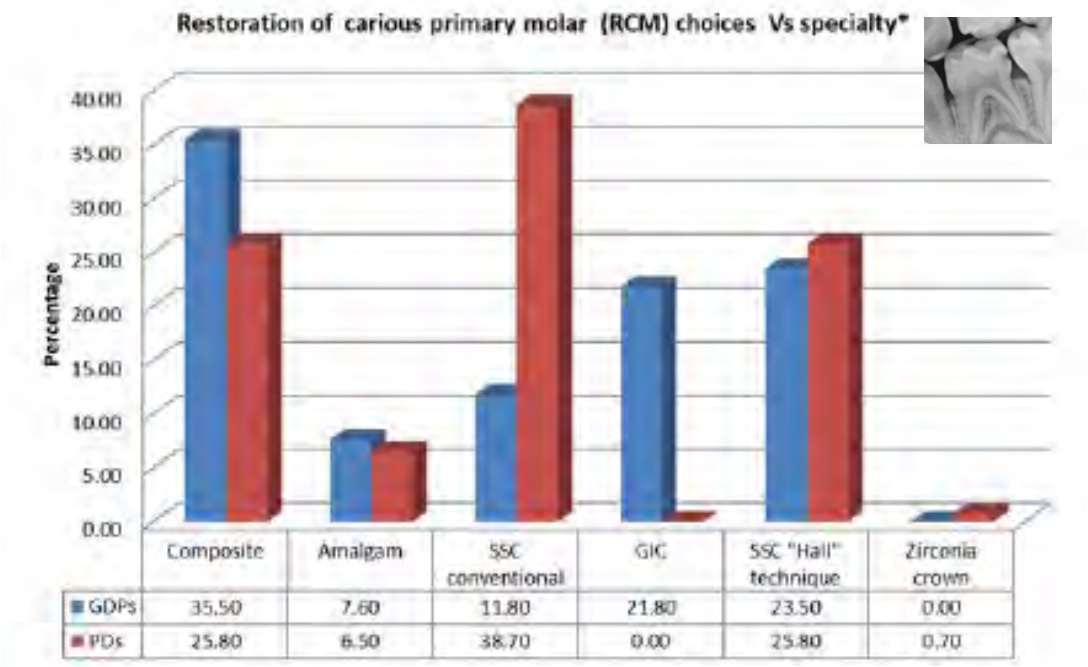


Figure 3. First choice of management of 74 (see radiograph inset) according to specialty.* denotes statistical significance (p >0.05). SSC: Stainless Steel Crown; GIC: Glass Ionomer Cement.

(n=12, 38.7%). Significantly so, 21.8% of GDPs (n=26) would choose GIC while all none of the PDs (n=0) chose GIC. In addition, a small proportion of GDPs (n=11, 7.4%) and PDs (n=2, 6.5%) chose amalgam, whilst none of the GDPs (n=0) and 0.7% of PDs (n=1) suggested zirconia crowns as a final restoration.

3.2. Results for the second question (PM), *the medicament of choice in a pulpotomy* (Fig 4); overall, those surveyed chose the following: Ferric Sulphate (FS) (n=61, 40.7%), followed by Formocresol (FC) (n=55, 36.7%), Mineral Trioxide Aggregate (MTA) (n=21, 14%) then Calcium Hydroxide (CH) (n=13, 8.7%). Cross tabulating the PM choice and specialty (Fig 5) revealed no statistically significant difference between PM choices of PDs and GDPs (p=0.281). The majority of GDPs chose FS (n=48, 40.3%), followed by FC (n=42, 35.3%), MTA (n=16, 13.4%) and finally CH (n=13, 10.9%). While 41.9% of PDs (n=13) chose FS and an equal proportion chose FC too, followed by MTA (n=5, 16.1%). No PD chose CH as a PM medicament (n=0, 0%).

3.3. Results for the third and fourth questions (HT), *t awareness and practice of the Hall Technique.* The majority of those surveyed (n=91, 60.6%) had heard about the HT while those who had not heard about it were 39.4% (n=59). However an overall majority (n=122, 81.4%) had not used the HT clinically, compared to 18.6% (n=28) who had (Fig. 6).

Cross tabulating awareness and practice of the HT with specialty revealed different results between GDPs and PDs (Fig. 7), which were statistically significant for both categories (both *p values*=0.003). In both the GDP and PD groups, the majority had heard about the HT (54.6% and 83.8% respectively) and the majority had not practiced the HT (86.5% and 61% respectively). The proportion of PDs whom had heard about the HT (n=26, 83.8%) was statistically significantly higher (p=0.003) than GDPs whom had heard of the HT (n=65, 54.6% of GDPs). There was a larger proportion of GDPs (n=103, 86.5%) who had not used the HT compared to PDs (n=19, 61.2%). Moreover, the proportion of PDs whom had practiced the HT (n=12, 38.8%) was statistically significantly higher (p=0.003) than GDPs whom had practiced the HT (n=16, 13.5%).

3.4. Results for questions 5 and 6 *related to sealing dental caries (SDC) in primary and permanent teeth.* The majority of those surveyed did not believe that sealing in caries in primary and permanent teeth was a viable option (Fig. 8). When asked if sealing in, rather than removing, caries in primary teeth was a viable option the majority disagreed (n=85, 56.6%) while 43.7% agreed (n=65). Moreover, when asked if sealing in a carious non-cavitated enamel lesion in permanent teeth was a viable option, the majority of those surveyed disagreed (n=80, 53.3%) as opposed to those who agreed (n=70, 46.6%). When cross tabulating the specialty and the concept of SDC in primary and permanent teeth, no statistically significant differences (p=0.517, p= 0.182 for both dentitions respectively) between GDPs and PDs were found (Fig. 9). GDPs opinions regarding SDC in primary teeth were divided; against (n=71, 59.6%) and

for (n=48, 40.4%) and SDC in permanent teeth; against (n=66, 55.5%) and for (n=53, 44.5%). PDs opinions regarding SDC in primary teeth were also divided; against (n=14, 45.2%) and for (n=17, 54.8%) and SDC in permanent teeth; against (n=14, 45.2%) and for (n=17, 54.8%). Therefore, there was, a tendency for both GDPs and PDs to have *opposite* views regarding SDC. PDs tended to accept SDC in primary teeth and permanent teeth compared to GDPs, although this was not statistically significant.

4. Discussion

Management of dental caries, a disease of high prevalence in the GCC region,[10] represents a challenge for those who dentally care for children, whether they are GDPs or PDs.[4] As dentists, we know that there appears to be more than one solution for a said clinical problem as such, a spectrum of solutions exist.[3] As examples for the latter, the HT,[10] in addition to sealing caries in permanent teeth as an ultraconservative modality[11] challenged the surgical caries management model. Also,

Table 1. This table shows the overall and specific responses to the questions tabled in this study (N=150). GDP: General Dental Practitioner, PD: Paediatric Dentist.

Question	Total (N = 150) (%)		GDPs (n=119) (%)		PDs (n=31) (%)		Pearson's Chi Square test
Question 1 (RCM: Restoring Carious Molar) **When you have an asymptomatic non cavitated DO carious 74 (LLD), and the lesion is far away from pulp, in a 6-year old cooperative healthy child, what would you first and final choice to be?**							
Non-restorative remineralization/chemical caries control	36 (24)		28 (23.5)		8 (25.8)		0.007*
Operative treatment and restoration with composite (+/- LA)	114 (76)		91 (76.5)		23 (74.2)		
Operative treatment and restoration with amalgam (+/- LA)	50 (33.3)		42 (35.3)		8 (25.8)		
Operative treatment and restoration with GIC (+/- LA)	11 (7.4)		9 (7.6)		2 (6.5)		
Operative treatment and restoration with conventional stainless steel crown (SSC) (+/- LA)	26 (17.4)		14 (11.8)		12 (38.7)		
Operative treatment and restoration with preformed zirconia crown (ZC) (+/- LA)	26 (17.4)		26 (21.8)		0 (0)		
Operative treatment and restoration with Zirconia Crown (+/- LA)	1 (0.7)		0 (0)		1 (3.2)		
Question 2: (PM: Pulpotomy Medicament Choice) **If the above tooth caries in tooth 74 reached the pulp and required a pulpotomy what would your medicament of choice for the pulpotomy be?**	N = 150 (%)						0.291
Formocresol (FC)	61 (40.7)		48 (40.3)		13 (41.9)		
Ferric sulphate (FS)	55 (36.7)		42 (35.3)		13 (41.9)		
Calcium Hydroxide (CH)	13 (8.7)		13 (10.9)		0 (0)		
MTA/Biodentine/Laser/Others	21 (14)		16 (13.4)		5 (16.1)		
Question 3 & 4 (HT: Hall Technique)	Yes	No	Yes	No	Yes	No	
Have you ever heard about the Hall technique in managing the carious primary molar?	97 (65.4)	52 (34.6)	65 (54.6)	54 (45.4)	26 (83.9)	5 (16.2)	0.003*
Have you ever used the Hall technique in managing the carious primary molar?	28 (18.6)	122 (81.4)	16 (13.5)	103 (86.5)	12 (38.7)	19 (61.2)	
Question 5 & 6 (SDC: Sealing Dental Caries)	Yes	No	Yes	No	Yes	No	
Do you believe that sealing in caries, rather than removing caries is a viable treatment method in primary teeth	65 (43.4)	85 (56.6)	48 (40.4)	71 (59.6)	17 (54.8)	14 (45.2)	0.517
Do you believe that sealing in a non cavitated enamel carious lesion, rather than removing caries is a viable treatment method in permanent teeth	70 (46.7)	80 (53.3)	53 (44.5)	66 (55.5)	17 (54.8)	14 (45.2)	0.182

when a primary tooth pulpotomy is conducted, the dilemma of the choice of the appropriate medicament arises, the best of which has yet to be agreed upon.[5] These contemporary debates and concepts were the drive behind conducting this survey in the GCC region.

4.1. Discussion of managing a carious primary molar (RCM)

When dealing with a primary tooth the conventional surgical "*fill after drill*" philosophy had been accepted as the norm for decades[12] although this had been challenged and investigated[4]. The surgical approach means giving local analgesia (LA) to the child by injection to anaesthetise the tooth, drilling the carious tissue out using a high and slow speed drill, and restoring the primary tooth with various restorative materials such as amalgam, GIC, compomers, composite, SSCs,[12] and other newer materials like Zirconia crowns.[13] In our study a majority (n=114, 76%) would follow the classical surgical doctrine and restore with various materials, while a minority (n=36, 24%) would seal-in the caries. Although longevity studies have shown that composites[14] and SSCs,[12] last longer in posterior primary teeth[15] compared to GIC[16] no agreement between dentists exists. Our study confirmed this disagreement over which material was considered the most appropriate for a given clinical situation; in this case an asymptomatic class II "*do*" carious 74 with radiographic caries away from the pulp in a cooperative 6 year old (see x-ray inset in Figures 1, 2 and 3). It was clear that the majority of those surveyed favoured the conventional "*drill and fill*" modality compared to the "*biological modality*". The single largest group (Fig. 2) was "remove caries and restore with

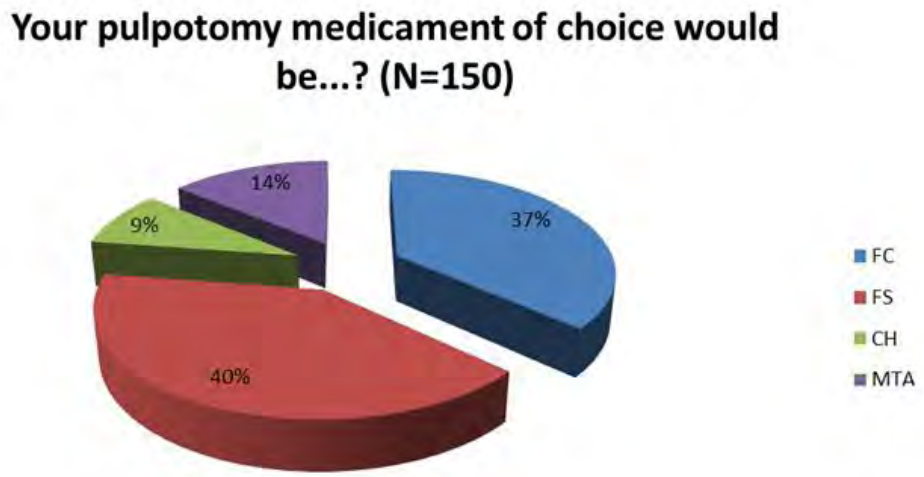


Figure 4. Overall pulpotomy medication of choice for tooth 74. FC: Formocresol; FS: Ferric Sulphate; CH: calcium hydroxide; MTA: Mineral Trioxide Aggregate.

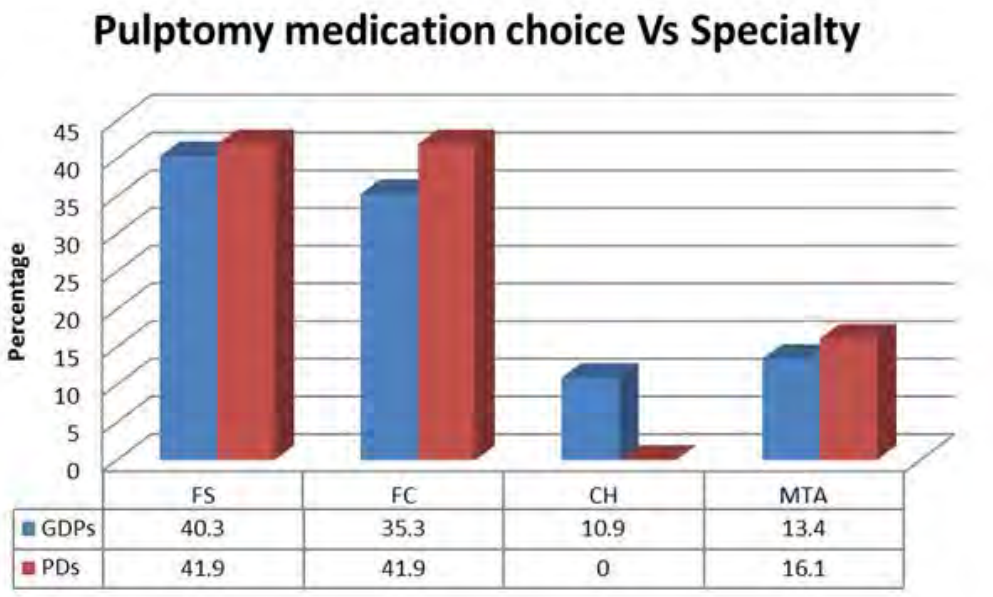


Figure 5. Pulpotomy medication of choice for tooth 74 and specialty (GDP or PD). * FC: Formocresol; FS: Ferric Sulphate; CH: calcium hydroxide; MTA: Mineral Trioxide Aggregate.

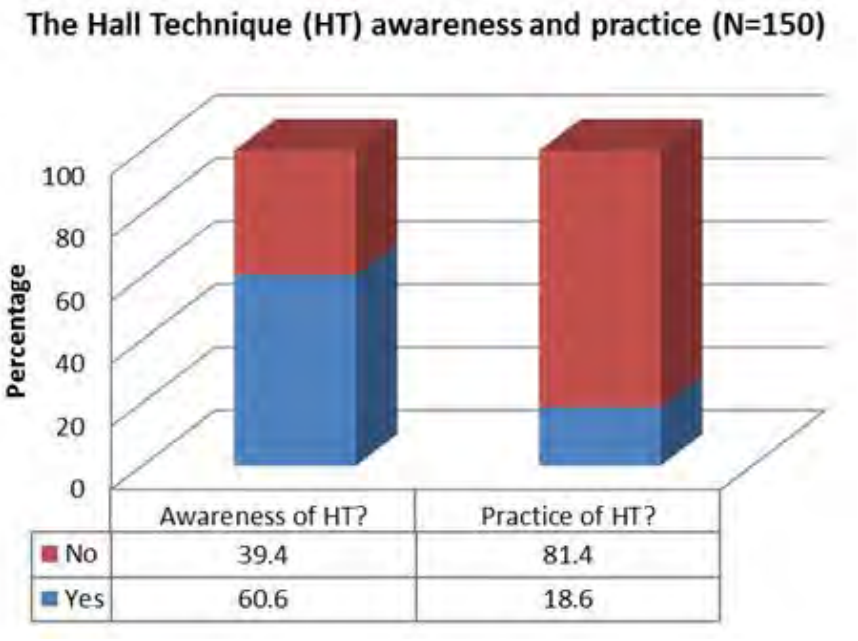


Figure 6. Overall results for Hall Technique awareness and practice.

composite' (33.3%). Although SSCs, both HT SSCs and conventional SSCs when considered together, would represent a larger majority (17.4%+24.2%= 41.8%), they were considered separately in this study, as they represented two different modalities of treatment (biological Vs conventional).

The choice of material differed significantly between GDPs and PDs: GDPs tended to choose composite and GIC more than PDs, while PDs tended to choose conventional SSCs more than GDPs ($p<0.05$) while, interestingly, no PD chose GIC at all. The choice of GIC for Class II lesions, chosen by GDPs in the case, had been previously reported to have a high failure rate.[6] Moreover, the choice of SSCs by most of the PDs in our study was in agreement with the latest guidelines and systematic reviews that favour SSCs multi-surface carious primary molars.[15]

None of the GDPs and only one PD chose Zirconia possibly because it is a newer material on the market with a lot of promise, requires extensive crown preparation and is expensive.

Finally, a few PDs and GDPs chose amalgam, indicating that this material is falling out of favour in the GCC region.

4.2. Discussion of the choice of pulpotomy medicament (PM)

The American Academy of Pediatric Dentistry (AAPD) suggested two treatment options for vital primary teeth with deep caries approaching the pulp. These treatment options were indirect pulp therapy (IPT) and cervical pulpotomy.[17] GDPs were more likely to attempt IPT on primary teeth than paediatric dentists to treat deep caries in asymptomatic primary teeth.[18] A primary molar pulpotomy is defined as the clinical procedure involving the removal of the inflamed and infected coronal pulp tissue while maintaining vital healthy radicular pulp. Following amputation of the coronal pulp, the remaining pulp is treated with one of the following medicaments[19]: Formocresol (FC), Ferric sulphate (FS), Mineral trioxide aggregate(MTA) and Calcium hydroxide (CH). The debate about which medicament to use has engaged the dental literature for a long time, subsequently affecting the clinical decisions of PDs and GDPs alike. This was indeed reflected in our study. As there was no uniform agreement on what constitutes the ideal PM in a given scenario (Fig. 4) and not one PM had an outright majority. Historically, FC has been the medicament of choice for the primary tooth pulpotomy. Buckley in 1904 first used equal parts of tricresol and formalin, although the procedures and formulation have changed since Buckley's first publication,[20] FC has remained popular as a medicament for vital pulp therapy. Dunston and Coll[21] reported that 81% of surveyed USA paediatric dentist diplomates used either diluted or full-strength FC, 18% used FS, and only 1% used some other medicament or technique for primary tooth pulpotomies. FC popularity as a pulp therapy medicament has decreased in some countries and banned in others such as the United Kingdom (UK) because of its alleged cytotoxicity, potential mutagenicity and immune sensitization.[22,23] However, in the USA, a recent survey showed that FC is still the most popular pulpotomy medicament, despite published concerns regarding its potential toxicity among both GDPs and PDs.[18] Despite the fact that the British Society of Paediatric Dentistry (BSPD) guidelines had discouraged the use of FC[19] the AAPD most recent pulp therapy guidelines[17] recommended Buckley's Solution of FC as a pulpotomy medicament in primary

teeth, which in the GCC region had created a lot of confusion. This was even noted in our study; PDs used either FS or FC as a PM (equally n=13, 41.9% for each). MTA, FS and CH are used as alternatives to FC as pulpotomy medicaments.[19] CH has been used, but with less long term success because it has been shown to cause internal resorption in primary teeth.[24] FS is a coagulative and haemostatic agent and it has been found to have high clinical (100%) and radiographic (97%) success rates.[25] Meta-analysis of six prospective controlled trials[23] showed that both FC and FS had similar clinical and radiographic outcomes. Overall clinical success of FS was 78 -100% and radiographic success was 42 - 97%. MTA has also been reported as a pulp therapy medicament with very high (more than 95%) 2 year-follow up clinical and radiographic success rates.[26] The choice of pulpotomy medicaments vary among dental practitioners and also between countries. A 2012 USA survey[18] reported that 69% of general dentists and 68% paediatric dentists used FC; 15% of GDPs and 23% PDs used FS and only 3% of GDPs and 1% PDs reported using MTA. In an analysis of 47 trials and 3910 randomised teeth, a recent Cochrane systematic review in 2014[5] found no evidence to identify a superior PM although MTA or FS were highlighted as "preferable". Smaïl-Faugeron et al, stated[4] that the "cost of MTA may preclude its clinical use and therefore FS could be used". This seemed to be the case in our study, as the first choice by all those surveyed was FS (40.7%), followed by FC (36.7 %) but MTA came in 3rd position (14%) followed last by CH (8.7%). It was interesting to

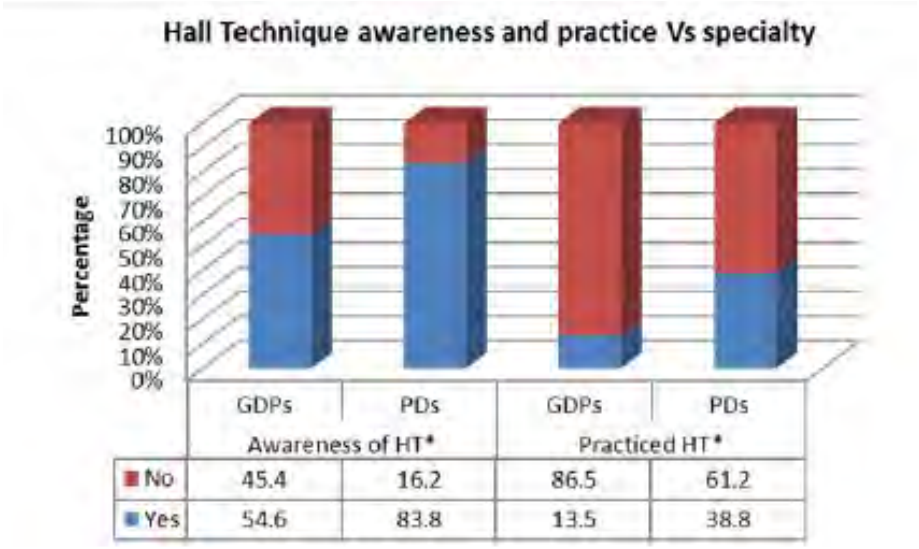


Figure 7. Awareness and practice of the Hall technique per specialty. *denotes statistical significance (*p* >0.05).

Figure 8. Sealing in caries in primary and permanent teeth. The majority of those surveyed opted for "No" in both dentitions.

notice in our study that, although not statistically significant, there was a tendency for PDs to avoid the use of CH [CH causes internal resorption[19,17]] and chose either FS or FC equally (thus adhering either to the AAPD or the BSPD school of thought). Despite this, background training of those surveyed showed no clear relationship with the PM choice. Finally small proportions of GDPs and PDs (13.4% and 16.1% respectively) chose MTA as a PM medicament. No reason can be extrapolated, however as mentioned above MTA is known to be a costly material.

4.3. Discussion of the Hall technique (HT)

The HT[6,10] is a method in which an asymptomatic, non- pulpally involved and aseptic carious primary molar lesion is managed unconventionally. The lesion is "biologically" treated by isolating it from the oral cavity; by cementing a conventional SSC on the tooth with glass ionomer cement in a child friendly play manner.[27] There is no LA, drill nor is there any tooth cutting carried out[6]. The first appointment involves fitting orthodontic separators mesially and distally to the tooth intended for restoration with the HT. The second appointment involves removal of separators 3-5 days after the first appointment and selection and cementation of the SSC with GIC by digital and patient bite pressure.[10]

There was a mixed international reaction to the development to the HT in paediatric dentistry circles[28] with many authors supporting it[29,30] and others condemning it outright.[8] In the UK, some had gone so far as to describe it as the "Gold Standard" for restoring the multi-surface carious molar.[9] Our study investigated the knowledge and practice of the HT. It showed that a majority of those surveyed had heard of (n=91, 60.6%) but not practiced (n=122, 81.4%) the HT. The speciality had a significant impact on this as PDs were more aware of, and had practiced the HT more, when compared to GDPs (p=0.003 and p=0.003 respectively). This can be understood as the HT trials were designed and spearheaded in postgraduate paediatric dentistry environments[29] and developments disseminated in specialists postgraduate conferences, attended mostly by PDs.[1] However, some of the said studies were conducted in the primary dental service setting, i.e., GDPs.[6] Ideally; the ultimate aim of developing the HT was for GDPs becoming the end users of the HT in order to share the burden of caries management between GDPs and PDs. This was because most children are seen by GDPs not PDs. It appeared that our study had shown that there is a large gap between knowledge and practice of the HT in this region. One can also apply conjecture and assume that other confounding factors, such as opposition to the HT may also play a part in avoidance of practice, in addition to lack of appropriate hands on courses to cover the subject. However, the latter points were not investigated in this study and warrant further investigation. Finally, it may be useful to recall the responses highlighted in section a) of this paper's discussion (RCM), as less than a quarter of the respondents only, would choose the HT as a treatment modality, in the given straight forward scenario.

