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Constantinus Politis
MD, DDS, MM, MHA, PhD
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Dear Readers,

In a section of Foreign Affairs (Volume 100, Number 5, 2021), Dr. Chonira Aturupane of Stanford University points out that during the COVID-19 pandemic a number of challenges stood in the way of effective policymaking: the prevalence of unreliable information; the degree to which uncertainty and unpredictable factors can derail the best-laid plans; the importance of comprehensive and feasible implementation plans. We will concentrate on the first issue, the importance of credible data.

Credible data, reliable information in science does not equal the absence of fake news. Credibility in scientific reporting requires at least the following dimensions to be assessed: method and data transparency; adequate sample size and power; validity of the data; adequate use of secondary data; analytic reproducibility and robustness; effect replicability; independent study sponsoring. Respecting all these requirements should lead to evidence-based data and evidence-based medicine (EBM).

Yet, on the reporting site in journals, the cornerstone of EBM has shifted far too much from original research towards the higher positioned systematic reviews and meta-analysis. Many thousands of pages have been filled with answering questions nobody was waiting for. Further on, unexperienced readers should not assume that level 1 evidence is always the best choice or appropriate for the research question. An item often overlooked is the natural history of a condition. For reviewers of most journals it is nearly impossible to adequately assess all items which define the quality of a study: randomization, blinding, a description of the randomization and blinding process, description of the number of subjects who withdrew or dropped out of the study; the confidence intervals around study estimates, and a description of the power analysis and the statistical methods used. Most reviewers are no statisticians.

This only can be solved if the number of journals is sufficiently reduced to allow for a thorough change of the review process. Before getting to the clinical reviewers, language experts should filter out inadequate manuscripts and trained statisticians should filter out studies which are underpowered, unvalidated or ill-designed. Only then should clinical reviewers assess the manuscript. This requires journals to be digital only with a well-developed staffing connected in the cloud and funded by independent academic consortia. The digital only version, and of course open access, allows for post-hoc comments or corrections to be added as a section to published papers.

As for systematic reviews and meta-analysis, these are very often conducted by PhD students or Master students in the fulfillment of a PhD or a Masters Program. It is cheap, fills pages, whether the question is relevant or not. It is very often easily accepted in high ranked journals, creating easily gained impact factors, citations and h-index points, and all of this usually at a young research age.

It is time to attach less importance to systematic reviews if the question they try to answer is not relevant. More is to be gained in well-conducted clinical research, but this is tedious work requiring resources and an experienced research team. In the clinical reality of surgical departments this is a rare phenomenon. The consequence of this surgical reality is that younger surgeons write manuscripts and publish articles and seasoned surgeons write book chapters or books or invited sessions in journals.

There is yet another