4.4. Discussion of sealing dental caries (SDC)

The therapeutic treatment of carious lesions in primary and permanent teeth by complete removal of caries and restoring the defective tooth structure had classically been advocated as the only treatment modality for many years. When taking primary teeth into account, this was confirmed to be the case by those surveyed in the first question in our study. On the other hand, the thought of SDC, especially in a permanent tooth, may be considered malpractice by many; however, it is now becoming acceptable that the therapeutic treatment of carious lesions by complete removal

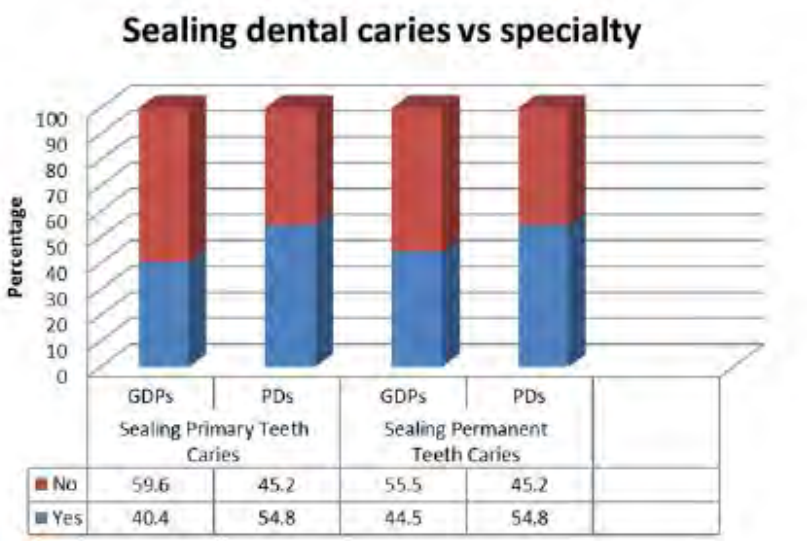


Figure 9. Sealing-in caries and specialty (GDP or PD). No statistically significant results were found between GDPs and PDs.

of caries and restoring the defective tooth structure is only one of the treatment modalities used.[31] SDC in permanent teeth where the carious lesion is partially removed or completely left has been employed as an accepted therapeutic technique by some with ten year results[32] and current available evidence supports the SDC approach.[31,33,34] There are several techniques of SDC that are currently employed, ranging from indirect pulp capping[17] either by incomplete removal of caries and sealing over the carious lesion closest to the pulp or by stepwise caries removal where only partial removal of caries is employed, followed by temporary restoration of the tooth for few months. Finally the tooth is re-entered the rest of the carious lesion, if any present, is removed and the final restoration is placed.[31] Another technique[35] is the no caries removal technique where the entire carious lesion is sealed in permanent teeth as well as primary teeth as highlighted above in the HT section. In permanent teeth, the amount of bacteria detected after conventional caries removal was higher than that which remained in sealed caries lesions.[36] A systematic review and meta-analysis of incomplete caries removal studies[37] concluded that in complete caries removal appeared superior compared to complete caries excavation, especially in lesions very close to the pulp. However, evidence levels are currently insufficient for definitive conclusions because of high risk of bias within the studies. A qualitative examination of private dentists' treatment decisions towards non-cavitated carious lesions concluded that the practitioners based their their decisions on their practical clinical experience and dentists' knowledge of the evidence-based recommendations did not lead to higher compliance with these recommendations.[38]
In our survey, we had attempted to assess the opinion of the surveyed dentists regarding sealing decay in primary and permanent teeth. It was clear that the majority did not believe that SDC was a viable option for both the primary and permanent teeth (56.6% and 53.3 %) although we specified "enamel non-cavitated lesion" in the latter question. This indicated that there was reluctance in the GCC region to accept this new concept, and concurred with the pro "*drill and fill*" results from the first question in this survey. Whether the participant was a PD or GDP had no significant bearing on this result (p=0.517 and p=0.182), although there was a slight tendency for PDs to be tolerant to SDC in both dentitions. This correlated in part with the result seen above with regards to the HT, in essence a method for SDC in primary teeth.
Therefore, the hypothesis, that the surveyed GCC dentists; agreed on treatment options for RCM when faced with a non-pulpally involved carious primary molar in a *cooperative child*, agreed on the PM used in a primary molar pulpotomy, had practiced the HT, and agreed to the concept of SDC in primary and permanent teeth was rejected. However they were aware of the HT. Therefore, there is a great need to organise continuing dental education courses for GDPs and PDs in the GCC region to update them with contemporary guidelines and recommendations related to RCM, PM, HT and SDC.
On a final note, ideally we would have liked the sample of PDs to be the same size of GDPs in this study, however, it is known that there are fewer specialist PDs per paediatric dental population (average 7 per 100000 in the USA) compared to GDPs (60 per 100000 persons in the USA).[39] In the UK, there are 242 registered PDs, compared to 41,000 GDPs (personal communication, General Dental Council, UK, 2016). Therefore, our study sample effectively reflected the relative proportions of the said groups in society.[40]

5. Conclusion

Upon surveying the opinion of a group of dentists in the GCC region, we can conclude that there were disagreements amongst them in relation to the concepts of RCM, PM, HT and SDC. They did not agree on treatment choices for RCM, although the majority would surgically remove rather than seal asymptomatic non- pupal caries in a primary molar. There was no agreement of the PM choices for a primary tooth pulpotomy. The majority were aware of the HT but only a minority used it. A majority did not believe in SDC in both dentitions. Therefore there was a reluctance to accept new concepts, such as the HT and SDC. PDs choice of RCM significantly differed from GDPs, and their awareness of HT and practice of HT were more favourable.

Disclosure of potential conflicts of interest

Ethical approval: "All the procedures (questionnaires) performed in this study were in accordance with the ethical standards of Mohammed Bin Rashid University of Medicine and Health Science (MBRU) and the Hamdan Bin Mohammed College of Dental Medicine (HBMCDM), Dubai, United Arab Emirates and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards."
Informed consent: "Verbal informed consent was obtained from all individual participants included in the study."
Conflict of Interest: The authors declare that they have no conflict of interest.
Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors Contributions: IH (principle author): Concept and design of study, bulk of write up of article, editing, data gathering, analysis and graphs. MH: Design of study, data gathering and sealing caries section in article. MK: Design of study, data gathering and pulpotomy section in article. AKH: Protocol and statistical analysis and tables.

Acknowledgements: The authors would like to thank the participants in this study and also Dr Eman AlNuami, Dr Ghada Hussain and Dr Reem AlSadek for their efforts in distributing and collecting the questionnaires at the three venues.

References

1. Foley JI. Short communication: A pan-European comparison of the management of carious primary molar teeth by postgraduates in paediatric dentistry. Eur Arch Paed Dent. 2012;13(1):41-46. [PubMed] Google Scholar(9) Scopus(5)
2. Evans D, Conway D, Duane B, et al. Scottish Dental Clinical Effectiveness Programme (SDCEP). Prevention and management of dental caries in children. Dental clinical guidance. 2010. [internet: available http://www.sdcep.org.uk/wp-content/uploads/2013/03/SDCEP_PM_Dental_Caries_Full_Guidance1.pdf Last accessed 27th September 2016].
3. Kidd E. Should deciduous teeth be restored? Reflections of a cariologist. Dent Update. 2012;39(3):159-162, 165-166. doi:10.12968/denu.2012.39.3.159 [PubMed] Google Scholar(27)
4. Innes NP, Clarkson JE, Speed C, et al; FiCTION Trial Collaboration. The FiCTION dental trial protocol-filling children's teeth: indicated or not? BMC Oral Health. 2013;13:25 doi: 10.1186/1472-6831-13-25 [Full text links] [Free PMC Article] [PubMed] Google Scholar(19) Scopus(16)
5. Smaïl-Faugeron V, Courson F, Durieux P, et al. Pulp treatment for extensive decay in primary teeth. Cochrane Database Syst Rev. 2014;(8):CD003220. doi:10.1002/14651858.CD003220.pub2 [Full text links] [PubMed] Google Scholar(133) Scopus(38)
6. Ricketts D, Lamont T, Innes NPT, et al. Operative caries management in adults and children.Cochrane Database Syst Rev. 2013;(3):CD003808. doi: 10.1002/14651858.CD003808.pub3 [Full text links] [PubMed] Google Scholar(184) Scopus(123)
7. Croll TP, Killian CM, Simonsen RJ. The Hall technique: serious questions remain. Inside Dentistry. 2015;11(7):30-32.
8. Deery C. The Hall technique: a paradigm shift in our care of children with caries. Dental Update. 2015;42(10): 903-904. [PubMed] Google Scholar(0)
9. Al-Bluwi GS. Epidemiology of dental caries in children in the United Arab Emirates. Int Dent J. Int Dent J. 2014;64(4):219-228. doi: 10.1111/idj.12114 [Full text links] [PubMed] Google Scholar(9) Scopus(4)
10. Innes N, Evans D, Hall N. The Hall Technique for managing carious primary molars. Dent Update. 2009;36(8):472-474, 477-478. [PubMed] Google Scholar(19) Scopus(9)
11. Ricketts DN, Kidd EA, Innes N, et al. Complete or ultraconservative removal of decayed tissue in unfilled teeth. Cochrane Database Syst Rev. 2006;(3):CD003808. doi: 10.1002/14651858.CD003808.pub2 [Full text links] [PubMed] Google Scholar(217) Scopus(115)
12. Duggal MS, Curzon MEJ, Fayle SA, Toumba JK, Robertson, AJ. Restorative Techniques in Paediatric Dentistry. An Illustrated Guide to the restoration of primary teeth. London: Martin Dunitz Ltd; 2002. Google Scholar(27)
13. Walia T, Salami AA, Bashiri R, et al. A randomised controlled trial of three aesthetic full-coronal restorations in primary maxillary teeth. Eur J Paediatr Dent. 2014;15(2):113-118. [PubMed] Google Scholar(18) Scopus(10)
14. Pinto Gdos S, Oliveira LJ, Romano AR, et al. Longevity of posterior restorations in primary teeth: Results from a paediatric dental clinic. J Dent. 2014;42(10):1248-1254. doi: 10.1016/j.jdent.2014.08.005 [Full text links] [PubMed] Google Scholar(14) Scopus(13)
15. Seale NS, Randall, R. The use of stainless steel crowns: a systematic literature review. Pediatr Dent. 2015;37(2):145-160. [Full text links] [PubMed] Google Scholar(14) Scopus(5)
16. Qvist V, Poulsen A, Teglers PT, Mjör IA.. The longevity of different restorations in primary teeth. Int J Paediatr Dent. 2010;20(1):1-7. doi: 10.1111/j.1365-263X.2009.01017.x [Full text links][PubMed] Google Scholar(54) Scopus(34)
17. American Academy of Pediatric Dentistry. Guidelines on pulp therapy for primary and immature permanent teeth: Reference manual 2014. [internet: available http://www.aapd.org/media/policies_guidelines/g_pulp.pdf. Last accessed 15th October 2016].
18. Bowen JL, Mathu-Muju KR, Nash DA, et al. Pediatric and General dentists' attitudes toward pulp therapy for primary teeth. Pediatr Dent. 2012;34(3):210-215.Ped Dent. 2012;34:210–15. [Full text links] [PubMed] Google Scholar(18) Scopus(12)
19. Rodd HD, Waterhouse PJ, Fuks AB, et al ; British Society of Paediatric Dentistry. Pulp therapy in primary molars. Int J Paediatr Dent. 2006;16 Suppl 1:15-23. doi: 10.1111/j.1365-263X.2006.00774.x [Full text links] [PubMed] Google Scholar(175)
20. Buckley JP. The chemistry of pulp decomposition, with a rational treatment for this condition and its sequelae. Am Dent J. 1904;3:764-771. Google Scholar(107)
21. Dunston B, Coll JA. A survey of primary tooth pulp therapy as taught in US dental schools and practiced by diplomates of the American Board of Pediatric Dentistry. Pediatr Dent. 2008;30(1):42-48. [Full text links] [PubMed] Google Scholar(63)
22. Lewis B. Formaldehyde in dentistry: a review for the millennium. J Clin Pediatr Dent. 1998; 22(2):167-177. [PubMed] Google Scholar(93) Scopus(39)
23. Peng L, Ye L, Guo X, et al. Evaluation of formocresol versus ferric sulphate primary molar pulpotomy: a systematic review and meta-analysis. Int Endod J. 2007;40(10):751-757. doi: 10.1111/j.1365-2591.2007.01288.x [Full text links] [Free PMC Article][PubMed] Google Scholar(75) Scopus(37)
24. Zurn D, Seale NS. Light-cured calcium hydroxide vs formocresol in human primary molar pulpotomies: a randomized controlled trial. Pediatr Dent. 2008;30(1):34-41. [Full text links] [PubMed] Google Scholar(45) Scopus(28)
25. Fei AL, Udin RD, Johnson R. A clinical study of ferric sulfate as a pulpotomy agent in primary teeth. Pediatr Dent. 1991;13(6):327-332. [PubMed] Google Scholar(176) Scopus(77)
26. Ansari G, Ranjpour M. Mineral trioxide aggregate and formocresol pulpotomy of primary teeth: a 2-year follow-up. Int Endod J. 2010;43(5):413-418. doi: 10.1111/j.1365-2591.2010.01695.x [Full text links] [PubMed] Google Scholar(59) Scopus(36)
27. Ghaith B, Hussein I. The "All Hall" case: a case report of maximum capacity use of the hall technique in a single child patient. Dental Tribune Middle East and Africa. 2015;5(6):20-24. [Internet: available http://epaper.dental-tribune.com/dti/564ddbb06b878/#/20 Last Accessed 3rd January 2017]. Google Scholar(0)
28. Hussein, I. The Hall technique: The novel method in restoring the carious primary molar that is challenging old concepts. A new tool in the general dentist's toolbox? Dental Tribune Middle East and Africa. 2015;5(1):18-20. [Internet: available http://www.dental-tribune.com/epaper/issues. Last accessed 3rd January 2017]. Google Scholar(1)
29. Santamaria R, Innes N, Machiulskiene V, et al. Acceptability of different caries management methods for primary molars in a RCT. Int J Paediatr Dent. 2015;25(1):9-17. doi: 10.1111/ipd.12097 [Full text links] [PubMed] Google Scholar(30) Scopus(23)
30. Ludwig KH, Fontana M, Vinson LA, et al. The success of stainless steel crowns placed with the Hall technique: a retrospective study. J Am Dent Assoc. 2014;145(12):1248-1253. doi: 10.14219/jada.2014.89 [Full text links] [PubMed] Google Scholar(20) Scopus(16)
31. Bjørndal L, Kidd EA. The treatment of deep dentine caries lesions. Dent Update. 2005; 32(7):402-404, 407-410, 413. [PubMed] Google Scholar(65) Scopus(29)
32. Mertz-Fairhurst EJ, Curtis JW Jr, Ergle JW, et al. Ultraconservative and cariostatic sealed restorations: results at year 10. J Am Dent Assoc. 1998;129(1):55-66. [Full text links] [PubMed] Google Scholar(524) Scopus(293)
33. Ricketts DN, Kidd EA, Innes N, Clarkson J. Complete or ultraconservative removal of decayed tissue in unfilled teeth. Cochrane Database Syst Rev. 2006;(3):CD003808. doi: 10.1002/14651858.CD003808.pub2 [Full text links] [PubMed] Google Scholar(217) Scopus(115)
34. Thompson V, Craig RG, Curro FA, et al. Treatment of deep carious lesions by complete excavation or partial removal:a critical review. J Am Dent Assoc. 2008;139(6):705-712. [Full text links] [Free PMC Article] [PubMed] Google Scholar(174) Scopus(95)
35. Kidd, EA. How 'clean' must a cavity be before restoration? Caries Res. 2004;38(3):305-313. doi: 10.1159/000077770 [Full text links] [PubMed] Google Scholar(320)

36. Maltz M, Henz SL, de Oliveira EF, et al. Conventional caries removal and sealed caries in permanent teeth: a microbiological evaluation. J Dent. 2012;40(9):776-782. doi: 10.1016/j.jdent.2012.05.011 [Full text links] [PubMed] Google Scholar(43) Scopus(23)
37. Schwendicke F, Dörfer CE, Paris S. Incomplete caries removal: a systematic review and meta-analysis. J Dent Res. 2013;92(4):306-314. doi: 10.1177/0022034513477742 [Full text links] [PubMed] Google Scholar(127) Scopus(86)
38. O'Donnell JA, Modesto A, Oakley M, et al. Sealants and dental caries: insight into dentists' behaviors regarding implementation of clinical practice recommendations. J Am Dent Assoc. 2013;144(4):24-30. [Full text links] [Free PMC Article] [PubMed] Google Scholar(22) Scopus(12)
39. Nainar SM, Feigal RJ. Geographic distribution of pediatric dentists in private practice in the United States. Pediatr Dent. 2004;26(6):526-529. [Full text links] [PubMed] Google Scholar(17) Scopus(8)
40. Pride JR, Morgan A. The changing demographics of dentistry [Internet: Available from: http://www.dentaleconomics.com/articles/print/volume-93/issue-2/features/the-changing-demographics-of-dentistry.html Last accessed 5 January 2017]

Iyad HUSSEIN
DDS (Damascus, Syria), MDentSci (Leeds, UK)
GDC Stat.Exam (London, UK), MFDSRCPS (Glasgow, UK)
Assistant Clinical Professor Paediatric Dentistry
Hamdan Bin Mohammed College of Dental Medicine (HBMCDM)
Mohammed Bin Rashid University of Medicine and Health Sciences (MBRU)
Dubai, United Arab Emirates

CV

Dr Iyad HUSSEIN is an assistant clinical professor in paediatric dentistry at Hamdan Bin Mohammed College of Dental Medicine (HBMCDM) at Mohammed Bin Rashid University of Medicine and Health Sciences (MBRU), Dubai, United Arab Emirates since 2014.
Iyad's career spanned over 27 years as a dental surgeon in various posts in England and Scotland (Leeds Dental Institute and Dundee Dental Hospital). Iyad qualified in 1990 from Damascus University with a DDS. He obtained his MDentSci from Leeds University and passed the UK's GDC statutory examination to become a UK fully registered dental surgeon and holds the title of a UK "Specialist in Paediatric Dentistry". He is a Member of the Royal College of Physicians and Surgeons of Glasgow (UK). He has several scientific publications in international and British dental journals.

Questions

The Hall technique involves

- ❑ a. Drilling a tooth;
- ❑ b. Numbing a tooth;
- ❑ c. Sealing caries with a composite;
- ❑ d. Sealing caries with a preformed metal crown.

Dentists in the GCC region carrying out pulpotomies

- ❑ a. Agree on the pulpotomy medicament;
- ❑ b. Use formocresol only;
- ❑ c. Disagree on the pulpotomy medicament;
- ❑ d. Use ferric sulphate only.

MTA in paediatric dentistry is a

- ❑ a. Pulpotomy medicament;
- ❑ b. Pulpectomy medicament;
- ❑ c. An inexpensive material widely used;
- ❑ d. A restorative material.

Of the GCC dentists surveyed in this paper

- ❑ a. 100% had used the Hall technique;
- ❑ b. 1% had used the Hall technique;
- ❑ c. 81.5% had never used the Hall technique;
- ❑ d. 100% had never heard of the Hall technique.

A COMPREHENSIVE REVIEW OF SYSTEMIC FACTORS ASSOCIATED WITH PERI-IMPLANT DISEASES

Mohammed Alshehri[1a*]

[1]Dental Department, King Khalid University Hospital, King Saud University, Riyadh, Saudi Arabia

[a]BDS, AEGD, SSC-ARD, SF-DI, Consultant in Cosmetic Restorative and Implant Dentistry

Received: February 01, 2017
Revised: February 23, 2017
Accepted: March 06, 2017
Published: March 07, 2017

Academic Editor: Constantinus Politis, MD, DDS, MM, MHA, PhD, Professor and Chairperson, University of Leuven, Leuven, Belgium

Cite this article:
Alshehri M. A comprehensive review of systemic factors associated with periimplant diseases. Stoma Edu J. 2017;4(1):37-43.

ABSTRACT

DOI: 10.25241/stomaeduj.2017.4(1).art.3

Background: A variety of systemic factors have been associated with peri-implant diseases.
Objective: The aim of the present comprehensive review was to assess current literature regarding the systemic factors associated with the etiology of peri-implant diseases.
Results: Both normal and premalignant oral mucosa cells (NOK and POE9i) displayed uptake of PLGAChiNPs in a time and concentration-dependent manner, both in 2D and 3D models. A higher and more rapid uptake of PLGAChi NPs by precancerous cell line POE9i was observed when compared to NOKs. Interestingly, DPCs did not display internalized PLGAChi NPs, even at the highest concentration of 200 g/mL.
Data source: Databases were searched till January 2017 using different combinations of the following key words: "acquired immune deficiency syndrome"; "cancer"; "diabetes mellitus"; "genetic"; "peri-implant diseases"; "peri-implantitis", "renal"; and "risk-factors".
Study selection: Clinical studies assessing the systemic factors associated with the etiology of peri-implantitis were included. Letters to the Editor, case-reports, case-series, in-vitro studies, studies on animal models and commentaries were excluded.
Data extraction: The pattern of the present comprehensive review was customized to primarily summarize the pertinent information.
Data synthesis: Poorly-controlled diabetes mellitus (DM) is a significant risk factor for peri-implant diseases; however, under optimal glycemic control dental implants can osseointegrate in patients with DM. Osteoporosis and rheumatoid arthritis have been associated with peri-implant diseases; however, implant surface modifications and optimal oral hygiene maintenance are essential parameters that can facilitate osseointegration in these patients. Although irradiation is a significant risk-factor for peri-implant diseases; studies have shown that osseointegration and survival of implants is possible in cancer patients. There is a weak evidence that HIV infection is no more a contradiction for implant therapy. Although systemic diseases are significant risk-factors for dental implant failure, proper management of the systemic disorder and optimal oral hygiene may support osseointegration and survival of dental implants in medically-compromised patients.
Keywords: acquired immune deficiency syndrome, cancer, diabetes mellitus, genetic, peri-implant diseases.

1. Introduction

Although studies[1-3] have reported implant success and survival rates of up to 100%; a number of systemic factors have been reported to jeopardize the success and survival of dental implants.[4, 5] According to a consensus report from the 6th European Workshop on Periodontology, peri-implantitis is defined as the presence of inflammation of the peri-implant mucosa and concurrent loss of supporting alveolar bone.[6]

***Corresponding author:**

Dr Mohammed Alshehri, BDS, AEGD, SSC-ARD, SF-DI, Dental Department, King Khalid, University Hospital, King Saud University, Riyadh, Saudi Arabia.
Tel/Fax: +96.655.380.333 / +966.114.672.428, e-mail: dr_mzs@hotmail.com

Mombelli et al.[7] described peri-implantitis as a site-specific inflammatory condition, which displays clinical and radiographic features that are similar to those in patients with chronic periodontitis. Data regarding the prevalence of peri-implantitis is inconsistent. In the study by Koldsland et al.,[8] the prevalence of peri-implantitis ranged between 11.3% and 47.1%; whereas Mombelli et al.[9] reported peri-implantitis in 20% of their study population during 5 to 10 years of follow-up. In the study by Zitzmann and Berglundh,[6] the frequency of peri-implantitis varied between 28% and at least 56% of the participants and 12% and 43% of individual implants. Peri-implant diseases are categorized into two types namely, peri-implant mucositis and peri-implantitis. Peri-implant mucositis is characterized by inflammation of soft tissues around the implant without any signs of peri-implant alveolar bone loss.6 Patients with peri-implant mucositis exhibit bleeding on probing (BOP), peri-implant probing depth ≥ 4mm and/or suppuration.[10,11]

A variety of factors, local as well as systemic factors have been associated with the etiology of peri-implantitis.[12-16] It is well known that poor oral hygiene, tobacco smoking, poor bone quality and quantity, jaw location and bruxism are among the most common local factors associated with the etiology of peri-implantitis. Nevertheless, the contribution of systemic factors such as immunosuppression (as observed in patients with acquired immune deficiency syndrome, osteoporosis, poorly-controlled diabetes mellitus and cancer) and use of medications (such as bisphosphonates and corticosteroids) that have also been associated with the etiology of peri-implantitis cannot be disregarded (Fig. 1).[17-21] Considering the length of the article, the author dedicated the present article to comprehensively review the systemic risk-factors associated with the etiology of peri-implantitis. The aim of the present comprehensive review was to provide an overview of current literature regarding the systemic conditions associated with the etiology of peri-implantitis.

2. Materials and methods

2.1. Focused question

The addressed focused question was "Which systemic conditions are associated with the etiology of peri-implant diseases?"

2.2. Literature search strategy

PubMed/Medline, Scopus, EMBASE, ISI Web of knowledge and Google-Scholar databases were searched from till January 2017 using the following key words: "arthritis", "cancer", "diabetes mellitus"; "acquired immune deficiency syndrome"; "renal disorders"; "osteoporosis", "peri-implant/periimplant" and "genetics".

Clinical studies assessing the local risk-factors associated with the etiology of peri-implant diseases were included.

2.3. Eligibility criteria

Results from only clinical studies were included. Letters to the Editor, historic reviews, case-reports, case-series, in-vitro studies, studies on animal models and commentaries were excluded. The pattern of the present comprehensive review was customized to primarily summarize the pertinent information.

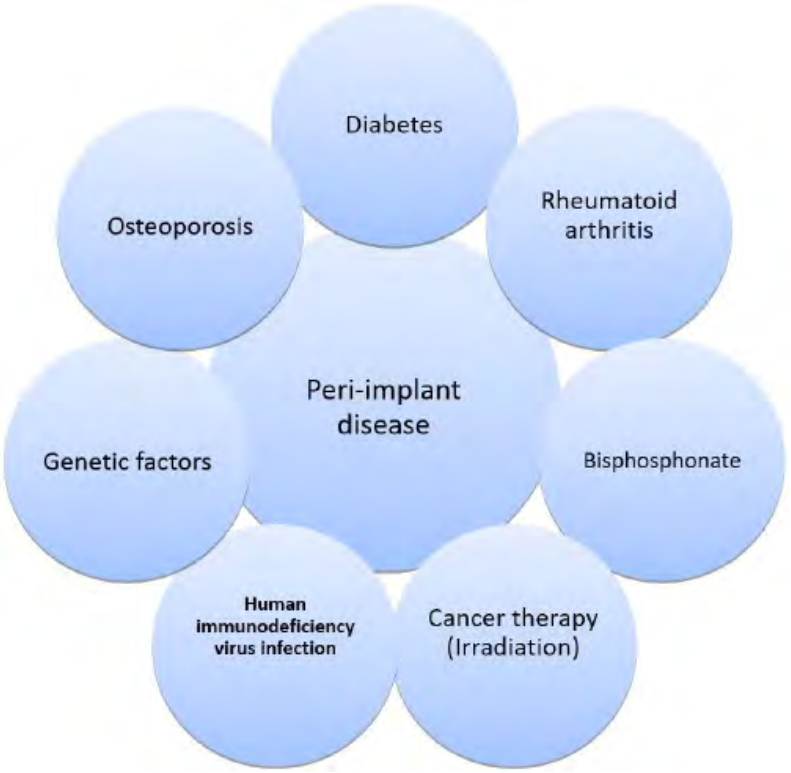


Figure 1. Systemic factors associated with peri-implant diseases.

3. Results

3.1. Diabetes mellitus

Diabetes mellitus (or diabetes) is a common metabolic disorder characterized by hyperglycemia due to impaired insulin secretion, insufficient insulin action, or both.[22] The main types of diabetes include type 1 diabetes and type 2 diabetes. Type 1 diabetes is associated with pancreatic beta (β)-cell destruction and accounts for 5-10% of the subjects with diabetes. Type 2 diabetes is associated with a relative, rather than an absolute insulin deficiency and accounts for 90-95% of all individuals with diabetes.[23] Individuals with poorly-controlled diabetes are more susceptible to develop complications after implant therapy compared to individuals with well-controlled diabetes.[24]

Chronic hyperglycemia has been related with tissue damage, since endothelial cells take up glucose passively in an insulin-independent manner.[25,26] Hyperglycemia is also associated with an altered host resistance, for example, defective migration of polymorphonuclear leukocytes, impaired phagocytosis and an exaggerated inflammatory response to microbial products.[27]

The treatment of diabetes focuses on the attainment of an optimal glycemic control in order to impede complications.

Individuals with diabetes are more susceptible to periodontal disease, which is also recognized as the sixth complication of diabetes.[28-32]

The underlying pathophysiology that increases the risk of periodontal bone loss in subjects with diabetes is poorly understood; however it has been associated with the formation and accumulation of glucose-mediated advanced glycation end-products (AGEs).

AGEs accumulate in the plasma and tissues (including the periodontium) during the process of normal aging, but to an accelerated degree in subjects with diabetes.[33] AGEs contribute to periodontal destruction by activating receptors called "Receptor for AGEs (RAGE)" located on the periodontium and by reducing the production of matrix proteins, such as collagen and osteocalcin by gingival and periodontal fibroblasts.[34-38]

It has been suggested that the pathogenesis of diabetes and its complications are associated with an increased RAGE expression.[29,39]

Other cell types with RAGE expression include glomerular epithelial cells (podocytes), endothelial cells, vascular smooth muscle cells, inflammatory mononuclear phagocytes and lymphocytes.[39] Therefore, an impaired glycemic status may negatively affect the outcome of implant therapy. In a systematic review, Javed and Romanos[19] reported that under optimal glycemia control, dental implants can osseointegrate and remain functionally stable over long durations in patients with diabetes.

3.2. Bisphosphonates

Bisphosphonates (BPs), (such as alendronate, risendronate, ibandronate, and clodronate) are important group of drugs used for the treatment of metabolic and oncologic pathologies involving the skeletal system. The mode of action of BPs depends on the drugs' chemical structure. The two main categories of BPs are the "non-nitrogen" and "nitrogen-containing" BPs.[40] Non-nitrogen-containing BPs are metabolized rapidly, whereas nitrogen-containing BPs are much more potent and are not metabolized.[41] These drugs act by inhibiting osteoclastic activity and inducing their apoptosis.[18] BPs may be administered by either oral or intravenous routes. Oral BPs are used in the treatment of diseases such as osteoporosis and Pagets' disease; while intravenous BPs are administered to patients with breast cancer, multiple myeloma, bone metastasis and malignant hypercalcemia. The chief complication observed in patients under either oral or intravenous BP therapy is osteonecrosis of the jaw (ONJ).[42] It has been suggested that all patients under bisphosphonate therapy who are expected to receive dental implants should be informed of the possible risks of development of ONJ and consequent implant loss beforehand; and an informed-consent must be obtained prior to installation of dental implants in these individuals.[14,15]

Although, the risk of developing ONJ in patients using BPs is estimated to be minimal (approximately 0.09%), there still exists a controversy over the placement of dental implants in patients treated with BPs.[43] Results from case-reports[44-47] have shown that dental implants can osseointegrate and remain functionally stable in patients under BP therapy. Similar results have been reported in retrospective studies.[48,49] Results by Bell and Bell50 showed comparable implant survival rates between patients using BPs and controls, that is, 95% and 96.5% respectively. Brooks et al.[47] placed 10 implants in a patient on bisphosphonate therapy out of which, 9 implants osseointegrated successfully giving a success rate of 90%. Likewise, results from a case-report by Wang et al.[44] also showed implant healing to be uneventful with no alterations in the healing process of dental implants in a patient using BPs. Fugazzotto et al.[51] showed that a history of bisphosphonate therapy was not associated with the occurrence of ONJ following installation of immediately-loaded dental implants.

In their systematic review, Javed and Almas[18] reported that the incidence of implant failure in patients taking BPs is minimal.

The authors also concluded that placement of dental implants in patients taking BPs can have a positive outcome.[18]

3.3. Osteoporosis and rheumatoid arthritis

Osteoporosis is a metabolic disease of bone characterized by low bone mineral density (BMD) and reduced bone mass due to impaired bone metabolism and imbalanced osteoblastic and osteoclastic activities.[52,53] In osteoporotic bone, osteoblasts demonstrate impaired proliferative, synthetic and reactive ability to cellular mediators.[52,54,55]

Underlying causes of osteoporosis include pre- and postmenopausal estrogen deficiency, excessive glucocorticoid intake, eating disorders such as anorexia nervosa and celiac disease.[56,57] Although the bone quality and strength are compromised in osteoporotic patients; osteoporosis is not considered a contraindication for implant the-rapy.[58,59] In a recent

systematic review, Javed et al.[60] assessed the effect of osteogenic coatings on the osseointegration of implants under induced osteoporotic conditions. Nearly 80% studies reported that osteogenic coatings around implant surfaces enhance bone formation, bone-to-implant contact (BIC) and bone volume (BV) under osteoporosis-like conditions. This could possibly be accredited to the increase in surface roughness of the implant caused by osteogenic coatings, which facilitate the attachment of osteoprogenitor cells to the implant surface. Holahan et al.[59] conducted a retrospective study to evaluate whether a diagnosis of osteoporosis affected the survival rate of osseointegrated dental implants. In this study[59], a total of 3,224 implants placed in 746 female patients aged at least 50 years old at the time of implant placement were assessed. The results showed that patients with a diagnosis of osteoporosis or osteopenia were not significantly more likely to develop implant failure compared to those without such a diagnosis.[59]

Krennmair et al.[61] evaluated the implant treat-ment outcomes for patients suffering from autoimmune rheumatoid arthritis (RA) with or without concomitant connective tissue diseases (CTD). In this study,[61] 34 female patients (25 iso-lated RA; nine RA+CTD) were included. At the mean duration of follow-up of nearly 46 month, all implants presented a survival rate of 100%. In isolated RA patients, acceptable marginal bone loss (MBL) (mean: 2.1 mm; SD: 0.5 mm), pocket depth (mean: 2.8 mm; SD:3.2 mm) and healthy soft-tissue conditions (plaque/bleeding/gingiva index Grade 0 in 80%) were observed.[61] Results from a case-series report,[62] showed a high implant survival rate during follow-up with a cumulative 3-year implant success rate of 96.1%. In this study, RA patients demonstrated acceptable MBL (mean: 2.1 +/- 0.5 mm) and satisfactory soft tissue conditions; whereas CTD patients showed increased MBL (mean: 3.1 +/- 0.7 mm).

The study[62] concluded that a high implant and prosthodontic success rate can be anticipated in patients suffering from RA; however, the authors emphasized that optimal oral hygiene assists in ensuring stable long-term survival of dental implants in patients with RA.[62]

3.4. Irradiation

Osteoradionecrosis is usually observed several years following radiotherapy and is associated with local trauma within the hypovascular–hypocellular hypoxic tissues (that occurs as a result of radiation-induced endarteritris).[63] In this regard, the interval between the end of cancer therapy and placement of dental implants may contribute to the success or failure of osseointegration. Studies[64-66] have investigated the required time interval between radiotherapy and implant installation that may influence osseointegration; however the results remain debatable. In a systematic review, Zen Filho et al.[67] assessed the safety of dental implants placed in irradiated bone and to discuss their viability when placed post-radiotherapy. Eight publications were assessed in this systematic review[67] and the results showed a total of 331 patients received 1237 implants. The time interval between irradiation and dental implantation ranged from 6 to 15 months. The overall implant failure rate of 9.53% and osseointegration success rates ranged between 62.5% and 100%.[67] In another review, Javed et al.[20] assessed the implant survival rate after oral cancer therapy. In total, 21 studies were included in this review out of which, 16 studies reported that dental implants can osseointegrate and remain functionally stable in patients having undergone radiotherapy following oral cancer surgery.[20] The authors concluded that dental implants can osseointegrate and remain functionally stable in patients having undergone oral cancer treatment.[20]

3.5. Human immunodeficiency virus infection

Human immunodeficiency virus (HIV) infection is characterized by progressive immune system failure that gives rise to the development of opportunistic infections and neoplasms. The virus invades CD4+ T lymphocytes, macrophages and dendritic cells, and the CD4+ T cell counts gradually decrease as a result of direct cytopathic action or cytotoxic CD8+T lymphocyte-mediated attack. In a recent systematic review, Ata-Ali et al.[68] attempted to answer the following focused question "does HIV infection have an impact upon dental implant osseointegration?" The combinations of search terms resulted in a list of 132 titles. Consequently, 101 studies were excluded on the basis of the evaluation of the title and abstract, thereby leaving 9 articles for eligibility assessment. Amongst the studies included in this systematic review, a total of 173 dental implants were placed in 80 patients (135 implants in 56 HIV-positive individuals and 38 implants in 24 HIV-negative patients -control groups). A single loss of dental implant osseointegration was recorded in an HIV-positive patient.[68] In the study by Stevenson et al.[69], 40 dental implants were placed in 20 HIV-infected patients. No implant osseointegration failures were recorded after 6 months of follow-up. Similarly, in another study of 39 dental implants placed in 24 HIV-infected patients, no implant osseointegration failures were recorded after 12 months of follow-up.[70] Should dental implants placed in HIV positive patients sustain bone levels in the long-term (5 years or longer) requires further investigations.

3.6. Genetic factors

Jacobi-Gresser et al.[71] assessed diagnostic markers to predict titanium implant failure.

The study reported that tumor necrosis factor-alpha (TNF-α) and interleukin 1-beta (IL-1*β*) release on titanium stimulation were significantly higher among patients with implant failure.

The results showed that IL-1*β*/TNF-*α* release and number of risk genotypes were significantly associated with implant failure.[71]

Vaz et al.[72] examined IL-1 gene clusters in 155 patients with 100 successful implants and 55 unsuccessful implants.

The authors concluded that successful implants were associated with a negative genetic test and that unsuccessful implants were associated with a positive genetic test.[72]

Casado and colleagues reported that the IL-6 genotype was 1.53 times more likely to convey peri-implant disease if the individuals had the GC

genotype and allele G.

4. Conclusion

Although systemic diseases such as poorly controlled DM, RA and osteoporosis are significant risk-factors for dental implant failure, proper management of the systemic disorder and optimal oral hygiene may support osseointegration and survival of dental implants in medically-compromised patients.

Conflict of interest and financial disclosure

The author reports no conflict of interest and there was no external source of funding for the present study.

References

1. Carames J, Tovar Suinaga L, Yu Yc, Perez A, Kang M. Clinical advantages and limitations of monolithic zirconia restorations full arch implant supported reconstruction: case series. Int J Dent. 2015;2015:392496. doi: 10.1155/2015/392496. [Full text links] [Free PMC Article] [PubMed] Google Scholar (16) Scopus (10)
2. Fenner N, Hämmerle Ch, Sailer I, Jung Re. Long-Term Clinical, Technical, And Esthetic Outcomes Of All-Ceramic Vs. Titanium Abutments On Implant Supporting Single-Tooth Reconstructions After At Least 5 Years. Clin Oral Implants Res. 2016;27(6):716-723 doi: 10.1111/clr.12654. [Full text links] [PubMed] Google Scholar (15) Scopus (5)
3. Jeong MA, Jung MK, Kim SG, Oh JS. Implant stability measurements in the long-term follow-up of dentis implants: a retrospective study with Periotest. Implant Dent. 2015;24(3):263-266. doi: 10.1097/Id.0000000000000239. [Full text links] [PubMed] Google Scholar (4) Scopus (2)
4. Romanos GE, Javed F, Delgado-Ruiz RA, Calvo-Guirado JL Peri-implant diseases: a review of treatment interventions. Dent Clin North Am. 2015;59(1):157-178. doi: 10.1016/j.cden.2014.08.002 [Full text links] [PubMed] Google Scholar (39) Scopus (20)
5. Tonetti MS. Risk factors for osseodisintegration. Periodontol 2000. 1998;17:55-62. [Full text links] [PubMed] Google Scholar (144) Scopus (74)
6. Zitzmann NU, Berglundh T. Definition and prevalence of peri-implant diseases. J Clin Periodontol. 2008;35(8 Suppl):286-291. doi: 10.1111/j.1600-051x.2008.01274.x. Review. [Full text links] [PubMed] Google Scholar (854) Scopus (468)
7. Mombelli A, van Oosten MA, Schurch E, Jr., Land NP. The microbiota associated with successful or failing osseointegrated titanium implants. Oral Microbiol Immunol. 1987;2(4):145-151. [Full text links] [PubMed] Google Scholar (1713) Scopus (1035)
8. Koldsland OC, Scheie AA, Aass AM. Prevalence of peri-implantitis related to severity of the disease with different degrees of bone loss. J Periodontol. 2010;81(2):231-238. doi: 10.1902/jop.2009.090269. [Full text links] [PubMed] Google Scholar (298) Scopus (161)
9. Mombelli A, Müller N, Cionca N. The epidemiology of peri-implantitis. Clin Oral Implants Res. 2012;23 Suppl 6:67-76. doi: 10.1111/j.1600-0501.2012.02541.x. Review. [Full text links] [PubMed] Google Scholar (347) Scopus (192)
10. Khammissa RA, Feller L, Meyerov R, Lemmer J. Peri-implant mucositis and peri-implantitis: clinical and histopathological characteristics and treatment. SADJ. 2012;67(3):122, 124-126. Review. [PubMed] Google Scholar (30) Scopus (13)
11. Jankovic S, Aleksic Z, Dimitrijevic B, et al. Prevalence of human cytomegalovirus and Epstein-Barr virus in subgingival plaque at peri-implantitis, mucositis and healthy sites. A pilot study. Int J Oral Maxillofac Surg. 2011;40(3):271-276. doi: 10.1016/j.ijom.2010.11.004 [Full text links] [PubMed] Google Scholar (23) Scopus (14)
12. Tsigarida AA, Dabdoub SM, Nagaraja HN, Kumar PS. The influence of smoking on the peri-implant microbiome. J Dent Res. 2015;94(9):1202-1217. doi: 10.1177/0022034515590581. [Full text links] [Free PMC Article] [PubMed] Google Scholar (24) Scopus (18)
13. Ferreira SD, Silva GL, Cortelli JR, Costa JE, Costa FO. Prevalence and risk variables for peri-implant disease in Brazilian subjects. J Clin Periodontol. 2006;33(12):929-935. doi: 10.1111/j.1600-051x.2006.01001.x. [Full text links] [PubMed] Google Scholar (363) Scopus (168)
14. Degidi M, Nardi D, Piattelli A. 10-year prospective cohort follow-up of immediately restored XiVE implants. Clin Oral Implants Res. 2016 Jun;27(6):694-700. doi: 10.1111/clr.12642. [Full text links] [PubMed] Google Scholar (12) Scopus (4)
15. Miyata T, Kobayashi Y, Araki H, Ohto T, Shin K. The influence of controlled occlusal overload on peri-implant tissue. Part 3: a histologic study in monkeys. Int J Oral Maxillofac Implants. 2000;15(3):425-431. [PubMed] Google Scholar (225) Scopus (117)
16. Wahlström M, Sagulin GB, Jansson LE. Clinical follow-up of unilateral, fixed dental prosthesis on maxillary implants. Clin Oral Implants Res. 2010;21(11):1294-1300. [PubMed] Google Scholar (34) Scopus (19)
17. Vohra F, Al-Rifaiy MQ, Almas K, Javed F. Efficacy of systemic bisphosphonate delivery on osseointegration of implants under osteoporotic conditions: lessons from animal studies. Arch Oral Biol. 2014;59(9):912-920. doi: 10.1016/j.archoralbio.2014.05.016. [Full text links] [PubMed] Google Scholar (21) Scopus (10)
18. Javed F, Almas K. Osseointegration of dental implants in patients undergoing bisphosphonate treatment: a literature review. J Periodontol. 2010;81(4):479-484.doi: 10.1902/jop.2009.090587. [Full text links] [PubMed] Google Scholar (92) Scopus (53)
19. Javed F, Romanos GE. Impact of diabetes mellitus and glycemic control on the osseointegration of dental implants: a systematic literature review. J Periodontol. 2009;80(11):1719-1730. doi: 10.1902/jop.2009.090283. [Full text links] [PubMed] Google Scholar (225) Scopus (132)
20. Javed F, Al-Hezaimi K, Al-Rasheed A, Almas K, Romanos GE. Implant survival rate after oral cancer therapy: a review. Oral Oncol. 2010;46(12):854-859. doi: 10.1016/j.oraloncology.2010.10.004. [Full text links] [Free PMC Article] [PubMed] Google Scholar (63) Scopus (37)
21. Lu SY, Huang CC. Resolution of an active peri-implantitis in a chronic steroid user by bone augmentation with PepGen P-15 and a barrier membrane. J Oral Implantol. 2007;33(5):280-287. doi: 10.1563/1548-1336(2007)33[280:ROAAPI]2.0.CO;2. [Full text links] [PubMed] Google Scholar (12) Scopus (3)
22. Classification and diagnosis of diabetes. Diabetes Care. 2015;38 Suppl S8-S16. doi: 10.2337/dc15-s005. [Full text links] [PubMed] Google Scholar (778) Scopus (476)
23. Diagnosis and classification of diabetes mellitus. Diabetes Care. 2005;28 Suppl 1:S37-S42. https://doi.org/10.2337/diacare.28.suppl_1.S37 [Full text links] [PubMed] Google Scholar (13301) Scopus (806)
24. Fiorellini JP, Chen PK, Nevins M, Nevins ML. A retrospective study of dental implants in diabetic patients. Int J Periodontics Restorative Dent. 2000;20(4):366-373. [PubMed] Google Scholar (199) Scopus (97)
25. Ceriello A, Motz E. Is oxidative stress the pathogenic mechanism underlying insulin resistance, diabetes, and cardiovascular disease? The common soil hypothesis revisited. Arterioscler Thromb Vasc Biol. 2004;24(5):816-823. doi: 10.1161/01.ATV.0000122852.22604.78. Review. [Full text links] [Free article] [PubMed] Google Scholar (1364)
26. Zhang Y, Qu Y, Niu T, Wang H, Liu K. O-GlcNAc modification of Sp1 mediates hyperglycaemia-induced ICAM-1 up-regulation in endothelial cells. Biochem Biophys Res Commun. 2017;484(1):79-84. doi: 10.1016/j.bbrc.2017.01.068. [Full text links] [PubMed] Google Scholar (0) Scopus (1)
27. Soory M. Hormone mediation of immune responses in the progression of diabetes, rheumatoid arthritis and periodontal diseases. Curr Drug Targets Immune Endocr Metabol Disord. 2002;2(1):13-25. [PubMed] Google Scholar (53) Scopus (28)
28. Löe H. Periodontal disease. The sixth complication of diabetes mellitus. Diabetes Care. 1993;16(1):329-334. [PubMed] Google Scholar (1377) Scopus (638)
29. Lamster IB, Lalla E. Periodontal disease and diabetes mellitus: discussion, conclusions, and recommendations. Ann Periodontol. 2001;6(1):146-149. doi: 10.1902/annals.2001.6.1.146 [PubMed] Google Scholar (62) Scopus (15)
30. Javed F, Näsström K, Benchimol D, et al. Comparison of periodontal and socioeconomic status between subjects with type 2 diabetes mellitus and non-diabetic controls. J Periodontol. 2007;78(11):2112-2119. doi: 10.1902/jop.2007.070186.

[Full text links] [PubMed] Google Scholar (153) Scopus (105)
31. Javed F, Al Amri MD, Al-Kheraif AA, et al. Efficacy of non-surgical periodontal therapy with adjunct Nd:YAG laser therapy in the treatment of periodontal inflammation among patients with and without type 2 diabetes mellitus: A short-term pilot study. J Photochem Photobiol B. 2015;149:230-234. doi: 10.1016/j.jphotobiol.2015.06.013.
[Full text links] [PubMed] Google Scholar (15) Scopus (11)
32. Javed F, Al-Kheraif AA, Salazar-Lazo K, et al. Periodontal inflammatory conditions among smokers and never-smokers with and without type 2 diabetes mellitus. J Periodontol. 2015;86(7):839-846. doi: 10.1902/jop.2015.150120.
[Full text links] [PubMed] Google Scholar (19) Scopus (14)
33. Wautier JL, Guillausseau PJ. Advanced glycation end products, their receptors and diabetic angiopathy. Diabetes Metab. 2001;27(5 Pt 1):535-542.
[Full text links] [PubMed] Google Scholar (324) Scopus (209)
34. Fong Y, Edelstein D, Wang EA, Brownlee M. Inhibition of matrix-induced bone differentiation by advanced glycation end-products in rats. Diabetologia. 1993;36(9):802-807.
[PubMed] Google Scholar (35) Scopus (22)
35. Schmidt Am, Weidman E, Lalla E, et al. Advanced glycation endproducts (AGEs) induce oxidant stress in the gingiva: a potential mechanism underlying accelerated periodontal disease associated with diabetes. J Periodontal Res. 1996;31(7):508-515.
[Full text links] [PubMed] Google Scholar (289)
36. Lalla E, Lamster IB, Stern DM, Schmidt AM. Receptor for advanced glycation end products, inflammation, and accelerated periodontal disease in diabetes: mechanisms and insights into therapeutic modalities. Ann Periodontol. 2001;6(1):113-118. doi: 10.1902/annals.2001.6.1.113.
[PubMed] Google Scholar (146) Scopus (81)
37. Oldfield MD, Bach LA, Forbes JM, et al. Advanced glycation end products cause epithelial-myofibroblast transdifferentiation via the receptor for advanced glycation end products (RAGE). J Clin Invest. 2001;108(12):1853-1863. doi: 10.1172/JCI11951
[Full text links] [Free PMC Article] [PubMed] Google Scholar (451)
38. Sajithlal G, Huttunen H, Rauvala H, Munch G. Receptor for advanced glycation end products plays a more important role in cellular survival than in neurite outgrowth during retinoic acid-induced differentiation of neuroblastoma cells. J Biol Chem. 2002;277(9):6888-6897. doi: 10.1074/jbc.M107627200.
[Full text links] [PubMed] Google Scholar (57) Scopus (43)
39. Kim W, Hudson BI, Moser B, et al. Receptor for advanced glycation end products and its ligands: a journey from the complications of diabetes to its pathogenesis. Ann N Y Acad Sci. 2005;1043:553-561. doi: 10.1196/annals.1338.063.
[Full text links] [PubMed] Google Scholar (101) Scopus (79)
40. Green JR. Bisphosphonates: preclinical review. Oncologist. 2004;9 Suppl 43-13. doi: 10.1634/theoncologist.9-90004-3. Review.
[Full text links] [PubMed] Google Scholar (440) Scopus (300)
41. Frith JC, Mönkkönen J, Blackburn GM, Russell RG, Rogers MJ. Clodronate and liposome-encapsulated clodronate are metabolized to a toxic atp analog, adenosine 5'-(beta, gamma-dichloromethylene) triphosphate, by mammalian cells in vitro. J Bone Miner Res. 1997;12(9):1358-1367. doi: 10.1359/jbmr.1997.12.9.1358.
[Full text links] [PubMed] Google Scholar (465)
42. Vahtsevanos K, Kyrgidis A, Verrou E, et al. Longitudinal cohort study of risk factors in cancer patients of bisphosphonate-related osteonecrosis of the jaw. J Clin Oncol. 2009;27(32):5356-5362. doi: 10.1200/jco.2009.21.9584.
[Full text links] [PubMed] Google Scholar (293) Scopus (197)
43. Sambrook P, Olver I, Goss A. Bisphosphonates and osteonecrosis of the jaw. Aust Fam Physician. 2006;35(10):801-803.
[Full text links] [PubMed] Google Scholar (100) Scopus (74)
44. Wang HL, Weber D, Mccauley LK. Effect of long-term oral bisphosphonates on implant wound healing: literature review and a case report. J Periodontol. 2007;78(3):584-594. doi: 10.1902/jop.2007.060239. Review.
[Full text links] [PubMed] Google Scholar (173) Scopus (74)
45. Pirih FQ, Zablotsky M, Cordell K, Mccauley LK. Case report of implant placement in a patient with paget's disease on bisphosphonate therapy. J Mich Dent Assoc. 2009;91(5):38-43.
[PubMed] Google Scholar (11) Scopus (5)
46. Torres J, Tamimi F, Garcia I, et al. Dental implants in a patient with Paget disease under bisphosphonate treatment: a case report. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;107(3):387-392. doi: 10.1016/j.tripleo.2008.11.024.
[Full text links] [PubMed] Google Scholar (23) Scopus (9)
47. Brooks JK, Gilson AJ, Sindler AJ, et al. Osteonecrosis of the jaws associated with use of risedronate: report of 2 new cases. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007;103(6):780-786. doi: 10.1016/j.tripleo.2006.10.010.
[Full text links] [PubMed] Google Scholar (89) Scopus (57)
48. Tallarico M, Canullo L, Xhanari E, Meloni SM. Dental implants treatment outcomes in patient under active therapy with alendronate: 3-year follow-up results of a multicenter prospective observational study. Clin Oral Implants Res. 2016;27(8):943-949. doi: 10.1111/clr.12662
[Full text links] [PubMed] Google Scholar (9) Scopus (3)
49. Al-Sabbagh M, Robinson FG, Romanos G, Thomas MV. Osteoporosis and bisphosphonate-related osteonecrosis in a dental school implant patient population. Implant Dent. 2015;24(3):328-332. doi: 10.1097/id.0000000000000234.
[Full text links] [PubMed] Google Scholar (8) Scopus (3)
50. Bell BM, Bell RE. Oral bisphosphonates and dental implants: a retrospective study. J Oral Maxillofac Surg. 2008;66(5):1022-1024. doi: 10.1016/j.joms.2007.12.040.
[Full text links] [PubMed] Google Scholar (139) Scopus (73)
51. Fugazzotto PA, Lightfoot WS, Jaffin R, Kumar A. Implant placement with or without simultaneous tooth extraction in patients taking oral bisphosphonates: postoperative healing, early follow-up, and the incidence of complications in two private practices. J Periodontol. 2007;78(9):1664-1669. doi: 10.1902/jop.2007.060514.
[Full text links] [PubMed] Google Scholar (137) Scopus (79)
52. Torricelli P, Fini M, Giavaresi G, Giardino R. Human osteoblast cultures from osteoporotic and healthy bone: biochemical markers and cytokine expression in basal conditions and in response to 1,25(OH)2D3. Artif Cells Blood Substit Immobil Biotechnol. 2002;30(3):219-227.
[PubMed] Google Scholar (27)
53. NIH consensus development panel on osteoporosis prevention, diagnosis, and therapy, March 7-29, 2000: highlights of the conference. South Med J. 2001;94(6):569-573.
[PubMed] Google Scholar (2) Scopus (178)
54. Wong MM, Rao LG, Ly H, et al. In vitro study of osteoblastic cells from patients with idiopathic osteoporosis and comparison with cells from non-osteoporotic controls. Osteoporos Int. 1994;4(1):21-31.
[PubMed] Google Scholar (49) Scopus (41)
55. Neidlinger-Wilke C, Stalla I, Claes L, et al. Human osteoblasts from younger normal and osteoporotic donors show differences in proliferation and TGF beta-release in response to cyclic strain. J Biomech. 1995;28(12):1411-1418.
[Full text links] [PubMed] Google Scholar (115)
56. Abraham A, Cohen A, Shane E. Premenopausal bone health: osteoporosis in premenopausal women. Clin Obstet Gynecol. 2013;56(4):722-729.doi: 10.1097/grf.0b013e3182a8ae55
[Full text links] [Free PMC Article] [PubMed] Google Scholar (12) Scopus (7)
57. Corina M, Vulpoi C, Brănişteanu D. Relationship between bone mineral density, weight, and estrogen levels in pre and postmenopausal women. Rev Med Chir Soc Med Nat Iasi. 2012;116(4):946-950.
[PubMed] Google Scholar (32) Scopus (13)
58. Erdoğan O, Shafer DM, Taxel P, Freilich MA. A review of the association between osteoporosis and alveolar ridge augmentation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007;104(6):738 E731-713. doi: 10.1016/j.tripleo.2007.04.008. Review.
[Full text links] [PubMed] Google Scholar (70) Scopus (37)
59. Holahan CM, Koka S, Kennel KA, et al. Effect of osteoporotic status on the survival of titanium dental implants. Int J Oral Maxillofac Implants. 2008;23(5):905-910.
[PubMed] Google Scholar (99) Scopus (69)
60. Javed F, Vohra F, Zafar S, Almas K. Significance of osteogenic surface coatings on implants to enhance osseointegration under osteoporotic-like conditions. Implant Dent. 2014;23(6):679-686. doi: 10.1097/id.0000000000000161.
[Full text links] [PubMed] Google Scholar (31) Scopus (22)
61. Krennmair G, Seemann R, Piehslinger E. Dental implants in patients with rheumatoid arthritis: clinical outcome and peri-implant findings. J Clin Periodontol. 2010;37(10):928-936. doi: 10.1111/j.1600-051x.2010.01606.x.
[Full text links] [PubMed] Google Scholar (30) Scopus (14)
62. Weinlander M, Krennmair G, Piehslinger E. Implant prosthodontic rehabilitation of patients with rheumatic disorders: a case series report. Int J Prosthodont. 2010;23(1):22-28.
[PubMed] Google Scholar (16) Scopus (10)
63. Marx RE, Johnson RP. Studies in the radiobiology of osteoradionecrosis and their clinical significance. Oral Surg Oral Med Oral Pathol. 1987;64(4):379-390.
[PubMed] Google Scholar (268) Scopus (399)
64. Schoen PJ, Raghoebar GM, Bouma J, et al. Prosthodontic rehabilitation of oral function in head-neck cancer patients with dental implants placed simultaneously during ablative tumour surgery: an assessment of treatment outcomes and quality of life. Int J Oral Maxillofac Surg. 2008;37(1):8-16. doi: 10.1016/j.ijom.2007.07.015.

[Full text links] [PubMed] Google Scholar (88) Scopus (60)
65. Schoen PJ, Raghoebar GM, Bouma J, et al. Rehabilitation of oral function in head and neck cancer patients after radiotherapy with implant-retained dentures: effects of hyperbaric oxygen therapy. Oral Oncol. 2007;43(4):379-388. doi: 10.1016/j.oraloncology.2006.04.009. [Full text links] [PubMed] Google Scholar (97) Scopus (63)
66. August M, Bast B, Jackson M, Perrott D. Use of the fixed mandibular implant in oral cancer patients: a retrospective study. J Oral Maxillofac Surg. 1998;56(3):297-301. [Full text links] [PubMed] Google Scholar (46) Scopus (33)
67. Zen Filho EV, Tolentino Ede S, Santos PS. Viability of dental implants in head and neck irradiated patients: a systematic review. Head Neck. 2016;38 Suppl 1:E2229-40. doi: 10.1002/hed.24098. Review. [Full text links] [PubMed] Google Scholar (8) Scopus (5)
68. Ata-Ali J, Ata-Ali F, Di-Benedetto N, Bagán L, Bagán JV. Does HIV infection have an impact upon dental implant osseointegration? A systematic review. Med Oral Patol Oral Cir Bucal. 2015;20(3):E347-356. Review. [Full text links] [Free PMC Article] [PubMed] Google Scholar (8)
69. Stevenson GC, Riano PC, Moretti AJ, et al. Short-term success of osseointegrated dental implants in HIV-positive individuals: a prospective study. J Contemp Dent Pract. 2007;8(1):1-10. [PubMed] Google Scholar (37) Scopus (16)
70. Oliveira MA, Gallottini M, Pallos D, et al. The success of endosseous implants in human immunodeficiency virus-positive patients receiving antiretroviral therapy: a pilot study. J Am Dent Assoc. 2011;142(9):1010-1016. [Full text links] [PubMed] Google Scholar (28) Scopus (19)
71. Jacobi-Gresser E, Huesker K, Schütt S. Genetic and immunological markers predict titanium implant failure: a retrospective study. Int J Oral Maxillofac Surg. 2013;42(4):537-543. doi: 10.1016/j.ijom.2012.07.018. [Full text links] [PubMed] Google Scholar (47) Scopus (22)
72. Vaz P, Gallas MM, Braga AC, et al. IL1 gene polymorphisms and unsuccessful dental implants. Clin Oral Implants Res. 2012;23(12):1404-1413. doi: 10.1111/j.1600-0501.2011.02322.x. [Full text links] [PubMed] Google Scholar (25) Scopus (15)
73. Casado PL, Villas-Boas R, De Mello W, Duarte ME, Granjeiro JM. Peri-implant disease and chronic periodontitis: is interleukin-6 gene promoter polymorphism the common risk factor in a Brazilian population? Int J Oral Maxillofac Implants. 2013;28(1):35-43 .doi: 10.11607/jomi.2867. [PubMed] Google Scholar (21)

Mohammed ALSHEHRI
BDS, AEGD, SSC-ARD, SF-DI
Dental Department, King Khalid University Hospital King Saud University, Riyadh, Saudi Arabia

CV

Dr Alshehri graduated from the College of Dentistry, King Saud University in 2001. Academically, he has acquired a Certificate in Advanced Education in General Dentistry at the University of Southern California, School of Dentistry. Thereafter, Dr Alshehri joined the SBARD Program wherein he obtained the Saudi Specialty Certificate in Advanced Restorative Dentistry. Subsequently, he was able to obtain a Certificate for Saudi Fellowship in Dental Implant and is currently a Fellow of International Team for Implantology (ITI). Professionally, Dr Alshehri has conducted multiple research projects, has obtained a number of patents and has made local and international presentations. Currently, Dr Alshehri is a Consultant in Cosmetic, restorative and implant dentistry at College of Medicine and University Hospitals and board member of the Saudi Dental Society.

Questions

Osteoradionecrosis is usually observed several years following radiotherapy; and is associated with local trauma within the hypovascular-hypocellular hypoxic tissues.

- ❑ a. The first statement is true but the second statement is false;
- ❑ b. The first statement is false but the second statement is true;
- ❑ c. Both statements are true;
- ❑ d. Both statements are false.

Osteoporosis is a metabolic disease of bone characterized by:

- ❑ a. low bone mineral density;
- ❑ b. reduced bone mass due to impaired bone metabolism;
- ❑ c. imbalanced osteoblastic activity;
- ❑ d. all of the above.

The mode of action of bisphosphonates depends on the drugs':

- ❑ a. Physical structure;
- ❑ b. Chemical structure;
- ❑ c. Half-life;
- ❑ d. Side-effects.

All of the following are local risk-factors of peri-implant diseases EXCEPT:

- ❑ a. Implant diameter;
- ❑ b. Tobacco smoking;
- ❑ c. Poor bone quality;
- ❑ d. Quantity of bone.

CARIES DETECTION WITH LASER FLUORESCENCE DEVICES. LIMITATIONS OF THEIR USE

Andreas Spaveras[1a], Angeliki Tsakanikou[2b], Frantzeska Karkazi[3c], Maria Antoniadou[1d*]

[1] Department of Operative Dentistry, Dental School, National and Kapodistrian University of Athens, Greece
[2] Department of Operative Dentistry, Dental School, Semmelweis University, Budapest, Hungary
[3] Department of Operative Dentistry, Dental School, Comenius University of Bratislava, Slovakia

[a]DMD, Postgraduate Student
[b]DMD
[c]MD Dr
[d]DDS, PhD, Assistant Professor

Received: March 09, 2017
Revised: March 24, 2017
Accepted: April 02, 2017
Published: April 03, 2017

Academic Editor: Dana Cristina Bodnar, DDS, PhD, Professor, "Carol Davila" University of Medicine and Pharmacy Bucharest, Bucharest, Romania

Cite this article:
Spaveras A, Tsakanikou A, Karkazi F, Antoniadou M. Caries detection with laser fluorescence devices. Limitations of their use. Stoma Edu J. 2017; 4(1):44-51.

ABSTRACT

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

Background: Dental caries is one of the most prevalent human diseases worldwide. The modern concept of minimal invasive dentistry includes early detection of incipient caries lesions and its treatment. Several optical and digital detection methods are available.
Objective: This literature review presents the utility and limitations of laser fluorescence caries detection devices DIAGNOdent (DD) and DIAGNOdent Pen (DDpen) (KaVo Dental GmbH, Biberach/Riβ, Germany) for carious lesions on the occlusal surfaces of the permanent dentition.
Data sources: All available in vitro and in vivo studies from Google Scholar, PubMed and Scopus machines corresponding to caries, DIAGNOdent, DIAGNOdent Pen and laser fluorescence as key words, were reviewed.
Data extraction: Certain limitations of the studies were the inadequate analysis of the experimental protocols, the widespread sample use of the third molar, mistakes in sample handling and the limited number of studies evaluating the detection capability of DD and DDPen for secondary caries.
Data synthesis: DD and DDPen are useful devices for caries detection on the occlusal tooth surfaces. Their main advantages are the very high reproducibility of measurements (>0.90), the ease of handling and the quantification and monitoring capacity. Their main limitations are the relatively low specificity for enamel lesions, the necessity of unstained surfaces and absence of plaque and pastes during measurements and the absence of a universal, clinically functional calibration value (COV).
Conclusion: Further studies are required for more reliable data analysis and clinical interpretation of the relevant results.
Keywords: caries, DIAGNOdent, DIAGNOdent Pen, laser fluorescence, laser.

1. Introduction

Dental caries is one of the most widespread human diseases around the world and one of the most important problems in contemporary dentistry. The prevalence of dental caries is higher in the elderly and people of lower socioeconomic status. Nevertheless, it affects not only children but also adults.[1] A substantial decline of caries prevalence has been documented during the last decades, especially in the western world, primarily due to multiple fluoride products and the caries prevention methods available.[2]

Nowadays, dental caries in smooth and interproximal surfaces of permanent dentition is not so frequent as compared to caries in pits and fissures of the posterior teeth. Most commonly, occlusal caries occur more often in premolars and first molars.[3,4] The difficulty of prompt clinical diagnosis in occlusal areas is due to the anatomical features of these surfaces as well as the use of topical fluoride products. Fluoride can prevent the collapse of the superficial enamel layer and influence the remineralization process. Therefore, large dentine lesions might be less visible even when they have progressed substantially. This phenomenon reaches the percentage of 10-40% in molars and it is described as "hidden caries".[5]

The caries disease is an imbalance of the

***Corresponding author:**

Dr Maria Antoniadou, DDS, PhD, Assistant Professor, Department of Operative Dentistry, Dental School, National and Kapodistrian University of Athens, Greece. Thivon 2 Str., PO Box 11527, Goudi, Athens, Greece, Tel/Fax: +306.944.342.546, e-mail: mantonia@dent.uoa.gr

dynamic processes of demineralization and remineralization of the teeth and in its initial stages it can be halted. Enamel demineralization is a daily process that does not necessarily lead to caries. Early intervention can turn an active lesion into an inactive one. If the degree of demineralization does not exceed a certain point, the process may come to a standstill, even if the enamel surface has been minimally affected. The conversion of a lesion from active to inactive requires early diagnosis and careful monitoring, in order to minimize the restorative intervention.[6] From this point of view, modern caries detection means should permit monitoring of the caries process before the early lesion progresses to an extensive cavity.

The main objective of this paper is to give an overview of the use and utility of the two available caries detection devices of the occlusal surfaces of the permanent dentition, DIAGNOdent (DD) and DIAGNOdent Pen (DDPen) (KaVo Dental GmbH, Biberach/Riβ, Germany), whose function is based on the fluorescence laser beam.

2. The criteria for the evaluation of caries diagnostic means

The criteria used for the diagnostic evaluation of caries are expressed through specific indicators which are defined in numerical scales and form the diagnostic accuracy of a test. Specificity and sensitivity are the two dimensions, widely used for the description and quantification of several diagnostic techniques. Specificity refers to the correct identification of the healthy dental tissues, while sensitivity refers to the correct identification of caries. The above indicators are expressed as values between 0 and 1 (100%). As these values approach 1, the qualitative effect is higher and they should be at least 0.75 for sensitivity and above 0.85 for specificity.[7] Methods with low sensitivity can lead to suboptimal treatment, whereas methods with low specificity, to overtreatment. The caries detection methods with low sensitivity should be combined with techniques that are distinguished by high specificity and vice versa.

The accuracy of a method in most studies occurs from the sensitivity and specificity values and is often described by the area below the ROC curve (Receiver Operating Characteristics). The accuracy of the sum of the measurements obtained in a procedure is called reliability or otherwise repeatability and has a key role in the effectiveness of the procedure.

2.1. Conventional caries diagnostic means

In everyday clinical practice, direct visual observation is the most established method of tooth decay detection as it is easy and inexpensive. This method is mainly based on the subjective interpretation during visual examination and is often combined with radiographs and tactile examination with a metal probe.[8]

Many studies indicate that visual observation is characterized by lower sensitivity in relation to specificity with the latter exceeding 0.85 for caries diagnosis in occlusal surfaces.[9,10,11] Lussi et al.[12], in an vitro study, showed that the sensitivity of visual observation as a diagnostic method becomes double in case of dentine caries (0.62) when compared to that of enamel (0.31). Gimenez et al.[13] in a systematic review report that publications in respect to the accuracy of optical observation as a 'diagnostic instrument' do not exhibit sufficient qualitative methodology as far as the selection of the samples is concerned. They also underline that visual observation constitutes a reliable a clinical caries detection method. In another systematic review, Bader et al.[14] mention that the optical observation displays high specificity, but low efficiency for sensitivity and repeatability.

As compared to the above laboratory studies, clinical studies report higher specificity than sensitivity in response to visual observation.[15] The difficulty with the clinical studies is the lack of proper identification of the healthy dental tissues by the devices due to the frequent presence of dental calculus, bacterial plaque, saliva and food remnants. The use of established optical calibration systems such as ICDASII or Ekstrand's criteria seems to contribute to a more accurate caries detection system, given the fact that they provide guidelines and a rational quantification of lesions.[15] The combined use of visual observation and tactile sensation with the use of metal probe does not appear to significantly improve the diagnostic capability of direct visual observation. Agnes et al. emphasize the possibility of damaging the adjacent tooth with the sharp edge of the probe.[16] On the other hand, the visual observation assisted by loops of 1,5X to 4,5X shows increased detection sensitivity.[17]

Bitewing radiographs are a useful means of detecting interproximal caries; however, their advantage is quite limited to occlusal carious lesions, due to the overlay phenomenon.[18] Furthermore, 40-60% of the tooth's metal ions have to be lost so as the lesion becomes visible radiographically. This is another reason why the radiographic imaging is not used clinically for the detection of incipient caries lesions.[19]

Therefore, the most important limitations of conventional diagnostic tools are their low sensitivity, specificity and reproducibility, the difficulty to determine the activity of the lesion and the inability to monitor its progression. For all these reasons, either more accurate detection methods or a combination of the above methods should be used. In this respect, the dental technology has invested in the development of numerous caries detection devices. Some of these diagnostic tools are based on infrared radiation, impedance spectroscopy, digital imaging as in the DIFOTI system (Electro-Optical Sciences N.Y.), photo thermal radiometry as in the Canary System (Quantum Dental Technologies, Canada) as well as on visible spectrum fluorescence and laser fluorescence.

2.2. Fluorescence of sound and carious tooth substance

Fluorescence is the property of a medium to absorb low wavelength radiation such as ultraviolet (1-400nm) emitting longer wavelengths of visible light (430-450nm). Teeth have the ability to emit fluoresce. This phenomenon can be observed when the incident radiation is shown in the ultraviolet spectrum, as in the cases of exposure to black light illumination or when the person is found at high altitude. The primary fluorescence of teeth, otherwise known as auto-fluorescence, arises from the internal biological structures of the cells, with responsible elements being several enzymes, vitamins, uranium glass and endogenous fluorophores, present in dentin and enamel.[20] Dentin emits more autofluo-rescence than enamel, with the emission peak being at 450nm. Although the exact chemical mechanism of tooth auto-fluorescence has not yet been ascertained, the greater amount of organic components of dentine seems to be the reason for its higher fluoresce values.[21] It has been found that decayed tissues emits more fluoresce than healthy ones upon stimulation by red laser or infrared irradiation. This seems to be the result of both demineralization processes and the presence of bacteria byproducts in the decayed tissue.[22]

2.3. Caries detection methods based on visible spectrum fluorescence

Quantitative fluorescence (Quantitative Light – induced Fluorescence, QLF) is a method used to detect the demineralization of enamel in the early stages. The technique relies on the ability of enamel to emit strong auto-fluorescence under certain circumstances. Hypomineralised enamel shows a decrease demission of fluorescence spectrum as compared to that of healthy enamel. With the use of the QLF method, demineralized areas can be detected before they become clinically visible, since the sensitivity of the specific technique is particularly high. Limitations of this technique were found in the detection of dentine caries also in the deep enamel lesions (400μm), where the results were not so accurate.[23]

2.4. Caries detection devices based on laser fluorescence

The difference in fluorescence between sound and carious tooth structures was the fundamental concept behind the development of devices capable of quantifying the decayed tissue fluorescence. Methods based on fluorescence are divided into those that use visible spectrum stimulating rays such as the QLF and those based on laser ray fluorescence such as the DIAGNOdent and the DIAGNOdent Pen (KaVo Dental GmbH, Birebach/Riβ, Germany).[23] Sundström et al.[24] in a pioneering study, stimulated carious and sound tooth structures by laser beams of different wavelengths (337nm, 488nm, 515nm, 633nm), and calculated the emitted fluorescence. The 488nm wavelength was selected as the most appropriate wavelength for the detection of incipient caries with this technique.

3. DIAGNOdent Device and DIAGNOdent Pen Device

3.1. DIAGNOdent Device

The light source of DD is a diode laser with a wavelength of 655nm and a maximum power of 1mW. The red laser beam is transferred through a descending optical fiber to its edge, made of sapphire. Two different tip designs are available. The wedge-shaped which is used for occlusal surfaces and the straight one designed for smooth dental surfaces. The excitation optical fiber, i.e. one that carries the light beam on the tissues, is surrounded by nine concentric optical fibers of smaller diameter that collect the fluorescent radiation together with the surrounding light from the dental surfaces. All optical fibers have a diameter of 40 microns and they are carved at their end to receive or transmit the light radiation in similar manner.[25] A specially designed filter pre-vents the diffusion of ambient light (λ<655nm) and thus only the fluorescent light is collected and converted into an electrical signal. Then, the signal is displayed on two LED screens and expressed as a integer number between 0 and 99. One screen displays the current measured value while the other records the maximum value of detection.[22]

3.1.1. Correlation detection values of DD

Most clinical studies currently use the suggested measurements [Cut-Off Values (COV)] of the DD as they appeared in the clinical study of Lussi et al.[12] In this study, seven examiners evaluated 332 occlusal surfaces of 240 patients. After histological examination, they found that the values between 0-13 correspond to healthy dental tissues; values between 14-20 correspond to enamel caries and values between 21-29 to dentin caries.[12] In the same study, the restorative intervention is suggested for values between 20-29. However, Tranaeus et al.[26] suggested lower intervention values.[20-25] Anttonen et al.[27] suggested intervention values greater than 30, emphasizing that for values greater than 40, the probability of overtreatment is greatly reduced. Heinrich-Weltzien et al.[28], compared the validity of various proposed COV, concluding that the superficial lesions in dentin (D3) with rates between 17-21 showed the lowest discrepancy (0,48 to 0,51). For deeper dentin lesions (D4), the manufacturer's suggested values (>34) had the best performance (0.51). Therefore, the proposed correlations of COV for DD vary considerably between studies and have changed several times even by the manufacturer. As a general observation, it is worth mentioning, that laboratory studies use lower COV for dentin caries in relation to clinical studies.

3.1.2. Effect of exogenous factors on DD measurements

Exogenous factors that could possibly influenceDD values are various toothpastes and polishing pastes. In an in vitro study, the potential effect of ten different polishing pastes and four toothpastes

on DD measurements was examined, after their application to occlusal surfaces of molars and premolars. While toothpaste did not affect at all the DD values, seven of the polishing pastes have an effect on the measurements with pumice being the leading one. It seems that the intense auto-fluorescence of certain polishing pastes may alter the DD measurements, since their components cannot be completely removed from the pits and fissures of the occlusal surfaces of posterior teeth even after brushing and rinsing.[29] Also, Lussi et al.[30] in another in vitro study examined the influence of various toothpastes and prophylaxis paste remnants, as well as, powder remnants influencing DD readings. The results of this experiment showed, that only one toothpaste (Nupro mint/cherry medium, Dentsply De Trey, USA) and one polishing paste (Clinic, 3M, Bioggio, Switzerland) had a statistically significant effect on the measurements ($p<0.01$), after rinsing for 3-6 seconds. These formulations contain sticky elements, which in combination with the high porosity of the decayed tissue, are not sufficiently removed and thereby increasing the DD measurements. If the teeth are not intensely rinsed with water-air combination for at least ten seconds, an incorrect assessment may occur. This is more significant for the long term monitoring of lesions, rather than the detection of lesion per se.[30]

3.1.3. Effect of sample storage means in the DD measurements

The different storage means of the samples used in laboratory studies, such as chloramine solutions, formalin and thymol affect the final measurements of DD.[31] Kaul et al.[32] used 90 extracted molars in groups of ten and stored the eight groups in eight different solutions and one of them in a frozen state of -20°C for one year. It was shown that the most reliable method for teeth storing was the frozen state. According to this statement it has to be noted that only a few in vitro studies so far have used samples that were stored in a frozen state, a fact that should have an impact upon the clinical interpretation of the results.

3.1.4. Accuracy and repeatability of DD

The characteristics of accuracy and repeatability of the measurements of the DD and DDPen devices are well documented. Chu et al.[33] mention that different COV values show different results. In an in vivo study using COV by Lussi et al.,[12] the sensitivity (0.95) and specificity (0.11) differ considerably, while for COV=40, the sensitivity (0.70) and specificity (0.84) differ less. The authors propose the combination of visual observation with the use of DD for caries detection, as it offers better results in terms of specificity and quite good results in respect to sensitivity.

Jablonski-Momeni et al.,[5] in an in vitro study, examined 181 points of 100 posterior teeth comparing the DD detection capability with that of direct visual observation during ICDASII. The repeatability of the measurements for the DD between examiners was very high (0.957). Enamel (D1) and middle dentin (D3) have a specificity of D1:0.54, and D3:0.91 respectively, whereas the sensitivity was D1: 0.91 and D3: 0.70. Therefore, the ICDASII values were higher than those of DD. The researchers conclude that combining ICDASII and DD investigating methods provide better diagnostic results.

The first combined in vivo/in vitro study for the DD device was conducted by Reis et al.[35] who studied the caries detection of 57 third molars, both by direct visual observation and DD. The direct visual observation showed almost double in vivo and in vitro repeatability, both between different examiners (IR) (0.559) and between measurements of the same examiner (IA) (0.559) compared to that of DD. This study shows higher sensitivity of DD measurements than the visual method, which is not an usual finding in laboratory studies. The presence of pigments in pits and fissures of the occlusal surfaces may explain the above finding. The authors suggest using 19-20 COV for the differentiation of healthy versus carious dentin. They also proposed that the visual observation using ICDASII is quite a reliable caries detection system.[5]

Also in the study of De Paula et al.,[35] visual observation gave higher precision values than the DD. These findings are in agreement with the results by Rodrigues et al. and Agnes et al.[36,16] The combination of detection techniques e.g. visual observation, radiography and DD seems though to result to more accurate diagnosis of caries as mentioned also elsewhere.[37] But it should be noted that the actual clinical experience of the operator can affect the objectivity of the detection, either by visual observation or by using devices such as DD. Specifically, in a laboratory study, 3 undergraduate dental students, 3 general dentists and 3 academics were asked to evaluate 25 molars by visual observation and by using DD.

The results showed a substantial variation. The sensitivity of the measurements ranged from 0.188 to 0.769 and the specificity from 0.714 to 0.969. The group of the academics recorded the highest sensitivity of DD (0.667), while the group of the general dentists the highest specificity (0.942).

A substantial variation of measurements occurred in respect of sensitivity (0.755-0.953) and specificity (0.755-0.953) of the visual observation, with the students reaching the greatest sensitivity (0.80).[38] Ideally, a detection technique for the occlusal surfaces must have a very high sensitivity for D3 and D4 and moderate high specificity for detecting enamel caries.

The DD shows higher specificity for lesions at the level of dentin and lower for enamel lesions, since it is unable to identify the healthy tissues from the carious ones extending to the half of the enamel.

The sensitivity of DD can be increased for more deep caries, with values of 0.66 in D2 and 1 in D3. Sensitivity for the D1 level was reported at 0.74.[39]

3.2. DIAGNOdent Pen Device

The inability of DD to detect approximal caries was the primary cause of creating the DDPen (Fig.1).

Figure 1. The handpiece of the DDPen.

The DDPen follows the basic principles of the DD model. The main difference is the design of its tip which can be rotated to the longitudinal axis and thus permitting the detection of approximal caries. Also, DDPen uses the same optical sapphire fiber for the distribution of radiation and the detection of tooth fluorescence without the interference of other optical fibers (Fig. 2).

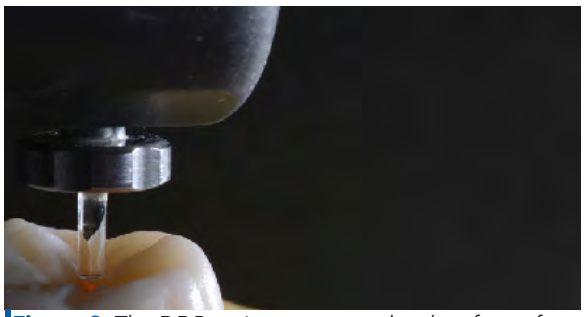


Figure 2. The DDPen tip over an occlusal surface of a molar.

Two different tips are available; a cylindrical one (CYL) with a diameter of 1.1 mm and a conical one (CON) with a diameter of 0.7mm. Although, the diameter of the CON is about 0.3mm thinner than that of DD and thus it would be expected to show better accuracy on pits and fissures, it seems that there is no significant difference between them[40] (Fig. 3).

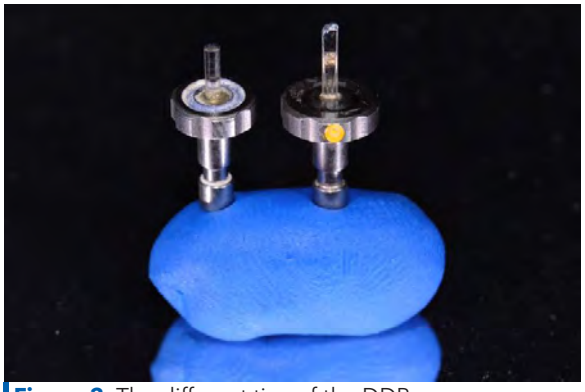


Figure 3. The different tips of the DDPen.

3.2.1. Accuracy and repeatability of DDPen

Lussi et al.[40] compared in vitro the accuracy of caries detection by DD and DDPen. In their study, 119 third molars, kept in frozen state at -20°C, were examined. DDpen showed higher specificity (0.71 to 0.91) compared to the DD (0.69-0.79), but relatively lower sensitivity (0.78 to 0.91) against the latter (0.81 to 0.96).

The main limitation of the study is that only third of the molars were used, whose occlusal surface varies considerably in different individuals as compared to other posterior teeth. Kuhnisch et al.[41] found that the reproducibility of DD of the same examiner (0.89) was similar to that of DDPen (0.88), while between different examiners reliability (0.86) was noted.

Sinanoglou et al.[42] evaluated in vivo the occlusal surfaces of 217 permanent molars and premolars, comparing the visual observation (ICDASII), DDPen and bitewing radiography.

One week after the first measurements, the patients were invited for re-examination and 82 teeth were reassessed with the above-mentioned techniques. Only the teeth with dentine caries were examined (64 of 227) and the clinical depth of the lesion was measured.

The reliability of DDPen was moderate to good, with AUC 0.55-0.64, but noticeably inferior in contrast to that of visual observation (AUC 0.71-0.76) that reached higher specificity values than sensitivity. At this point, it should be mentioned that the results of the evaluation for visual observation could have been affected by the subjective skills and the level of the examiner's acquaintance with the device.[15]

Moreover, the device detection capability was better for dentin caries (D3), a finding supported by many other studies.[14,15,43] The reproducibility for DDPen between different examiners (0.61, 0.65) and the same one (0.59. 0.65) was relatively low (16.42).

It is worth noting that in the study by Seremidi et al.[17] the teeth were stored in tap water for a long time, which is likely to have an impact on the fluorescence levels of the teeth.

The study by Achilleos et al.[43] revealed low sensitivity values (0.66-0.75) for DDPen, which may be attributed to the fact that the study was focused on the D1 level, where the performance of this device is reduced compared to the D3 level. Additionally, the relatively small number of samples[38] and the only one week period among the two measurements were reported as limitations of this study.

Mortensen et al.,[44] focusing on the level of D3, showed high repeatability for DDPen between different examiners (0.98). For COV=40, there was a very high specificity (0.97) but very low sensitivity (0.07). The authors support the idea that if the manufacturer's COV are applied in clinical practice, there will be a significant reduction of overtreatment, but also the detection of caries in D3 will be very low.

4. Secondary Caries detection with DD and DDPen devices

There are not many studies evaluating the detection capability of DD and DDpen for secondary caries, reported exclusively on the occlusal surfaces of permanent dentition. In a 2014 study, four examiners with different clinical and dental experience reviewed 60 posterior teeth restored with composite resin, by visual observation (Ekstrand criteria) and DDPen device. The reproducibility among the different examiners was very high (0.954). The researchers concluded that DDPen is a reliable method for secondary caries detection and should be combined with the visual observation for the correct diagnosis of secondary caries.[45]

Kositbowornchai et al.[46] investigated the detection capability of DD, under occlusal composite restorations, rather than tooth-resin interface. From the 100 teeth examined, only half were decayed and part of the caries was left on the pulpal wall. All the teeth were restored with composite resin (Z100 TM, 3 M, St. Paul, MN, USA) and the steps of etching and bonding were omitted. The repeatability values between different examiners (from 0.60 to 0.77) were lower than that of Hamishaki et al.,[45] while for the DD showed moderate sensitivity (0.74) and specificity (0.84). AUC value of the DD was moderate to good (0.79) and higher than that of digital radiography (0.65). Also there was no statistically significant difference in detection (p>0.05) between the two means. So it was suggested that the amount of fluorescence of composite resins does not affect the measurements of DD. However, the device is only recommended as an auxiliary means of caries detection. These results are similar to an in vitro study which examined the diagnostic capability of DD in 66 teeth with secondary caries, of which 48 were restored with amalgam and 18 with composite resin, where the sensibility was 0.77 and the specificity 0.81.[47] In another in vivo study, 30 molars were examined for the possible development of secondary caries, 12 months after the restoration with glass-ionomer cement and amalgam. The diagnostic methods were the DD and the radiographic control by using bitewing radiographs. The statistically significant difference between the minerals of dentin presented in all evaluation periods (p>0.001) shows the highest value before the removal of caries (0.74) and the lowest value after 12 months (0.04). This study evaluated the DD measurements only through the demineralization rate of tooth without any disclosing measured values of DD or the results of sensitivity, specificity and reproducibility.[48]

As a result, although DD and DDPen show accurate measurements with high repeatability for the detection of secondary caries, most authors are reluctant to their use compared to primary means such as the visual and radiographic examination proposing their combined use.

5. Conclusions

DD and DDPen are useful methods for occlusal caries detection. Their main advantages are the high reproducibility of measurements (>0.90), the ease of handling, the quantification of the carious lesions and the monitoring ability. However, they present significant limitations, such as the relatively low specificity for enamel lesions, the necessity of absence of stains, plaque and pastes during measurements and the absence of a single, clinically functional calibration value (COV). These limitations support the view that these means are to be used as auxiliary in detecting or monitoring caries lesions of questionable activity. Ideally, all optical and digital caries detection methods should have sensitivity, specificity, accuracy, repeatability, easiness in handling and access to all tooth surfaces. Nowadays, under the scope of the minimally invasive dentistry, it seems necessary for professionals to know and use both traditional and newer methods for incipient caries' detection in order to avoid overtreatment. As in vivo and in vitro data are based on methodological limitations, further studies should be conducted estimating the previous limitations and proceed with a more accurate evaluation of the specific devices.

Acknowledgments

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

References

1. Ekstrand KR. Improving clinical visual detection--potential for caries clinical trials. J Dent Res. 2004;83 Spec No C: C67-71. [PubMed] Google Scholar (102) Scopus (51)
2. Marthaler TM. Changes in dental caries 1953-2003. Caries Res. 2004;38(3):173-181. doi: 10.1159/000077752 [Full text links] [PubMed] Google Scholar (778) Scopus (374)
3. Carvalho JC. Caries process on occlusal surfaces: evolving evidence and understanding. Caries Res. 2014;48(4):339-346. doi: 10.1159/000356307 [Full text links] [PubMed] Google Scholar (36) Scopus (18)
4. Holmgren C, Gaucher C, Decerle N et al. Minimal intervention dentistry II: part Management of non-cavitated (initial) occlusal caries lesions--non-invasive approaches through remineralisation and therapeutic sealants. Br Dent J. 2014;216(5):237-243. doi: 10.1038/sj.bdj.2014.147 [Full text links] [PubMed] Google Scholar (19)
5. Jablonski-Momeni A, Ricketts DN, Rolfsen S, et al. Performance of laser fluorescence at tooth surface and histological section. Laser Med Sci. 2001;26(2):171-178. doi: 10.1007/s10103-010-0768-y [Full text links] [PubMed] Google Scholar (43) Scopus (22)
6. Guerrieri A, Gaucher C, Bonte E, et al. Minimal intervention dentistry: part 4. Detection and diagnosis of initial caries lesions. Br Dent J. 2012;213(11):551-557. doi: 10.1038/sj.bdj.2012.1087 [Full text links] [PubMed] Google Scholar (26) Scopus (14)
7. Karlsson L. Caries detection methods based on changes in optical properties between healthy and carious tissue. Int J Dent. 2010;2010:270729. doi: 10.1155/2010/270729 [Full text links] [Free PMC Article] [PubMed] Google Scholar (98)
8. Abalos C, Herrera M, Jiménez-Planas A, et al. Performance

of laser fluorescence for detection of occlusal dentinal caries lesions in permanent molars: an in vivo study total validation of the sample. Caries Res. 2009;43(2):137-141. doi: 10.1159/000209347
[Full text links] [PubMed] Google Scholar (21) Scopus (13)
9. Ashley PF, Ellwood RP, Worthington HV, et al. Predicting occlusal caries using the Electronic Caries Monitor. Caries Res. 2000;34(2):201-203. doi: 10.1159/000016590
[Full text links] [PubMed] Google Scholar (30) Scopus (12)
10. Attrill DC, Ahsley PF. Occlusal caries detection in primary teeth: a comparison of DiagnoDent with conventional methods. Br Dent J. 2001;190(8):440-443. doi: 10.1038/sj.bdj.4800998a
[Full text links] [PubMed] Google Scholar (204) Scopus (109)
11. Lussi A, Megert B, Longbottom C, et al. Clinical performance of a laser fluorescence device for detection of occlusal caries lesions. Eur J Oral Sci. 2001;109(1):14-19.
[Full text links] [PubMed] Google Scholar (451)
12. Gimenez T, Piovesan C, Braga MM, et al. Visual inspection for caries detection: a systematic review and meta-analysis. J Dent Res. 2015;94(7):895-904. doi: 10.1177/0022034515586763
[Full text links] [PubMed] Google Scholar (40) Scopus (24)
13. Bader JD, Shugars DA, Bonito AJ. A systematic review of the performance of methods for identifying carious lesions. J Publ Health Dent 2002;62(4):201-213.
[Full text links] [PubMed] Google Scholar (233) Scopus (145)
14. Gimenez T, Piovesan C, Braga MM, et al. Clinical relevance of studies on the accuracy of visual inspection for detecting caries lesions: a systematic review. Caries Res. 2015;49(2):91-98. doi: 10.1159/000365948
[Full text links] [PubMed] Google Scholar (12) Scopus (5)
15. Angnes G, Angnes V, Grande RH, et al. Occlusal caries diagnosis in permanent teeth: an in vitro study. Braz Oral Res. 2005;19(4):243-248. doi: /S1806-83242005000400002
[Full text links] [PubMed] Google Scholar (35) Scopus (8)
16. Seremidi K, Lagouvardos P, Kavvadia K. Comparative in vitro validation of VistaProof and DIAGNOdent pen for occlusal caries detection in permanent teeth. Oper Dent. 2012;37(3):234-245. doi: 10.2341/10-326-L
[Full text links] [PubMed] Google Scholar (33) Scopus (15)
17. Betrisey E, Rizcalla N, Krejci I, et al. Caries diagnosis using light fluorescence devices: VistaProof and DIAGNOdent. Odontology. 2014;102(2):330-335. doi: 10.1007/s10266-013-0105-6
[Full text links] [PubMed] Google Scholar (12) Scopus (6)
18. Yang J, Dutra V. Utility of radiology, laser fluorescence, and transillumination. Dent Clin North Am. 2005;49(4):739-752. doi: 10.1016/j.cden.2005.05.010
[Full text links] [PubMed] Google Scholar (69) Scopus (28)
19. Drakaki E. Laser-induced fluorescence made simple: implications for the diagnosis and follow-up monitoring of basal cell carcinoma. J Biomed Opt. 2014;19(3):030901. doi: 10.1117/1.JBO.19.3.030901
[PubMed] Google Scholar (11) Scopus (6)
20. Matsumoto H, Kitamura S, Araki T. Autofluorescence in human dentine inrelation to age, tooth type and temperature measured by nano second time-resolved fluorescence microscopy. Arch Oral Biol. 1999;44(4):309-318.
[Full text links] [PubMed] Google Scholar(76)
21. Hibst R, Paulus R, Lussi A. Detection of occlusal caries by laser fluorescence: Basic and clinical investigations. Med Laser Appl. 2001;16(3): 205-213. doi: 10.1078/1615-1615-00024
[Full text links] Google Scholar (231) Scopus (137)
22. Pretty IA, Smith PW, Edgar WM, et al. The use of quantitative light-induced fluorescence (QLF) to identify composite restorations in forensic examinations. J Forensic Sci. 2002;47(4):831-836.
[PubMed] Google Scholar (28)
23. Sundström F, Fredriksson K, Montán S, et al. Laser-induced fluorescence from sound and carious tooth substance: spectroscopic studies. Swed Dent J. 1985;9(2):71-80.
[PubMed] Google Scholar (179) Scopus (95)
24. Tranaeus S, Shi XQ, Angmar-Månsson B. Caries risk assessment: methods available to clinicians for caries detection. Com Dent Oral Epidemiol. 2005;33(4):265-273. doi: 10.1111/j.1600-0528.2005.00234.x
[Full text links] [PubMed] Google Scholar (110) Scopus (47)
25. Tranaeus S, Lindgren LE, Karlsson L, et al. In vivo validity and reliability of IR fluorescence measurements for caries detection and quantification. Swed Dent J. 2004;28(4): 173-182.
[PubMed] Google Scholar (37) Scopus(26)
26. Anttonen V, Seppä L & Hausen H. Clinical study of the use of the laser fluorescence device DIAGNOdent for detection of occlusal caries in children. Caries Res. 2003;37(1): 17-23. doi: 10.1159/000068227
[Full text links] [PubMed] Google Scholar(172) Scopus(93)
27. Heinrich-Weltzien R, Kühnisch J, Oehme T, et al. Comparison of different DIAGNOdent cut-off limits for in vivo detection of occlusal caries. Oper Dent. 2003;28(6): 672-680.
[PubMed] Google Scholar(56) Scopus(37)
28. Hosoya Y, Matsuzaka K, Inoue T, et al: Influence of tooth-polishing pastes and sealants on DIAGNOdent values. Quintessence Int. 2004; 35: 605-611.
[PubMed] Google Scholar(46) Scopus(28)
29. Lussi A, Reich E. The influence of toothpastes and prophylaxis pastes on fluorescence measurements for caries detection in vitro. Eur J Oral Sci. 2005;113(2):141-144. doi: 10.1111/j.1600-0722.2004.00195.x
[Full text links] [PubMed] Google Scholar(81)
30. Francescut P, Zimmerli B, Lussi A. Influence of different storage methods on laserfluorescence values: a two-year study. Caries Res. 2006; 40(3): 181-185. doi: 10.1159/000092223
[Full text links] [PubMed] Google Scholar(101) Scopus(86)
31. Kaul R, Kaul V, Farooq R, et al. Cut off values of laser fluorescence for different storage methods at different time intervals in comparison to frozen condition: A 1 year in vitro study. J Conserv Dent. 2014;17(2): 124-8. doi: 10.4103/0972-0707.128043
[Full text links] [Free PMC Article] [PubMed] Google Scholar(4) Scopus(2)
32. Chu CH, Lo EC, You DS. Clinical diagnosis of fissure caries with conventional and laser-induced fluorescence techniques. Lasers Med Sci. 2010; 25(3): 355-62. doi: 10.1007/s10103-009-0655-6
[Full text links] [Free PMC Article] [PubMed] Google Scholar(56) Scopus(29)
33. Reis A, Mendes FM, Angnes V, et al. Performance of methods of occlusal caries detection in permanent teeth under clinical and laboratory conditions. J Dent. 2006; 34(2): 89-96. doi: 10.1016/j.jdent.2005.04.002
[Full text links] [PubMed] Google Scholar(77) Scopus(51)
34. De Paula AB, Campos JA, Diniz MB, et al. In situ and in vitro comparison of laser fluorescence with visual inspection in detecting occlusal caries lesions. Lasers Med Sci. 2011; 26(1): 1-5. doi: 10.1007/s10103-009-0731-y
[Full text links] [PubMed] Google Scholar(25) Scopus(16)
35. Rodrigues J de A, de Vita TM, Cordeiro R de C. In vitro evaluation of the influence of air abrasion on detection of occlusal caries lesions in primary teeth. Pediatr Dent. 2008;30(1): 15-18.
[Full text links] [PubMed] Google Scholar(14) Scopus(10)
36. Pourhashemi SJ, Jafari A, Motahhari P, et al. An in-vitro comparison of visual inspection, bite-wing radiography, and laser fluorescence methods for the diagnosis of occlusal caries. J Indian Soc Pedod Prev Dent. 2009;27(2): 90-93. doi: 10.4103/0970-4388.55333
[Full text links] [PubMed] Google Scholar(16) Scopus(5)
37. Fung L, Smales R, Ngo H., et al. Diagnostic comparison of three groups of examiners using visual and laser fluorescence methods to detect occlusal caries in vitro. Austr Dent J. 2004;49: 67–71.
[Full text links] [PubMed] Google Scholar(52) Scopus(22)

38. Başeren NM, Gokalp S. Validity of a laser fluorescence system (DIAGNOdent) for detection of occlusal caries in third molars: an in vitro study. J Oral Rehabil. 2003;30(12): 1190-1194.
[Full text links] Google Scholar(34) Scopus(23)
39. Lussi A, Hellwig E. Performance of a new laser fluorescence device for the detection of occlusal caries in vitro. J Dent. 2006;34(7): 467-471. doi: 10.1016/j.jdent.2005.11.002
[Full text links] [PubMed] Google Scholar(147) Scopus(89)
40. Kühnisch J, Bücher K, Henschel V, et al. Reproducibility of DIAGNOdent 2095 and DIAGNOdent Pen measurements: results from an in vitro study on occlusal sites. Eur J Oral Sci. 2007;115(3): 206-211. doi: 10.1111/j.1600-0722.2007.00441.x
[Full text links] [PubMed] Google Scholar(52) Scopus(29)
41. Sinanoglu A1, Ozturk E, Ozel E. Diagnosis of occlusal caries using laser fluorescence versus conventional methods in permanent posterior teeth: a clinical study. Photomed Laser Surg. 2014;32(3): 130-137. doi: 10.1089/pho.2013.3625
[Full text links] [PubMed] Google Scholar(12) Scopus(6)
42. Achilleos EE, Rahiotis C, Kakaboura A, et al. Evaluation of a new fluorescence-based device in the detection of incipient occlusal caries lesions. Lasers Med Sci. 2013;28(1): 193-201. doi: 10.1007/s10103-012-1111-6
[Full text links] [PubMed] Google Scholar(34) Scopus(19)
43. Mortensen D, Dannemand K, Twetman S, et al. Detection of non-cavitated occlusal caries with impedance spectroscopy and laser fluorescence: an in vitro study. Open Dent J. 2014; 4(8):28-32. doi: 10.2174/1874210601408010028
[Free PMC Article] [PubMed] Google Scholar(12) Scopus(7)
44. Hamishaki KS, Chiniforush N, Monzavi A, et al. An in vivo comparison of two diagnostic methods in secondary caries detection. J Dent. 2014;11(1): 17-21.
[Free PMC article] [PubMed] Google Scholar(9)
45. Kositbowornchai S, Sukanya C, Tidarat T, et al. Caries detection under composite restorations by laser fluorescence and digital radiography. Clin Oral Investig. 2013;17(9):2079-2084. doi: 10.1007/s00784-012-0908-9
[Full text links] [PubMed] Google Scholar (12) Scopus (9)
46. Bamzahim M, Shi XQ, Angmar-Månsson B. Secondary caries detection by DIAGNOdent and radiography: a comparative in vitro study. Acta Odontol Scand. 2004;62(1):61-64.
[PubMed] Google Scholar (52) Scopus (37)
47. de Assunção Pinheiro IV, Borges BCD, de Lima KC. In vivo assessment of secondary caries and dentin characteristics after traditional amalgam restorations. Eur J Dent. 2012;6(3):263-269.
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Andreas SPAVERAS
Dentist, DMD, Postgraduate Student
Department of Operative Dentistry
Dental School, National and Kapodistrian University of Athens, Athens, Greece

CV

Dr Andreas Spaveras received his degree in dentistry (DMD) in 2013 from the Semmelweis University of Budapest, Hungary. Currently, he is a second year postgraduate student (MSc) at the Operative Department of the National and Kapodistrian University of Athens, Greece. He is a member of numerous dental study clubs such as the International Team for Implantology - ITI and has published several scientific articles. He is an enthusiast of esthetic dentistry and photography.

Questions

Hidden caries are predominantely found in:

- ❑ a. Incisors;
- ❑ b. Canines;
- ❑ c. Premolars;
- ❑ d. Molars.

The caries diagnosis in everyday clinical practice is based on:

- ❑ a. Visual inspection;
- ❑ b. Laser fluorescence;
- ❑ c. Visible spectrum fluorescence;
- ❑ d. Infrared radiation.

The most appropriate wavelength for the detection of incipient caries by laser fluorescence is:

- ❑ a. 337 nm;
- ❑ b. 488 nm;
- ❑ c. 515 nm;
- ❑ d. 633 nm.

Which are the most appropriate Cut-Off Values of the DIAGNOdent for dentin caries:

- ❑ a. 0-13;
- ❑ b. 14-20;
- ❑ c. 21-29;
- ❑ d. 20-29.

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QUANTIFICATION OF DENTAL MOVEMENTS IN ORTHODONTIC FOLLOW-UP: A NOVEL APPROACH BASED ON REGISTRATION OF 3D MODELS OF DENTAL CASTS

Daniele Maria Gibelli[1a*], Valentina Pucciarelli[1b], Luca Pisoni[1c], Francesca M.E. Rusconi[1d], Gianluca Martino Tartaglia[1e], Chiarella Sforza[1f]

[1]LAFAS, Laboratory of the Functional Anatomy of the Stomatognathic Apparatus
Department of Biomedical Sciences for Health, University of Milan, Milan, Italy

[a]MD, PhD
[b]BSc
[c]DDS, PhD
[d]MD
[e]DDS, PhD
[f]MD, Head

Received: February 28, 2017
Revised: March 21, 2017
Accepted: April 02, 2017
Published: April 03, 2017

Academic Editor: Mariana Păcurar, DDS, PhD, Professor and Head, University of Medicine and Pharmacy Târgu Mureș, Târgu Mureș, Romania

Cite this article:
Gibelli DM, Pucciarelli V, Pisoni L, Rusconi MEF, Tartaglia GM, Sforza C. Quantification of dental movements in orthodontic follow-up: a novel approach based on registration of 3D models of dental casts. Stoma Edu J. 2017;4(1):53-59.

ABSTRACT

DOI: 10.25241/stomaeduj.2017.4(1).art.5

Introduction: The assessment of dental displacement achieved by orthodontic procedures is important as it allows operators to verify their clinical treatment and provide adequate adjustments. Modern 3D image acquisition and elaboration systems may represent a valid method for the three-dimensional assessment of dental movement.
A novel protocol for the 3D assessment of success of orthodontic therapy is proposed, based on registration of surfaces.
Methdology: Pairs of casts of the upper dental arch, taken at two different time periods during the therapy, were chosen for three patients who underwent an orthodontic treatment. Dental casts were scanned by a 3D laser scanner: for each patient, the two 3D models were then registered according to the least distance at the area including palatal rugae. The chromatic map of changes within the dental arch and the RMS (Root Mean Square) point-to-point distance between the dental profiles from the two models were obtained, and compared with the same data from a control group including five adult individuals who did not undergo orthodontic therapy. Inter- and intra-observer errors were evaluated as well.
Results: The novel procedure proved to be repeatable and gave a detailed description of those dental areas most affected by orthodontic therapy: RMS values seem to be related with the weight of dental modifications and are far higher than the same parameters computed in the control group.
Conclusion: Further studies are needed in order to explore the possible correlation of RMS value with clinical parameters linked to the improvement of dental function and aesthetics due to orthodontic therapy.
Keywords: orthodontics, dental anatomy, laser scanner, RMS (root mean square).

1. Introduction

Orthodontics represents one of the most sensitive fields of research in dentistry, where the technological developments and treatment modalities are constantly applied in order to ameliorate anatomical and functional characteristics of the dental and facial profile.[1] During the past century orthodontic techniques have been developed in order to obtain more controlled and faster movement of dental elements: the main tasks are the improvement of dental occlusion and function, anatomical stability and facial aesthetics.[1] However, an important issue concerns the assessment of

***Corresponding author:**

Dr. Daniele Maria Gibelli, MD, PhD, Dipartimento di Scienze Biomediche per la Salute, Università degli Studi di Milano, Via Mangiagalli 31, I-20133, Milano, Italy
Tel: +39-02-50315399, Fax: +39-02-50315724, e-mail: daniele.gibelli@unimi.it

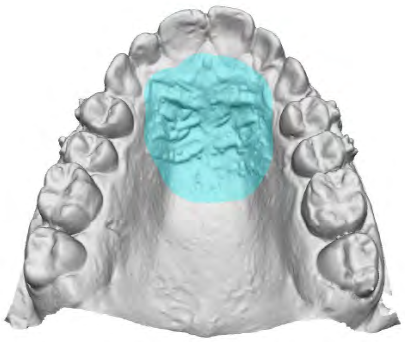

Figure 1. 3D model of a dental cast and selection of area including palatal rugae.

Figure 3. Example of chromatic map according to point-to-point distance between the two 3D models: blue areas are more vestibularized, whereas red and yellow areas are less vestibularized in the last cast than in the first one.

dental displacement due to orthodontic devices for verifying the success of therapy and provide adequate corrections. Most of these procedures are based on X-ray examinations (OPG or cephalometric radiographs.[1-3] In the last years modern 3D image acquisition systems, already applied to the study of facial modifications caused by dental displacement,[4] have been used also to detect the characteristics of dental movements. The main advantage concerns the chance of performing a three-dimensional assessment of dental morphology, more informative than the traditional radiological methods which are mainly based on the analysis of displacement of single landmarks or dental two-dimensional profile. In addition metrical measurements taken on digital models have been widely tested and proved to be reliable, with a high concordance with measurements taken directly on the plaster models.[5-7] However, surprisingly very few studies have tested 3D image acquisition systems so far for assessment of orthodontic therapies: an example was provided by Thiruvenkatachari et al. who first developed a protocol for 3D-3D superimposition of three-dimensional models of dental casts acquired through a laser scanner.[8]

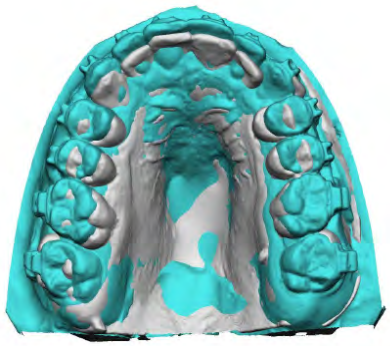

Figure 2. Example of registration according to area of palatal rugae: in white the earlier cast, in light blue the more recent one.

This procedure is based on the registration of 3D models of casts performed at different times and registration of surfaces according to the least point-to-point distance between the respective surfaces including palatal rugae. Displacement of molars was then assessed according to possible movements of their center of mass as calculated by the software.[8] The authors state that the use of laser scanner provides accurate and reliable measurements of dental displacement and might be a valid alternative to cephalometric radiographs.[8] However, the potential advantages which may derive from 3D-3D superimposition techniques have still to be explored: for example, the previously cited study took only the center of mass of the tooth into consideration, whereas techniques of registration may give information on the displacement of the entire surface of the dental crown, with a more anatomically adherent evaluation of dental arch modifications. In addition, the assessment of the translation of dental center of mass does not take into consideration the entire range of movements which may affect the 3D dental surface, such as rotation. A possible alternative is given by modern 3D image elaboration software, which are able to provide the registration of 3D surfaces and metrical parameters useful to assess the discordance between two models, expressed in terms of point-to-point mean and RMS (Root Mean Square) distance. In addition, the same procedure can generate a chromatic sheet able to immediately highlight areas affected by possible modifications.[9,10] These procedures may represent a novel point of view for the assessment of dental movements in orthodontic procedures.
The present article aims at exposing a protocol for 3D-3D registration of three-dimensional models of dental casts for the quantification of dental displacements, based on the calculation of point-to-point distance between two surfaces. This may provide additional information for evaluating the success of therapy and orthodontic procedures.

2. Materials and methods

Casts of the upper dental were chosen from three patients aged from 10 to 15 years who underwent

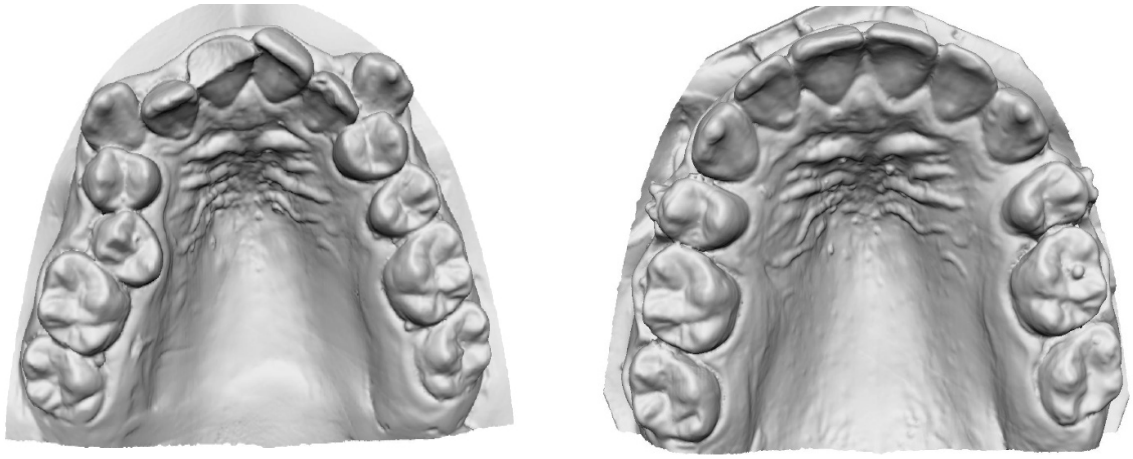

Figure 4. First patient: on the left, the 3D model from the first cast, showing a malposition of both canines; on the right, the 3D model from the second cast, after one year and the removal of the second premolar on the right side and the first on the left side, and consequent realignment of canines.

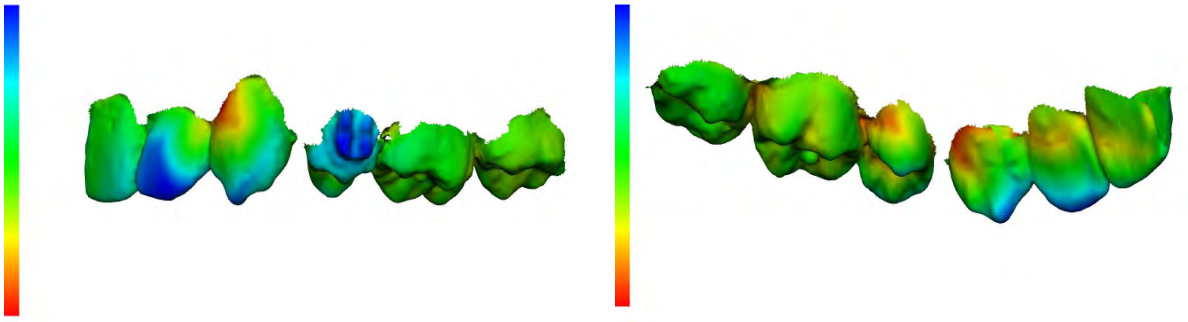

Figure 5. first patient, chromatic map of modifications of dental surfaces from the left side between the two casts (on the left vestibular surface, on the right lingual surface): blue areas are more vestibularized in the last cast, vice versa for the red and yellow areas. Green areas (including the first and second molar) remained unchanged.

an orthodontic treatment in a private dental office: all the patients were IOTN (index of orthodontics treatment needs) ≤3.[11] At least two dental casts were available for each patient, taken at different time periods during the therapy. The casts were scanned by a 3D laser scanner (iSeries, Dental Wings©, Montreal, Canada). According to the manufacter, the precision of the instrument is 15 µm. The 3D models were then elaborated through VAM© software (Canfield Scientific, Inc., Fairfield, NJ): first the palatal area including palatal rugae was manually selected in both surfaces (Fig. 1); then the software was requested to automatically register the two models in order to reach the minimum point-to-point distance between the selected areas (Fig. 2). Once the registration between the two surfaces was reached, the dental arch (dental crown surfaces) was manually defined on the 3D model obtained from the more recent cast, and a Region of Interest (RoI) was obtained. The software was then requested to select the RoI and to calculate the point-to point mean distance and RMS value (Root Mean Square) of the two models within the selected RoI. Mean values consider together positive and negative movements, whereas RMS values are all positive, and can provide a complete evaluation of the variations between two dental scans. Together with these quantitative parameters, a chromatic map of surface modifications of dental element extracted from the more recent dental cast is provided, with areas coloured in blue, green and red: the blue areas are more vestibularized in the last cast than in the earlier one, whereas the red areas are less vestibularized. Green areas do not show modifications between the two casts (Fig. 3). To test the method on a control group, the same procedure was applied on the dental arch models of five adult patients aged over 18 years who had longitudinal records taken but where no dental movements or modifications were expected. Time elapsed between the two casts was 1.5 years on average. The same procedures of registration, RoI selection, and calculation of RMS values on the control group was repeated by the same operator and by another observer: intra- and inter-observer differences were statistically assessed by Student's

Table 1. Details of dental modifications between the two casts in the three analysed patients, and comparison of correspondent RMS values with the control group.

	First cast	Second cast	RMS value	Average point-to-point distance
Patient 1	malposition of 3 teeth distal rotation of central incisors	removal of two teeth adjustment of malposition realignment of central incisors	1.61 mm	1.07 mm
Patient 2	malposition of a tooth	adjustment of malposition	1.13 mm	0.24 mm
Patient 3	distal rotation of central incisors right canine in eruption	correction of central incisors right canine erupted	0.98 mm	0.26 mm
Control group	-	-	0.26 mm (SD: 0.06 mm)	0.02 mm

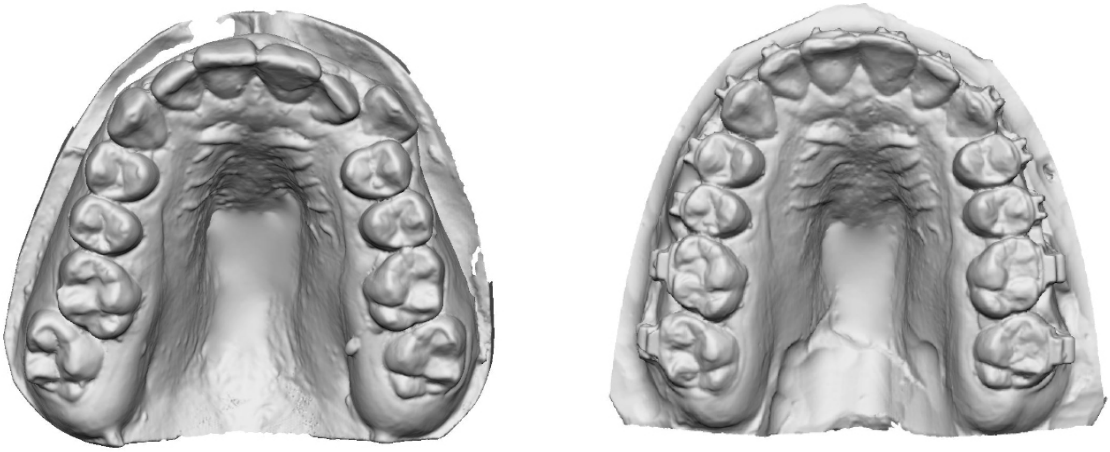

Figure 6. Second patient: on the left, the 3D model from the first cast, showing a malposition of the left canine; on the right, the 3D model from the second cast, after orthodontic therapy.

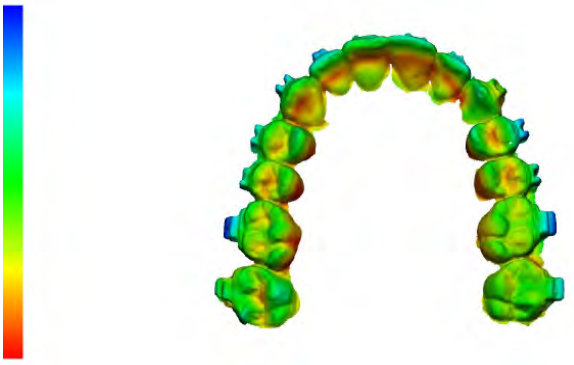

Figure 7. Second patient. Chromatic map of modifications of dental surfaces between the two casts: blue areas are more vestibularized in the second cast, vice versa for the red and yellow areas. Green areas remained unchanged.

t test ($p<0.01$). In addition the technical error of measurement (TEM) was evaluated.

3. Results

In the group of control subjects, on average the RMS value was 0.26 mm (SD: 0.06). No statistically significant differences were observed between measurements taken by the same operator or different observers ($p>0.01$). The technical error of measurement (TEM) was respectively 6.1% for intra-observer error and 9.6% for inter-observer error.

The first analysed patient was a female aged 12 years. She had a malposition involving both the canines and the second premolar on the right side. The orthodontic treatment was based on the removal of the second premolar on the right side and the first on the left side and the application of an orthodontic device, as shown by the second cast performed after one year (Fig. 4).

The registration and calculation of point-to-point distances between the two models highlights the mesial rotation of the lateral incisors and realignment of the canine, whereas the molars did not show any appreciable modification (Fig. 5). In addition the method was able to verify the novel orientation of the second premolar; mean RMS value between the dental profiles from the two 3D scans amounted up to 1.61 mm.

The second patient, a female aged 11 years, showed a malposition of the left canine: the application of an orthodontic device was able to produce an adjustment of the canine position, as shown by the second cast taken after four years (Fig. 6).

The procedures of registration were able to verify the vestibular translation of all dental elements,

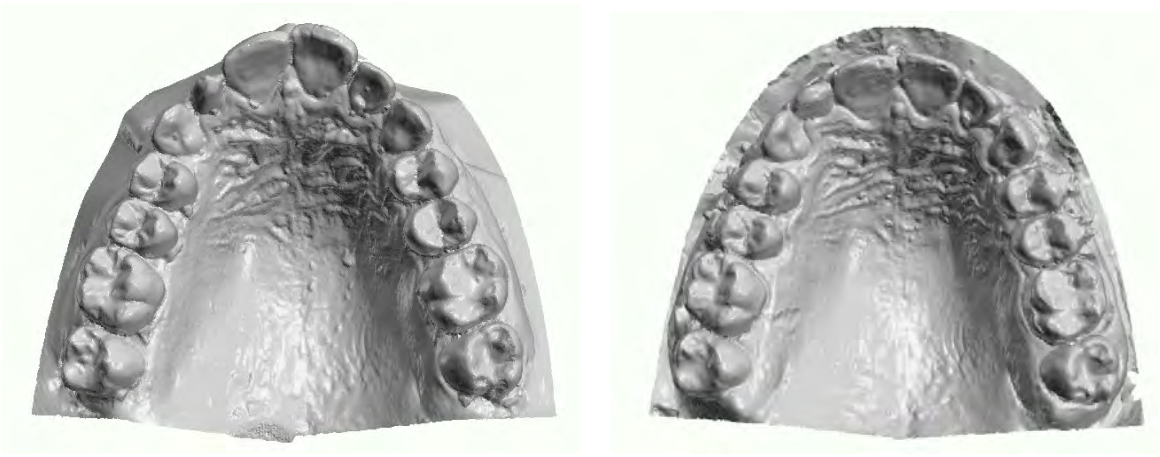

Figure 8. Third patient: on the left, the 3D model from the first cast, showing a malposition of the left canine; on the right, the 3D model from the second cast, after orthodontic therapy.

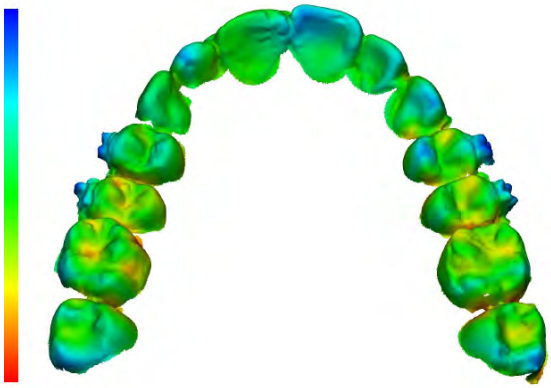

Figure 9. Third patient, chromatic map of modifications of dental surfaces between the two casts: blue areas are more prominent in the last cast, vice versa for the red and yellow areas. Most of modifications can be observed on the left central incisor and the left canine.

but for the left canine which remained in the same position and was realigned within the dental arch (Fig. 7). In addition, the method was able to accurate describe the novel presence of brackets and wire in the second cast, correctly assessed in blue areas (more vestibularized in the second cast than in the first one). The average RMS value was 1.13 mm.

The third patient was an 11 year old girl, who was chosen in order to test the detectability of lesser dental displacements like pathological overjet value. In detail, the central incisors were distally rotated, whereas the right canine was still erupting with the exposition of the tip. In the second cast, after orthodontic therapy, the central incisors were medially oriented, whereas the canine crown was erupted and in correct occlusion. The second cast was taken after four years.

The registration procedure correctly assessed the change in orientation of the left central incisor: in addition, the eruption of the canine was detected as well (Fig. 9); RMS value was 0.98 mm.

Interestingly, RMS value increased with the entity of dental displacement and number of involved teeth, and was in every case significantly higher than the same parameter shown by the control group (Table 1).

4. Discussion

In the last century orthodontics has seen a progressive update of technologies and clinical procedures, with an amelioration of dental position, functionality and aesthetics.[1] On the other side, a parallel issue concerns the assessment of dental displacement powered by orthodontic therapy, in order to verify the clinical success and provide corrections. Surprisingly, although the constant development of 3D image acquisition systems has represented a crucial revolution in dentistry, their application to the field of orthodontics is still at the beginning and most of their potentiality remains to be explored.[8] An example is provided by Thirvenkatachari et al. who proposed a protocol for the registration of 3D surfaces and calculation of displacement of the center of mass of dental elements.[8] This type of approach provides a metrical information but is not able to predict the modifications of the entire dental surfaces, especially where the movements do not consider dental translation. Another important aspect concerns the morphological assessment of dental movements, which may give an additional information for the evaluation of orthodontic therapies.

The present protocol may represent a proposal for an innovative analysis of dental movements: registration is based on the morphology of palatal rugae which are stable with time[12,13] and have been already used as reference point in 3D-3D superimposition of dental arches.[14] The procedure is repeatable and provides both morphological and metrical analyses of dental movements. The chromatic map of dental arches can give information concerning the specific movement of each dental element (rotation, translation or inclination), immediately readable by the operator.

On the other side, RMS value provides a reliable indication concerning the differences between the two casts, which seems to be adherent to the importance of modifications suffered by the patients. In addition, patients who were not treated from an orthodontic point of view, show lower RMS parameters, and this suggests that the metrical parameter is strictly linked to the general modification of the 3D position of dental crowns.
Some limits should be acknowledged: first, modifications highlighted by the registration procedures consider also dental eruption, and therefore are partly explained by orthodontic therapy. A possible improvement may consider the elaboration of each dental element, in order to separately consider already erupted elements.
Another important limit concerns the possible correlation of RMS with clinical parameters linked to the gain in dental function and aesthetics due to orthodontic therapy. This point is crucial, as it may verify if RMS value in registration of 3D models of dental cases do represent a potentially useful clinical parameter for assessing the success of therapy.

5. Conclusions

In conclusion, a novel protocol for the assessment of dental displacement in orthodontic therapy is proposed: further studies on a large sample of patients may provide additional information about the clinical advantages which may derive from its application.

Acknowledgments

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

References

1. Ghafari GG. Centennial inventory: the changing face of orthodontics. Am J Orthod Dentofacial Orthop. 2015;148(5):732-739. doi: 10.1016/j.ajodo.2015.08.011. [Full text links] [PubMed] Google Scholar (5) Scopus (3)
2. Bansal A, Prakash AT, Deepthi, Naik A. A noble, easy and conceptual radiographic analysis to assess the type of tooth movement (molar distalization). J Clin Diagn Res. 2015;9(8):ZC22-25. doi: 10.7860/JCDR/2015/13123.6286. [Free PMC Article] [PubMed] Google Scholar (0)
3. Jabbal A, Cobourne M, Donaldson N, Bister D. Assessing lower incisor inclination change: a comparison of four cephalometric methods. Eur J Orthod. 2016;38(2):184-189. doi: 10.1093/ejo/cjv027 [Full text links] [Free PMC Article] [PubMed] Google Scholar (4) Scopus (1)
4. Rosati R, De Menezes M, da Silva AM, et al. Stereophotogrammetric evaluation of tooth-induced labial protrusion. J Prosthodont. 2014;23(5):347-352. doi: 10.1111/jopr.12135 [Full text links] [PubMed] Google Scholar (3) Scopus (3)
5. Kim J, Lagravere MO. Accuracy of Bolton analysis measured in laser scanned digital models compared with plaster models (gold standard) and cone-beam computer tomography images. Korean J Orthod. 2016;46(1):13-19. doi: 10.4041/kjod.2016.46.1.13. [Full text links] [Free PMC Article] [PubMed] Google Scholar (9)
6. Kusnoto B, Evans CA. Reliability of a 3D surface laser scanner for orthodontic applications. Am J Orthod Dentofacial Orthop 2002;122(4):342-348. [Full text links] [PubMed] Google Scholar (219) Scopus (131)
7. Hayashi K, Sachdeva AU, Saitoh S, et al. Assessment of the accuracy and reliability of new 3-dimensional scanning device. Am J Orthod Dentofacial Orthop. 2013;144(4):619-625. doi: 10.1016/j.ajodo.2013.04.021. [Full text links] [PubMed] Google Scholar (40) Scopus (15)
8. Thiruvenkatachari B, Al-Abdallah M, Akram NC, Sandler J, O'Brien K. Measuring 3-dimensional tooth movement with a 3-dimensional surface laser scanner. Am J Orthod Dentofacial Orthop.2009;135(4):480-485.doi:10.1016/j.ajodo.2007.03.040. [Full text links] [PubMed] Google Scholar (59) Scopus (25)
9. Gibelli D, De Angelis D, Poppa P, Sforza C, Cattaneo C. An assessment of how facial mimicry can change facial morphology: implications for identification. J Forensic Sci. 2017;62(2):405-410. doi: 10.1111/1556-4029.13295. [Full text links] [PubMed] Google Scholar (3) Scopus (0)
10. Gibelli D, De Angelis D, Poppa P, Sforza C, Cattaneo C. A view to the future: a novel approach for 3D-3D superimposition and quantification of differences for identification from next-generation video surveillance systems. J Forensic Sci. 2017;62(2):457-461. doi: 10.1111/1556-4029.13290. [Full text links] [PubMed] Google Scholar (3)
11. Brook PH, Shaw WC. The development of an index of orthodontic treatment priority. Eur J Orthod. 1989;11(3):309-320. [PubMed] Google Scholar (949) Scopus (481)
12. English WR, Summitt JB, Oesterle LJ, Brannon RB, Morlang WM. Individuality of human palatal rugae. J Forensic Sci. 1988;33(3):718-726. [PubMed] Google Scholar (153) Scopus (68)
13. Lysell L. Plicae palatinae trasversae and papilla incisiva in man; a morphologic and genetic study. Acta Odontol Scand. 1955; (Suppl. 18):5-137. [PubMed] Google Scholar (103)
14. Jang I, Tanaka M, Koga Y, et al. A novel method for the assessment of three-dimensional tooth movement during orthodontic treatment. Angle Orthod. 2009;79(3):447-453. doi: 10.2319/042308-225.1. [Full text links] [PubMed] Google Scholar (59) Scopus (32)

Daniele Maria GIBELLI
MD, PhD
Dipartimento di Scienze Biomediche per la Salute
Università degli Studi di Milano
Via Mangiagalli 31, I-20133, Milano, Italy

CV

Daniele Maria Gibelli is a researcher in Human Anatomy in Università degli Studi di Milano (Department of Biomedical Sciences for Health). His fields of research are the morphological and metrical assessment of anatomical characteristics of bones and teeth, including the anatomical dimorphism, their modification with age, ethnic variability and the analysis of individualizing characteristics. He deals also with the analysis of facial anatomy both in healthy and pathological conditions, for studies concerning the assessment of facial symmetry, modifications with mimicry and anatomical uniqueness of facial structures.

Questions

Which instruments can be used to obtain a 3D virtual model of dental arches?

- ❑ a. Laser scans;
- ❑ b. Ultrasounds;
- ❑ c. Conventional orthopantomographs;
- ❑ d. Bite wing radiographs.

Which kind of modifications can be assessed on 3D virtual model of dental arches?

- ❑ a. Dental root reabsorption;
- ❑ b. Parodontal alterations;
- ❑ c. Dental crown movements;
- ❑ d. Temporomandibular disorders.

In the current study we assessed

- ❑ a. Three edentulous patients;
- ❑ b. Seven patients with deciduous dentition;
- ❑ c. Two patients submitted to orthognathic surgery;
- ❑ d. Three adolescent patients.

In the current study, we superimposed 3D virtual models of dental arches using

- ❑ a. The vestibular surface of anterior teeth;
- ❑ b. The palatal area including palatal rugae;
- ❑ c. The lingual surface of mandibular incisors;
- ❑ d. The occlusal surface of maxillary first molars.

DO POSTERIOR TEETH SUPRA-ERUPT WHEN OPPOSITE RESECTED SEGMENTS HAVE NOT BEEN PROSTHETICALLY RESTORED?

Arieh Shifman[1a], Shlomo Calderon[2b*]

[1]Department of Oral Rehabilitation, Sackler School of Medicine, Tel Aviv University, Tel Aviv, Israel
[2]Department of Oral and Maxillofacial Surgery, Rabin Medical Center, Beilinson Hospital, Petah Tikva, Israel

[a]DMD, Senior Clinical Lecturer
[b]DMD, Professor

Presented by Prof. Shlomo Calderon before the International College of Prosthodontists, Biennial Congress Torino, Italy, September 2013

Received: April 04, 2016
Revised: May 04, 2016
Accepted: May 20, 2016
Published: May 23, 2016

Academic Editor: Heinz Kniha, DDS, MD, PhD, Associate Professor, Ludwig-Maximilians- München University, München, Germany

Cite this article:
Shifman A, Calderon S. Do posterior teeth supra-erupt when opposite resected segments have not been prosthetically restored? Stoma Edu J. 2017;4(1):60-65.

ABSTRACT

DOI: 10.25241/stomaeduj.2017.4(1).art.6

Introduction: The aim of this study was to assess the rate and timing of possible supra-eruption of posterior teeth opposing resected segments in a select maxillofacial group of postsurgical patients.
Methodology: Twenty patients were included. 16 underwent simultaneous segmental mandibular resections and iliac bone graft reconstructions. The remaining 4 had partial maxillary resections with primary closure of the defect. No patient received any prosthetic restoration. Clinical photographs and radiographs at the last follow-up examinations were compared by superimposition to those obtained initially (mean 6.9 years).
Results: The results of this longitudinal retrospective study showed that not even slight supra-eruption had occurred in any of the 16 patients.
Conclusion: These findings are discussed with regard to their possible cause and prosthodontic implications.
Keywords: super-eruption, supra-eruption, occlusion, unopposed molars, resected segments.

1. Introduction

Postsurgical maxillofacial patients occasionally remain without further prosthetic treatment. Patients may prefer not to undergo restorative treatment for a variety of reasons, including lack of perceived esthetic impairment where only posterior segments are involved, limited functional impairment, reluctance to undergo additional surgery and also for reasons of financial constraints.

In a study reporting on a group of 28 patients who underwent ablative tumor surgery and mandibular reconstructions with osseocutaneous fibula free flap 13 patients were postoperatively rehabilitated with implant-supported prostheses, whereas 18 patients had no dental prosthetic rehabilitation.[1] These authors conclude that oral functions such as speech, diet tolerance and oral competence were not directly affected by the presence of prosthetic restorations. A decisive factor affecting oral function in these patients was the extent of soft-tissue loss.

In lieu of the accepted notion that the presence of molar teeth is essential for proper masticatory function and occlusal stability,[2-4] the shortened dental arch (SDA) concept emerged as paradigm shift, namely that two bilateral pairs of occlusal contacts (premolar occlusion) are sufficient for these functions.[5-7] Studies have shown that no marked adverse outcome has been displayed in SDA cases, such as temporomandibular (TM) overloading and TM disorders or parameters related to occlusal stability in the SDA arch (interdental spacing in the premolar area, overbite, increased wear of the remaining anterior teeth, or loss of alveolar bone supporting these teeth.[5-7]

Nonetheless, little attention has been given in the literature to possible supra-eruption (SE) of molar teeth in the opposing dental arch. Kiliaridis et al.[8] examined 84 unopposed molars in 53 patients

***Corresponding author:**

Professor Shlomo Calderon, DMD, Department of Oral and Maxillofacial Surgery, Beilinson Hospital, Rabin Medical Center IL-49100 Petah Tikva, Israel
Tel/Fax: +972-3-937-7207 / +972-3-937-7204, e-mail: scalder@netvision.net.il

and found that 15 teeth (18%) revealed no signs of SE, 49 teeth (58%) displayed SE of less than 2mm, whereas 20 teeth (24%) showed moderate to severe SE. Craddock and Youngson[9] examined 155 unopposed sites in 120 subjects and found the rate of SE in 83% of the sites. However, in both studies, the pattern of missing teeth was ill-defined and probably not displaying SDA situations.

In a questionnaire study of 200 Swedish dentists presented with a drawing of an SDA in the mandible in a virtual case, 85% of them suggested that marked SE of the maxillary molars would occur, whereas 13% believed in minor changes.[10] In a large sample of patients with SDA and extreme SDA, Sarita et al. found that SE of unopposed teeth was absent or mild in 12%, severe in 32% and to the opposing residual ridge (severe SE) in 56% of the subjects.[11] However, the authors did not provide data with regard to the pattern of posterior tooth loss, though alluding to gradual tooth loss in their study.

The aim of the present study was to assess the rate and timing of possible SE of unopposed posterior teeth in a select group of postsurgical patients.

2. Methodology

2.1. Subjects

The study group included consecutive patients who were hospitalized in the Department of Oral and Maxillofacial Surgery, Beilinson Campus, Rabin Medical Center, Israel, during the 1990-2009 period. The study protocol was reviewed and approved by the Rabin Medical Center Institutional Ethical Committee and in accordance with the Helsinki Declaration of 1975, as revised in 2000.

Medical data such as clinical photographs, radiographs, type of surgical procedures and histopathological findings, were gleaned from hospital records. The inclusion criteria were: (1) surgical resection of a tumor in a posterior region of one of the jaws limited to bone and attached soft tissues; (2) immediate mandibular reconstruction of non-continuity defects or alternatively, primary surgical closure of a maxillary defect; (3) no adjuvant therapy such as radiation therapy or chemotherapy; (4) no signs of temporomandibular disorders; (5) sound dentition with minimal restorations; (6) normal occlusion with good intercuspation; (7) no postoperative prosthodontic treatment and (8) keeping long-term follow-up visits.

2.2. Diagnostic evaluation

The complete evaluation of each patient was made at the preoperative stage. Frontal and lateral views of the face of the patient was photographed using a Nikon SLR regular end digital camera with 1:1 macro lens (105/2.8 Nikon macro lens focusing at 1.2 meters). Intraoral photographs of the dentition in maximal intercuspation and semi-open position were taken at a distance of 30 cm with 22 lens aperture with the same camera. Other imaging modalities such as CT, MRI, ultrasonography or angiography were rarely indicated for a complete evaluation of the individual patient and have not been used in this study. Initial and follow up orthopantomographic radiographs were obtained for all cases.

2.3. Surgical procedures

In the mandible, under general anesthesia via using a naso-endotracheal intubation, segmental resection of the lesion was carried out by the combined intra and extraoral approach (modified Risdon or submandibular approach). Intraoral wounds were closed by watertide locking and interupted sutures. Mandibular fragments were positioned by maxillo-mandibular fixation in maximal intercuspation, secured by Eric arch bars. Mandibular continuity was restored by using titanium reconstruction plates (DePuy Synthes Companies, West Chester, PA 19380, USA; Stryker Global Headquarters, Kalamazoo, MI 49002, USA). Full body or hollow screws were used to secure the fixation of mandibular stumps. [12,13] Cortico-cancellous particulate bone was harvested from the anterior iliac crest [14] supported by a crib-form allogenic split rib.[15] Soft tissues were closed by layers. In the maxilla, using oro-endotracheal intubation for general anesthesia, the lesion was resected in toto. Primary surgical closure of soft tissues was carried out, either by exploiting the buccal pad of fat or by a palatal rotated mucoperiosteal flap or a combination of both was used to facilitate closure. In the vast majority of patients, healing was uneventful, albeit in few patients healing was prolonged but complete; healing was spontaneous with the help of (or using) antiseptic irrigations (0.2% chlorhexidine gluconate).

2.4. Recall and documentation

Postoperatively, patients were placed on a regular recall schedule namely, once every 3 months for the first year and thereafter once a year.

Complete evaluation was made at the preoperative diagnostic stage.

Clinical photographs and radiographs at the last recall visit were compared to those obtained initially. Photographed slides were scanned by Umax Power Lock II scanner and some of the older slides were copied by Nikon - E 28 Slide Copying Adapter. Radiographs were scanned and superimposed on PC graphic program and the degree of supra eruption of the unopposed segments evaluated.

3. Results

Twenty patients who were found to fulfill the inclusion criteria were included in the study, namely sixteen with mandibular involvement (Table 1) and 4 patients with maxillary involvement. (Table 2). The age of the patients ranged from 7 to 61 (mean 29.4) in the mandibular group and from 11 to 61 (14.2) in the maxillary group. In most patients ameloblastoma or its variants appeared as a primary tumor of the jaws. In contrast as a primary soft tissue pathosis, patients afflicted by squamous cell carcinoma could not be enrolled in

Table 1. Mandibular Reconstruction Cases.

No.	Name	Age (yrs)	M/F	Diagnosis	Resection Site Location	Distal Tooth	Follow up (yrs)
1	S.L.	7	M	Ameloblastic fibroodontoma	RT mand	45	13
2	S.D.	10	M	Ameloblastic fibroodontoma	RT mand	43	13
3	S.S.	10	M	Ossifying fibroma	RT mand	45	7
4	C.E.	20	M	Blast injury	LT mand	33	11
5	Y.A.	20	F	Ameloblastoma	RT mand + condyle	41	14
6	K.Y.	20	M	Odontogenic keratocyst	RT mand	45	7
7	C.Y.	22	F	Ameloblastoma	LT mand	33	3.5
8	A.G.	26	M	Ameloblastic fibroma	RT mand	43	12
9	SH.T.	30	F	Giant cell tumor	RT mand	41	10
10	G.E.	32	M	Ameloblastoma	LT mand	35	2.2
11	C.B.	33	F	Ameloblastoma	LT mand	33	13
12	D.S.	38	F	Ameloblastoma	RT mand + condyle	42	5
13	R.A.	40	F	Aneurismal bone cyst	RT mand	44	10
14	V.E.	42	F	Ameloblastoma	LT mand	33	2.3
15	S.O.	59	F	Mucoepidermoid carcinoma	LT mand	35	4
16	R.Y.	61	M	Giant cell tumor	LT mand	31	7

Table 2. Maxillary Reconstruction Cases.

No.	Name	Age (yrs)	M/F	Diagnosis	Resection Site Location	Distal Tooth	Follow up (yrs)
1	B.A.	11	F	Ameloblastic fibroodontoma	RT max	13	9
2	C.M.	14	F	Ameloblastic fibroodontoma	LT max	23	10
3	K.Y.	16	M	Sialoodontogenic cyst	RT max	13	4
4	M.M.	16	F	Odontogenic myxoma	LT max	22	10

this study. The results of this study showed that not even slight SE had occurred in any patient. This is seen in examples of cases in Figs 1-5. The condition of the temporomandibular joints was not evaluated.

4. Discussion

The results of this long term retrospective study were unexpected. Super eruption had not occurred apparently even slightly in any single patient regardless of the age of the patient, the location and extent of the surgical resection and the follow up period.

These results are in contrast with those obtained by Sarita et al.[11] However, in their study tooth loss was gradual, whereas in our study loss of teeth occurred in a single surgical procedure. As a result, the tongue could immediately fill the intraoral space created. It is conjectured that the lateral aspect of the dorsum of the tongue came into contact with the occlusal surface of the posterior teeth and prevented their subsequent eruption. Stabilization of the mandible during swallowing that is normally affected by the occlusal intercuspal contact is affected by closure onto the interposed tongue.

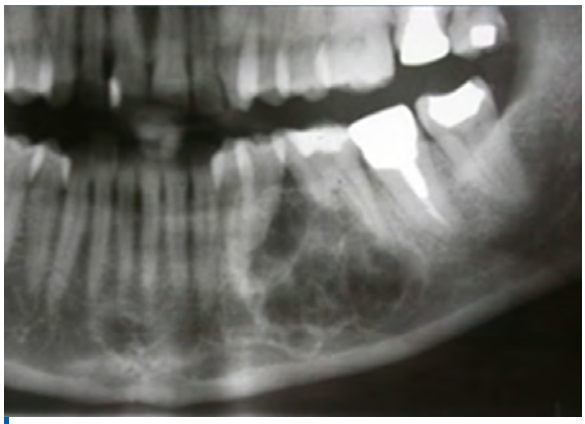

Figure 1. Ameloblastoma.

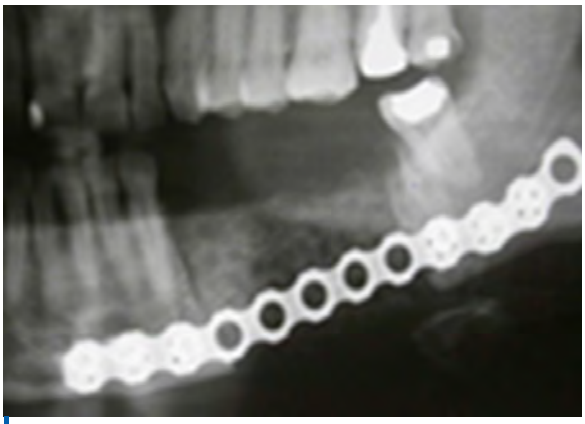

Figure 2. Six Months post-operative. Repair with split rib and reconstruction plate.

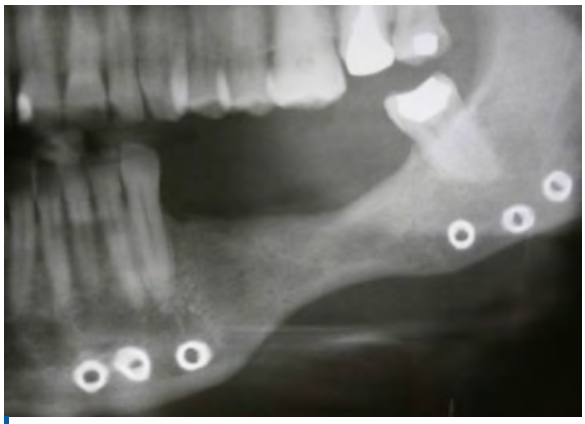

Figure 3. Six years post-operative. No supra-eruption of the teeth opposing the resected section.

Moreover, it seems that the ventral surface of the tongue can also function in this manner preventing super eruption of mandibular teeth. It is noteworthy that super eruption did not occur in patients were the surgical reduction extended beyond the definition of the SDA to include premolars, canines and even the incisor teeth. These situations may be considered as unilateral ultra-shortened dental arches. Even in patients who underwent partial glossectomies, the remaining tongue appeared to preserve oral function and hinder super eruption. However, prosthetically augmenting the palate for lowering the occlusal plane and thus enabling the remaining tongue to keep the bolus over the dorsal surface, is still advocated in some patients.[16] Further lowering the occlusal plane may bring it below the maximum ability of the buccinators contraction.[17]

To summarize, within the limits of this study, restoration of the posterior jaw defects merely for prevention of future super eruption appears unjustified. Thus the time-old principle by DeVan "Our objective should be the perpetual preservation of what remains rather than the meticulous restoration of what is missing." is still valid.[18]

5. Conclusion

Posterior teeth opposing unrestored resected segments of the maxilla or mandible did not supra-erupt over long periods of time. It is speculated that the interposition of the tongue to brace the mandible on swallowing prevents the unopposed molars and premolars from supra-erupting.

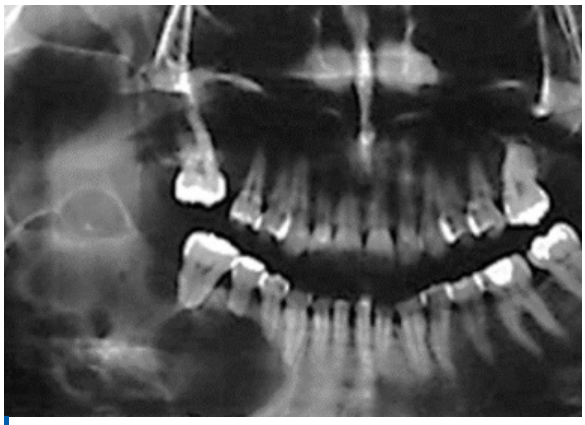

Figure 4. Ameloblastoma. Treated by hemi mandibulectomy and restored with split rib and reconstruction plates.

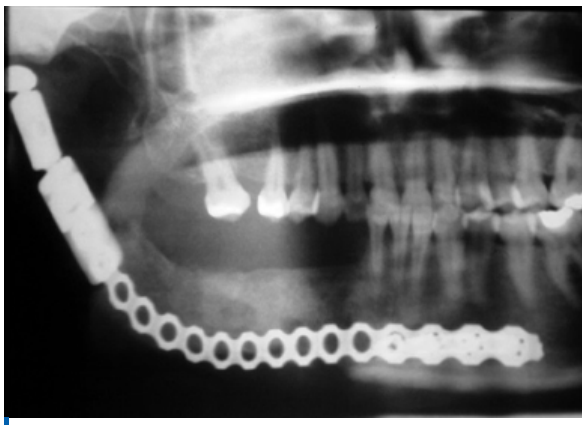

Figure 5. Twenty two years post operative. No supra-eruption of the unopposed maxillary teeth opposite the resected segment.

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

References

1. Iizuka T, Häfliger J, Seto I, et al. Oral rehabilitation after mandibular reconstruction using osteocutaneous fibula free flap with endosseous implants. Factors affecting the functional outcome in patients with oral cancer. Clin Oral Implants Res. 2005;16(1):69-79.doi: 10.1111/j.1600-0501.2004.01076.x [Full text links] [PubMed] Google Scholar (74) Scopus (57)
2. Beyron H. Optimal occlusion. Dent Clin North Am. 1969;13(3):537-554. [PubMed] Google Scholar (208) Scopus (85)
3. Devlin H, Wastell DG. The mechanical advantage of biting with the posterior teeth. J Oral Rehabil. 1986;13(6):607-610. [Full text links] [PubMed] Google Scholar (14) Scopus (9)
4. Mohl ND, Zarb GA, Carlson GE, Rugh JD. A Textbook of Occlusion. Chicago: Quintessence Publishing Co.; 1989:174, 182.
5. Witter DJ, Creugers NH, Kreulen CM, de Haan AF. Occlusal stability in shortened dental arches. J Dent Res. 2001;80(2):432-436. doi: 10.1177/00220345010800020601 [Full text links] [PubMed] Google Scholar (138) Scopus (63)
6. Armellini D, von Fraunhofer JA. The shortened dental arch: a review of the literature. J Prosthet Dent. 2004;92(6):531-535. doi: 10.1016/S002239130400530X. Review. [Full text links] [PubMed] Google Scholar (128) Scopus (56)
7. Walther W. The concept of a shortened dental arch. Int J Prosthodont. 2009; 22(5):529-530. [Full text links] Google Scholar (8) Scopus (1)
8. Kiliaridis S, Lyka I, Friede H, Carlsson GE, Ahlqwist M. Vertical position, rotation, and tipping of molars without antagonists. Int J Prothodont. 2000;13(6):480-486. [PubMed] Google Scholar (75) Scopus (38)
9. Craddock HL, Youngson CC. A study of the incidence of overeruption and occlusal interferences in unopposed posterior teeth. Brit Dent J. 2004;196(6):341-348; discussion 337. doi: 10.1038/sj.bdj.4811082 [Full text links] [PubMed] Google Scholar (53) Scopus (24)
10. Lyka I, Carlsson GE, Wedel A, Kiliaridis S. Dentists' perception of risks for molars without antagonists. A questionnaire study of dentists in Sweden. Swed Dent J. 2001;25(2):67-73. [PubMed] Google Scholar (22) Scopus (13)
11. Sarita PT, Kreulen CM, Witter DJ, van't Hof M, Creugers NH. A study on occlusal stability in shortened dental arches. Int J Prosthodont. 2003;16(4):375-380. [PubMed] Google Scholar (80) Scopus (29)
12. Raveh J, Sutter F, Hellem S. Surgical procedures for reconstruction of the lower jaw using the titanium-coated hollow-screw reconstruction plate system: bridging of defects. Otolaryngol Clin North Am. 1987;20(3):535-558. [PubMed] Google Scholar (100) Scopus (39)
13. Vuillemin T, Raveh J, Sutter F. Mandibular reconstruction with the THORP condylar prosthesis after hemimandibulectomy. J Craniomaxillofac Surg. 1989;17(2):78-87. [PubMed] Google Scholar (18) Scopus (7)
14. Burstein FD, Simms C, Cohen SR, Work F, Paschal M. Iliac crest bone graft harvesting techniques: a comparison. Plast Reconstr Surg. 2000;105(1):34-39. [Full text links] [PubMed] Google Scholar (89) Scopus (63)
15. Marx RE, Kline SN, Johnson RP, et al. The use of freeze-dried allogenic bone in oral and maxillofacial surgery. J Oral Surg. 1981;39(4):264-274. [PubMed] Google Scholar (73)
16. Marunick M, Tselios N. The efficacy of palatal augmentation prostheses for speech and swallowing in patients undergoing glossectomy: a review of the literature. J Prosthet Dent. 2004; 91(1):67-74. Review. doi: 10.1016/S0022391303007352 [Full text links] [PubMed] Google Scholar (57) Scopus (31)
17. Berry DC. The buccinator mechanism. J Dent. 1979;7(2):111-114. [PubMed] Google Scholar (6) Scopus (4)
18. DeVan MM. The nature of the partial denture foundation: Suggestions for its preservation. J Prosthet Dent. 1952; 2(2):210-218. doi: 10.1016/0022-3913(52)90048-6 Google Scholar (99) Scopus (45)

Arieh SHIFMAN
DMD, Senior Clinical Lecturer
Department of Oral Rehabilitation
Sackler School of Medicine
Tel Aviv University, Tel Aviv, Israel

CV

He graduated from the Hadassah Dental School Jerusalem (DMD). He got his advanced Education at Sloane Kettering USA specializing in Maxillofacial Prosthodontics and Prosthodontics. He is Head of the IDF Dental Prosthetic unit. He is also Chief Consultant in Maxillofacial Prosthodontics and Temporomandibular Disorders at the Beilinson Hospital Petach Tikva. He is Head of the Prosthodontics and Prosthodontic graduate program IDF. He is also Honorary member of the International College of Prosthodontists.

Questions

A "shortened dental arch" is defined as:

- ❑ a. An arch from canine to canine;
- ❑ b. An arch missing molar teeth;
- ❑ c. The presence of two bilateral pairs of occlusal contacts (premolar occlusion);
- ❑ d. The presence of 10 teeth per arch contacting each other.

Immediate bony reconstruction of a posterior segmental mandibular resection, without replacement of the lost teeth, leads to:

- ❑ a. Supra-eruption of the unopposed molars;
- ❑ b. No supra-eruption of the unopposed molars;
- ❑ c. Earlier loss of remaining teeth due to increased wear;
- ❑ d. Bilateral increase of the curve of Spee.

Which is not a possible adverse outcome of a shortened dental arch?

- ❑ a. Bruxism;
- ❑ b. Increased wear of the remaining anterior teeth;
- ❑ c. Interdental spacing in the premolar area;
- ❑ d. Temporo-mandibular-joint overload.

After ablative surgery with immediate bony reconstruction, supra-eruption of unopposed teeth is avoided because of:

- ❑ a. Old age;
- ❑ b. Follow-up visits;
- ❑ c. Tongue interposition;
- ❑ d. Absence of any tooth filling.

General

PREVALENCE OF MALOCCLUSIONS IN A SAMPLE OF 4-5-YEAR-OLD BULGARIAN CHILDREN

Keti Yovcheva[1a*], Miroslava Yordanova[1b], Svetlana Yordanova[1c], Nina Musurlieva[2d]

[1]Department of Orthodontics, Faculty of Dental Medicine, Medical University – Plovdiv, Bulgaria
[2]Department of Social Medicine and Public Health, Faculty of Public Health, Medical University – Plovdiv, Bulgaria

[a]DMD
[b]DMD, PhD
[c]DMD, PhD
[d]DMD, PhD

Received: October 11, 2016
Revised: November 14, 2016
Accepted: November 29, 2016
Published: December 01, 2016

Academic Editor: Ioan Danilă, DDS, PhD, Professor,"Gr. T. Popa" University of Medicine and Pharmacy Jassy, Jassy, Romania

Cite this article:
Yovcheva K, Yordanova M, Yordanova S, Musurlieva N. Prevalence of malocclusions in a sample of 4-5-year-old Bulgarian children. Stoma Edu J. 2017;4(1):66-71.

ABSTRACT

DOI: 10.25241/stomaeduj.2017.4(1).art.7

The aim of this study is to estimate the prevalence of malocclusions in a sample of 4-5-year-old children.
Methodology: 471 boys and girls participated in this observational cross-sectional epidemiological study. The presence of spacing, no spacing and crowding, anteroposterior, transverse and vertical occlusion relationships was assessed and analyzed.
Results: Normal occlusal relationships were found in 35.6% of all children. Generalized spacing was found in 78.2% of the subjects, followed by no spacing in 16.1% and crowding in 5.7%, respectively. Class I canine relationship was found in 64.1% of the children, followed by Class II in 29.1% and Class III in 9.6%. A flush terminal molar relationship was found in approximately 70% of the children, followed by mesial and distal molar relationships equally distributed. An increased and decreased overjet was observed in 9.5% and in 4.9% of the children. An anterior cross-bite was documented in 6.4% of all the examined children. An unilateral posterior cross-bite and a bilateral posterior cross-bite were observed in 3.2% and in 1.5% of the sample. A posterior edge-to-edge bite was found in 1.9%. A normal overbite was found in 30.1% of all children; a deep bite with and without gingival contact was registered in 27% and in 8.5% respectively; an anterior open bite was seen in 7.2% of the children and a posterior open bite in 1.3%. The percentage of mandible lateral deviation cases is 2.5%.
Conclusion: Due to the high prevalence of malocclusions with 64.4%, early attention may be given to orthodontic prevention measures.
Keywords: cross-sectional study, occlusal relationship, prevalence, prevention, malocclusions.

1. Introduction

The last study conducted on the prevalence of malocclusions in primary dentition in Bulgaria was in the middle of the 80's, where almost all of the children were included in organized contingents and strictly examined by a dentist or an orthodontist every year. At that time an oral health prevention program was developed, which included orthodontic services for the masses.[1,2] After the change in health politics, this program is no longer active and occlusal characteristics, prevalence and the types of malocclusions in the primary dentition are not regularly registered and analyzed. An optimal occlusion in primary dentition is essential for the further development of the occlusion in the permanent dentition.[3,4,5,6] The current preventive program for the Bulgarian children is mostly orientated to caries prevention and according to literature, caries-reducing measures are not likely to have a significant influence on the formation of malocclusions in primary dentition.[7]
We need some present-day data about the prevalence of malocclusions in primary dentition and the aim of this study is to estimate dental

***Corresponding author:**

Dr. Keti Yovcheva, DMD, Department of Orthodontics, Faculty of Dental Medicine, Medical University – Plovdiv, av. Hristo Botev 3, Plovdiv 4000, Bulgaria
Tel/Fax: +359.889.623.842 / +35. 932.631.651, e-mail: drketiyovcheva@gmail.com

health, prevalence of malocclusions and orofacial dysfunctions in a sample of 4-5-year-old Bulgarian kindergarden children.

2. Methodology

The subjects were randomly selected from different kindergardens in the city of Plovdiv. Inclusion criteria were the existence of fully developed primary dentition, no orthodontic treatment, Caucasian origin and a parental consent for participation in the study. A total of 471 boys and girls participated in this cross-sectional epidemiological study. The study was approved by the Ethics Committee of the Medical University – Plovdiv (P-7781).

A postgraduate student in Orthodontics carried out the entire diagnostic assessment of all the children. A specific form was designed for the purpose of this study which contains information about dental health, individual occlusion findings and functional status. All the findings were made under good lighting conditions. The metric parameters were recorded by using a metal ruler marked in 0.5 mm. In this paper, all the orthodontic findings will be described and the following parameters have been selected and analyzed:

The type of primary dentition was assessed as follows: with generalized spaces between the teeth and localized spaces (Type 1), no spaces (Type 2) or a crowded dentition (Type 3).

The overjet was measured in mm as a distance between the labial surface of the lower and upper incisors. A distance of (0-3 mm) was defined as a normal distance. An increased overjet was divided into two groups (3-6mm) and (>6mm), and a negative overjet (<0mm), all measured in mm. An anterior cross-bite was registered when one or more maxillary incisors or canines occluded lingually to the mandibular incisors or canines.

The criteria described by Foster & Hamilton[8] were used for the primary canine and molar relationship assessment.

- Class I - the tip of the maxillary primary canine tooth is in the same vertical plane as the distal of the mandibular primary canine
- Class II - the tip of the maxillary primary canine tooth is anterior to the distal surface of the mandibular primary canine.
- Class III - the tip of the maxillary canine is posterior to the distal surface of the mandibular primary canine.

Terminal plane relationships of the second primary molar:

- Flush terminal - The distal surfaces of the upper and lower second primary molars are in the same anteroposterior level.
- Mesial step - the maxillary terminal plane is posterior to the mandibular terminal plane
- Distal step - the maxillary terminal plane is anterior to the mandibular terminal plane.

Molar and canine occlusions for each child were recorded separately for the left and the right sides of the dentition.

We have distinguished correct lateral occlusal relationships, a unilateral and a bilateral cross bite, a posterior edge-to-edge bite and a scissor bite.

An occlusion of the incisal edges was assessed as an anterior edge-to-edge bite. An overbite was graded according to the coverage of the mandibular incisor by the most protruded maxillary incisor. A normal one, when up to half of the mandibular incisor is covered by the maxillary incisor. An increased overbite, when more than half of the mandibular incisor is covered by the maxillary incisor. An overbite with gingival contact was recorded when the mandibular incisor was fully covered by the maxillary incisor and there was a contact of the incisal edge with the gingiva. An absence of a vertical overlap of the lower incisors was described as an anterior open bite and divided into two groups: moderate (<3mm) and severe (>3mm).

Collection, evaluation and a statistical analysis of the data were conducted using Microsoft® Excel and SPSS Version 17.0 for Windows® (SPSS Inc., Chicago, IL., USA). Means and standard deviations were determined as descriptive statistical values in order to characterize univariate frequency distributions of various variables. A comparison of absolute frequencies of specific characteristics was tested with Pearson's chi-square test. The statistical significance was assessed at the 5% level.

3. Results

A total of 241 males and 230 females were examined. Normal occlusion relationships were found in 35.6% of the sample. 126 or 26.8% of the children have one malocclusion, followed by 129 children or 27.4% with two malocclusions, 27 or 5.7% with three malocclusions and then 21 or 4.5% with four malocclusions. The total distribution of malocclusions is 64.4%.

The most prevalent type of primary dentition is Type 1 with 78.2 % (with spacing), followed by 16.1% Type 2 (no spacing) and 5.7% Type 3 (crowding). The gender comparison is shown in Table 1. There is a statistically significant difference between girls and boys in the distribution of spacing, no spacing and crowding which is more prevalent in girls (with spacing $X2=13,308$, no spacing $X2= 10,429$, crowding $X2= 5,318$).

The prevalence of overjet is shown in Table 2. A total of 85.6% of all the children have a normal overjet, 8.7% an increased overjet, 0.8% an excessive overjet and 4.9% a decreased overjet. Gender and age comparison of the normal, increased and decreased overjet among 4 and 5-year-old boys and girls revealed no statistically significant differences. An anterior cross-bite was registered in 6.4% of all the children without significant differences in age and sex.

The distribution of different sagittal relationships of primary canine and second primary molars is shown in Table 3 and respectively in Table 4. A neutral occlusion of the primary canines was found in 60 % of all children, a distal occlusion in 30%

Table 1. Prevalence of spacing, no spacing and crowding in primary dentition.

Gender	Type 1	Type 2	Type 3	Total
Girls	172 (74.8%)	50 (21.7%)	8 (3.5%)	230 (100%)
Boys	196 (81.3%)	26 (10.8%)	19 (7.9%)	241 (100%)
Total	368 (78.2%)	76 (16.1%)	27 (5.7%)	471 (100 %)

Table 2. Prevalence of normal, increased and decreased overjet in 4- and 5-year old children.

Age	Overjet 0-3mm	Overjet 3-6 mm	Overjet >6 mm	Overjet < 0 mm	Total
4 years	138 (87.9%)	10 (6.4%)	2 (1.3%)	7 (4.5%)	157 (100%)
5 years	265 (84.4%)	31 (9.9%)	2 (0.6%)	16 (5.1%)	314 (100%)
Total	403 (85.6%)	41 (8.7%)	4 (0.8%)	23(4.9%)	471 (100 %)

Table 3. Primary canine sagittal relationships.

Age	Class I		Class II		Class III		Total
	Right	Left	Right	Left	Right	Left	
4 years	92 (58.6%)	102 (65.0%)	45 (28.7%)	37 (23.6%)	20 (12.7%)	18 (11.5%)	157 (100%)
5 years	181 (57.6%)	187 (59.6%)	103 (32.8%)	100 (31.8%)	30 (9.6%)	27 (8.6%)	314 (100%)
Total	273 (58.0%)	289 (61.4%)	148 (31.4%)	137 (29.1%)	50 (10.6%)	45 (9.6%)	471 (100 %)

Table 4. Second molar sagittal relationships.

Age	Flush terminal		Mesial step		Distal step		Total
	Right	Left	Right	Left	Right	Left	
4 years	117 (74.5%)	119 (75.8%)	21 (13.4%)	19 (12.1%)	19 (12.1%)	19 (12.1%)	157 (100%)
5 years	213 (67.8%)	222 (70.7%)	52 (16.6%)	43 (13.7%)	51 (16.2%)	47 (15.0%)	314 (100%)
Total	330 (70.1%)	341 (72.4%)	73 (15.5%)	62 (13.2%)	70 (14.9%)	66 (14.0%)	471 (100 %)

and a mesiocclusion in 10 %. A distribution of a flush terminal molar relationship in percentages is 70.1% on the right side and 72.4% on the left side of the examined subjects. The mesial step was assessed as 15.5% on the right side and 13.2% on the left side. And the distal step was assessed as 14.9% on the right side and respectively 14% on the left side. There are no statistically significant differences between gender in the primary canine relationships and the second primary molar relationships. But we found a statistically significant increase in Class II canine relationships between the age groups ($X2 = 3.479$, $p = 0.062$).

A normal overbite was found in 30.1% of the sample and an anterior edge-to-edge bite existed in 27.2% of all the children, with no significant differences between gender and age in the subgroups. A moderate anterior open bite (<3mm) and a severe anterior open bite (>3mm) were registered respectively in 6.8% and 0.4%. A posterior open bite was documented in 1.3% of all children. A deep overbite was found in 127 children (27.0%) and a deep overbite with gingival contact in 40 children (8.5%). Statistically significant was the fact that boys showed more deep bites with gingival contact ($X2 = 3.347$, $p = 0.067$) and also the difference between the age groups was statistically significant ($X2 = 3.497$, $p = 0.061$) - an increase of the frequency was observed with the increasing of the age.

A unilateral posterior cross-bite was observed in 3.2% of the sample and a bilateral posterior cross-bite in 1.5%. An edge-to-edge bite in the posterior region was found in 9 cases with a statistically significant difference in age comparison ($X2 = 8.156$, $p = 0.004$), the 4-year-olds showed more edge-to-edge bites than the 5-year-olds. In this sample, a scissor bite was not registered. The total percentage of mandible lateral deviation was 2.5%. A mandible deviation to the right side was found in two cases and 10 cases to the left side. The percentage prevalence of malocclusions in primary dentition is shown in Table 5.

Table 5. Percentage prevalence of malocclusions in primary dentition.

Type of malocclusion	Children with malocclusion	Percentage (%)
Class II canine occlusion	142	30.1%
Class III canine occlusion	45	9.6%
Anterior open bite	34	7.2%
Posterior open bite	6	1.3%
Deep overbite	127	27%
Deep overbite with gingival contact	40	8.5%
Anterior cross bite	30	6.4%
Posterior cross bite	Unilateral - 15 Bilateral - 7	3.2% 1.5%
Posterior edge-to-edge bite	9	1.9%
Mandible lateral deviation	12	2.5%

4. Discussion

The overall prevalence of malocclusions is high - 64.4%. According to the scientific literature, the prevalence of malocclusions in primary dentition varies from 22% to 93%[9,10] due to racial characteristics and different occlusion recording methods. We found a higher prevalence of malocclusions as compared to some previous studies conducted on the Bulgarian population by Nikolov & Atanasov,[11] who found 44.5% prevalence. The difference in prevalence is probably due to the fact that at that time a mass orthodontic prevention program was held. The generalized spacing in this sample is 78.2% and it is corresponding to the findings of Foster&Hamilton[8] with 70%. The prevalence of no spacing and crowding concurs with other studies,[4,12,13] but it is much lower than the results for the British children.[8] Our results for the prevalence of several concurrent malocclusions in primary dentition are in agreement with other studies.[14] The canine sagittal relationships showed that 60% of the children have Class I, 30% have Class II and 10% have Class III and the results are corresponding to the findings for the European population.[4,10,15]

Our study conducted on the Bulgarian population showed a percentage distribution of a flush terminal molar relation in 70.1% of the subjects on the right side and 72.4% on the left, which is similar to studies done by Nanda et al.[16] A mesial step and a distal step in this sample are equally distributed in 14.4% and 14.5%, respectively. Our results for the mesial step are in agreement with the findings of Baume[17] and Ravn,[18] but in disagreement with the results of Johannsdottir et al.,[19] who found that 60% of their sample had mesial step occlusal relationships in primary dentition. Our results for the distal step are similar to the findings by Grabowski et al.,[10] who found 15.5% "distalization" in primary dentition.

The normal overjet is in agreement with the results by Berneburg et al.,[14] but the increased overjet was assessed in 9.5% of this sample, which is lower than their findings. Our results for the decreased overjet are higher than other studies[10,14] but similar to the findings of Müssig.[15] An anterior cross-bite was observed in 6.4% of the sample, which resembles a study conducted by Kerouso[20] for the Finnish children.

The prevalence of a normal overbite is 30.1%. We also found 27.2% of an anterior edge-to-edge bite and, at the age of 5, it is a norm according to Hotz.[21] The findings are in agreement with the results by Nanda et al.,[16] Müssig[15] and Berneburg et al.[14] But on the other hand, the high frequency may be due to the self-correction of an anterior open bite after interrupting the action of external factors.[22] In this sample, a moderate anterior open bite(<3mm) and a severe anterior open bite (>3mm) were registered respectively in 6.8% and 0.4% of the children, which is in agreement with Berneburg et al.,[14] who found 4.6% prevalence of an anterior open bite. The prevalence of an anterior open bite in this sample is significantly less than the findings of Müssig[15] and Tschill et al.[4]

Our results showed prevalence of a deep bite and a deep bite with gingival contact, 27% and 8.5%, respectively, which is similar to the studies done by Müssig[15] and Grabowski et al.[10] In this sample, boys have more severe deep bites and there is also a statistically significant increase in prevalence of a deep bite with gingival contact with the increasing of the age, which concurs with other studies' results,[10,22] but it is in disagreement with the results of Berneburg et al.[14] A posterior cross-bite was seen in 4.7% and a posterior edge-to-edge bite in 1.9% of all the children in this study.

Other investigators report that a deciduous posterior cross bite ranges between 7-12%.[8,10,18] But our findings are similar to Hensel (12) and Stahl & Grabowski,[6] who report 5.1% and 4% respectively. Available literature suggests that the development of the occlusion and oral functions in primary dentition is a continuum for the further morphological and functional development of the stomatognathic system.[4,10] The correct development of a stable, functional and aesthetically acceptable occlusion is an integral component of a comprehensive oral

health care for all pediatric dental patients.[23] Further research is needed to establish the development of the dentition and malocclusions in the next stages of the dental development in this sample, and the relatively small sample size is a limitation of our study.

5. Conclusions

This cross sectional study provides present-day data about the prevalence of malocclusions in a sample of 471 Bulgarian children with primary dentition. Statistical differences in the type of dentition, a deep bite with gingival contact and a posterior edge-to-edge bite were found. Class II canine occlusion, a distocclusion, a deep bite, no spacing and crowding and an increased overjet were the epidemiologically-relevant malocclusions in our study.

Due to the high prevalence of malocclusions in deciduous dentition, it is necessary for children to be regularly examined at an early age and the occlusal development should be individually assessed. Early attention may be given to malocclusions and their prevention, and especially to those caused by external etiologic factors like bad habits and incorrect oral functions.

Acknowledgments

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

References

1. Atanasov K. Orthodontic prevention for the masses in Bulgarian. Dissertation, Plovdiv, Bulgaria: Medical University - Plovdiv,, 1989;8-10.
2. Mutafchiev V, Dinkova M, Hranova V. [Distribution of malocclusions and their main etiologic factors in kindergarten children in Bulgarian]. Stomatologiia. Stomatology.1988;70(3):55-61. Bulgarian.
3. Varrela J, Alanen P. Prevention and early treatment in orthodontics: a perspective. J Dent Res. 1995;74(8):1436-1438. doi: 10.1177/00220345950740080101 [Full text links] [PubMed] Google Scholar (37) Scopus (17)
4. Tschill P, Bacon W, Sonko A. Malocclusion in the deciduous dentition of Caucasian children. Eur J Orthod. 1997;19(4):361-367. [PubMed] Google Scholar (153) Scopus (59)
5. Kerosuo H. The role of prevention and simple interceptive measures in reducing the need for orthodontic treatment. Med Princ Pract. 2002;11Suppl 1:16-21. Review. [PubMed] Google Scholar (16) Scopus (4)
6. Stahl F, Grabowski R. Orthodontic findings in the deciduous dentition and early mixed dentition -- inferences for a preventive strategy. J Orofac Orthop. 2003;64(6):401-416. doi: 10.1007/s00056-003-0313-8 [Full text links] [PubMed] Google Scholar (90) Scopus (33)
7. Stahl F, Grabowski R. Malocclusion and caries prevalence: is there a connection in the primary and mixed dentitions? Clin Oral Investig. 2004;8(2):86-90. doi: 10.1007/s00784-003-0244-1 [Full text links] [PubMed] Google Scholar (61) Scopus (28)
8. Foster TD, Hamilton MC. Occlusion in the primary dentition. Study of children at 2 and one-half to 3 years of age. Br Dent J. 1969;126(2):76-79. [PubMed] Google Scholar (288) Scopus (126)
9. Thilander B, Pena L, Infante C, Parada SS, de Mayorga C.. Prevalence of malocclusion and orthodontic treatment need in children and adolescents in Bogota, Columbia. An epidemiological study related to different stages of dental development. Eur J Orthod. 2001;23(2):153-167. [PubMed] Google Scholar (444)
10. Grabowski R, Stahl F, Gaebel M, Kundt G. [Relationship between occlusal findings and orofacial myofunctional status in primary and mixed dentition. Part I: Prevalence of malocclusions]. J Orofac Orthop. 2007;68(1):26-37. doi: 10.1007/s00056-007-1606-0. German. [Full text links] [PubMed] Scopus (47)
11. Nikolov B, Atanasov K. [Development of dental arches from 3 to 6 years of age at norm and malocclusion] Stomatologiia. Stomatology. 1982;64(3):208-214. Bulgarian.
12. Hensel E. [Investigations on the development of malocclusions from the primary dentition to the mixed dentition] Fortschr Kieferorthop. 1991;52(6):353-358. German. Google Scholar (18) Scopus (14)
13. Abu-Alhaija ES, Qudeimat MA. Occlusion and tooth arch dimensions in the primary dentition of preschool Jordanian children. Int J Paediatr Dent. 2003;13(4):230-239. Google Scholar (90) Scopus (30)
14. Berneburg M, Zeyher C, Merkle T, et al. Orthodontic findings in 4- to 6-year-old kindergarten children fromsouthwest Germany. J Orofac Orthop. 2010;71(3):174-186. doi: 10.1007/s00056-010-9941-y [Full text links] [PubMed] Google Scholar (3) Scopus (2)
15. Müssig D. [The type and incidence of mandibular abnormalities and functional disorders in the deciduous dentition]. Fortschr Kieferorthop. 1991;52(2):110-114. German. [PubMed] Google Scholar (2)
16. Nanda RS, Khan I, Anand R.Age changes in the occlusal pattern of deciduous dentition. J Dent Res. 1973;52(2):221-224. doi: 10.1177/00220345730520020601 [Full text links] [PubMed] Google Scholar (88) Scopus (27)
17. Baume LJ. Physiological tooth migration and its significance for the development of occlusion. I. The biogenetic course of the deciduous dentition. J Dent Res. 1950;29(2):123-132. doi: 10.1177/00220345500290020301 [Full text links] [PubMed] Google Scholar (526) Scopus (90)
18. Ravn JJ. Longitudinal study of occlusion in the primary dentition in 3-7-year old children. Scand J Dent Res. 1980;88(3):165-170. [PubMed] Google Scholar (37)
19. Johannsdottir B, Wisth PJ, Magnusson TE. Prevalence of malocclusion in 6-year-old Icelandic children. Acta Odontol Scand. 1997;55(6):398-402. [PubMed] Google Scholar (87) Scopus (47)
20. Kerosuo H. Occlusion in the primary and early mixed dentitions in a group of Tanzanian and Finnish children. ASDC J Dent Child 1990;57(4):293-298. [PubMed] Google Scholar (99) Scopus (48)
21. Hotz R. [Dentistry for children and adolescents]. German. 2 ed, Stuttgart, Georg Thieme Verlag; 1981; 280-292.
22. Dimberg L, Lennartsson B, Arnrup K, Bondemark L. Prevalence and change of malocclusions from primary to early permanent dentition: a longitudinal study. Angle Orthod. 2015;85(5):728-734. doi: 10.2319/080414-542.1 [Full text links] [PubMed] Google Scholar (39) Scopus (15)
23. Majorana A, Bardellini E, Amadori F, Conti G, Polimeni A. Timetable for oral prevention in childhood--developing dentition and oral habits: a current opinion. Prog Orthod. 2015;16:39. doi: 10.1186/s40510-015-0107-8 [Full text links] [Free PMC Article] [PubMed] Google Scholar (4)

Keti YOVCHEVA
DDS, PhD, Postgraduate Student
Department of Orthodontics
Faculty of Dental Medicine
Medical University - Plovdiv, Bulgaria

CV

Dr Keti Yovcheva, DDS is a PhD and postgraduate student at the Department of Orthodontics, Faculty of Dental Medicine, in Medical University - Plovdiv, Bulgaria. Since 2010 she has been working as an assistant doctor at a private orthodontic practice. One of her main research interest is preventive and interceptive orthodontics.

Questions

Which is the most prevalent type of primary dentition found in this study?

- ❑ a. Type 1;
- ❑ b. Type 2;
- ❑ c. Type 3;
- ❑ d. none of them.

What is the total prevalence of malocclusions found in this study?

- ❑ a. 54.4%;
- ❑ b. 64.4%;
- ❑ c. 74.4%;
- ❑ d. 82.5%.

What is the prevalence of anterior open bite found in this study?

- ❑ a. 5.8%;
- ❑ b. 6.0%;
- ❑ c. 6.4%;
- ❑ d. 6.8%.

What is the prevalence of unilateral posterior cross bite found in this study?

- ❑ a. 4.5%;
- ❑ b. 4.2%;
- ❑ c. 3.2%;
- ❑ d. 3.0%.

NEWS THAT CAN IMPROVE YOUR PRACTICE: from IDS 2017

I remember with pleasure my first visit I made to my father at the time of me dental school period in 2005 at International Dental Show (IDS) in Cologne, Germany.
Since then, I have been visiting this world-wide exhibit, manufacturer and dental barometer worldwide for two years, where you can get acquainted with the latest news that can significantly improve your current work practice.
At the last working session of the Editorial Operative Team of Stomatology Edu Journal organized by the Editor-in-Chief, Prof. Jean François Roulet, the fresh Dr hc of the "Carol Davila" University of Medicine and Pharmacy in Bucharest, I was nominated to support a new heading: "Product News".
Of course, in order to better inform the readers of Stomatology Edu Journal, I will improve my information at the International Dental Show (IDS) with data from Dental Compare, Dental News, infoDent, Dental Economics, Dentistry Today etc.
Since I participated in the latest IDS in Cologne in March, 21-25, 2017 will present the leading technologies that have attracted my attention significantly:

- GC presented an intraoral scanner for beginners, Aadva IOS;
- 3Shape introduced the first wireless intraoral scanner, Trio 3;
- Condor has provided the first 2-generation miniature intraoral scanner that produces high-fidelity natural images;
- Zebris Medical has introduced an optical jaw measurement and occlusal analysis system;
- EMS has introduced a new oral hygiene device, AIRFLOW Prophylaxis Master;
- Dr. Choukroun introduced the new series of PRF DUO for A-PRF & i-PRF;
- Philips introduced the new Sonicare DiamondClean Smart toothbrush and the application that monitors the correct oral hygiene practices;
- Ivoclar Vivadent introduced 54 new products, including the PrograMill series consisting of four milling machines;
- Planmeca introduced the new Emerald intraoral scanner, which produces high-quality images;
- Komet will offer new burs for better polishing of composites and all-ceramics adjusting, finishing and polishing and sectioning all-ceramic restorations;
- DMG has introduced a new 3-D printer and related milling materials;
- Voco has set up a complete digital workflow.

Of course I could continue listing the significant products that were exposed this year by the dental manufacturers present. I reserve for the following numbers to give you a more detailed presentation.

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

DOI: 10.25241/stomaeduj.2017.4(1).prodnews

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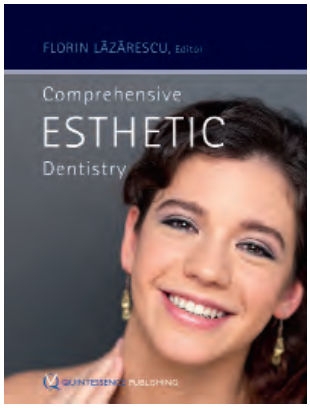
Comprehensive Esthetic Dentistry

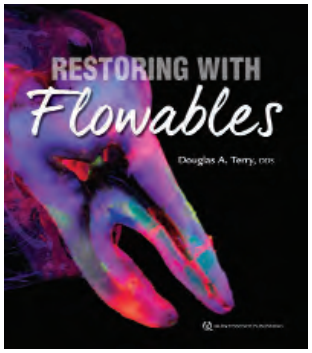


Authors: Florin Lazarescu (editor)
Publisher: Quintessence Publishing Co Inc
Language: English
ISSN: 978-1-85097-278-5
Edition: 1/e
Publish Year: 2015
Pages: 364, illustrated
Price: $ 228.00

A contemporary dentist has the task of providing his patients with aesthetic treatments, but also in harmony with the other functions of the stomatognathic system. The merit of this book lies with the editor, Dr. Florin Lăzărescu, who managed to raise a group of dental aesthetics specialists who successfully completed this book called "Comprehensive esthetic dentistry".
The book is divided into 15 chapters. The first eight chapters present introductory notions and general principles of dental and dento-facial esthetics, data of photographic examination, communication with the patient in the esthetic assessment integration of the provisional aesthetic rehabilitation in the treatment plan, materials used for aesthetic restorations, notions of minimally invasive procedures in esthetic dentistry, principles of adhesion to dental structures and tooth discoloration. The next seven chapters tackle practical aspects, esthetic restorations of the anterior and lateral teeth, the protocol for adhesive fixations in esthetic restorations, CAD-CAM systems and techniques in the dental office and the interdisciplinary prosthetic- orthodontic-periodontal approach of complex cases requiring teamwork. The book is exceptionally well designed and it gives the practitioner a wealth of useful dental esthetic solutions for both young and experienced doctors. Due to its exceptional qualities to clarify dental esthetics, this book has brought an intense sense of professional achievement and personal satisfaction to the authors and can be seen as a guide in which the practitioner finds an exclusive answer to the problems of dental esthetics that he has to solve in his daily activity.

DOI: 10.25241/stomaeduj.2017.4(1).bookreview.1

Restoring with Flowables



Authors: Douglas A. Terry
Publisher: Quintessence Publishing Co Inc
Language: English
ISSN: 978-0-86715-668-3
Edition: 1/e
Publish Year: 2017
Pages: 292, illustrated
Price: $ 148.00

The book entitled "Restoring with Flowables" by Dr. Douglas A. Terry presents innovative concepts in restorative dentistry. He shows the applications of next-generation flowable composites in a step-by-step manner.
This book has four chapters, starting with the historical perspective and the evolution of flowable composites. Then it approaches the general consideration of adhesion, and tooth preparation. According to aesthetic principles, in the last two chapters, the author talks about the clinical applications of flowable direct restorations in anterior and posterior teeth; sealants and preventive resin restorations; provisional fabrication, modification, and repair; tooth splinting; eliminating cervical tooth sensitivity; adhesive reattachments of tooth fragment; developing the ovate pontic site; bonding porcelain veneers and inlay cementation; stratification layering technique; restoration of anterior and posterior primary tooth; developing a post and core; and restoring form and function, among others. The book provides detailed and very well illustrated protocols of the adhesive design concept, evolution of flowable resin composites and applications of contemporary restorative dentistry. Whether you are an experienced clinician or a young dentist this book will give you a new perspective of minimally invasive and aesthetic restorations.

DOI: 10.25241/stomaeduj.2017.4(1).bookreview.2

Marian-Vladimir Constantinescu
DDS, PhD
Holistic Dental & Medical Institute of Bucharest - ROPOSTURO, Bucharest, Romania
e-mail:
dr.vladimir.constantinescu@gmail.com

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

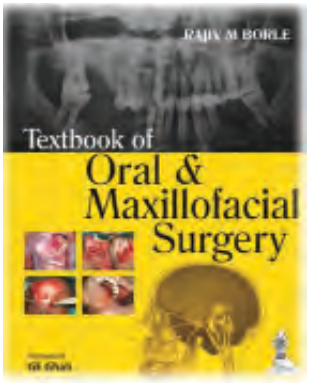
EVOLUTION: Contemporary Protocols for Anterior Single-Tooth Implants

Authors: Iñaki Gamborena / Markus B. Blatz
Publisher: Quintessence Publishing Co Inc
Language: English
ISSN: 978-0-86715-496-2
Edition: 1/e
Publish Year: 2015
Pages: 440, illustrated
Price: $ 362.00

Oral Implantology is the dentistry area with a constant evolution of its concepts, materials, and techniques. Drs. Iñaki Gamborena and Markus B. Blatz drafted a contemporary book about
Anterior Single-Tooth Implants Protocols which they suggestively called: EVOLUTION.
The book is divided into six chapters eloquently and amply illustrated, with more than 1,900 illustrations. The content of this book covers every step of the anterior single-tooth implant placement from the soft tissue characteristics to the final cementation.
The first three chapters talk about the peri-implant soft tissue, the clinical protocol with the platform shift concept and the ideal 3D implant placement. The last three chapters present orthodontics and the soft tissue grafting procedures, laboratory communication and the final cementation of the restoration.
Because of the step-by-step format this book allows readers to improve their experience in anterior implant placement for the ultimate goal: the best possible care for our patients.

DOI: 10.25241/stomaeduj.2017.4(1).bookreview.3

Textbook of Oral and Maxillofacial Surgery



Author: Rajiv M Borle
Publisher: Jaypee Brothers Medical Publishers (P) Ltd
Language: English
ISSN: 9789351520092
Edition: 1/e
Publish Year: 2014
Pages: 830, illustrated
Price: £ 78.00

The Textbook of Oral and Maxillofacial Surgery by Professor Rajiv M Borle is a contemporary guide and a compilation of the authors' personal experiences. The book is divided into twelve sections and tackles the basic principles of surgery, neurological disorders of the face and general anesthesia, dentoalveolar surgeries, diseases of the maxillary sinus and salivary glands, infection and trauma of the maxillofacial region, facial deformities and TMJ disorders, neoplastic condition of the head, neck and face. At the end of each chapter all the incorporations have been authenticated by giving the necessary bibliography.
This first edition of the book addresses undergraduate and postgraduate students in the field of Oral and Maxillofacial Surgery, Otolaryngology, and Plastic Surgery. Presented in an easy-to-follow format, the text is enriched with clinical photographs, radiographic images, charts and a lot of illustrations to provide better understanding.

DOI: 10.25241/stomaeduj.2017.4(1).bookreview.4

Florin-Eugen Constantinescu
DDS, PhD Student
Holistic Dental & Medical Institute of Bucharest - ROPOSTURO, Bucharest, Romania
e-mail:
dr.florin.constantinescu@gmail.com

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

1. Submitting the Article

The journal publishes articles written in English. All articles will be accompanied by the signed copyright form which can be returned by e-mail, fax (as scanned documents). All the responsibility for the originality of the material sent belongs to the author(s) alone. Each article will be evaluated by the peer-review committee composed of two independent peer-reviewers, in a blinded fashion, according to the peer-review protocol. All articles will be sent to the editor-in-chief at the following e-mail address: stomatology.edu@gmail.com. The articles will also be sent at the e-mail address of the co-editors-in-chief from your area (Americas, Europe, Asia-Pacific).

2. Articles sent for publishing

Stomatology Edu Journal (Stoma Edu J) publishes:
- original articles;
- reviews;
- case reports;
- consensus declaration coming from an association or from a group of specialists;
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All articles must be up to 3,000 and 4,500 words for meta-analysis (the word count is for the manuscript text only). Letters to the editor must not exceed 400 words of text and 5 references. Letters may have no more than 3 authors. Letters to the editor can be related to an article already published in the journal or it can represent original scientific contributions or events news/presentations etc. of interest for the reader.

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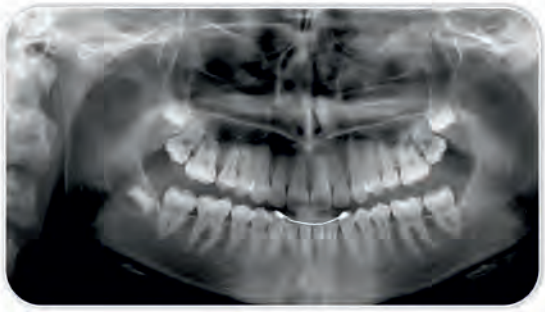

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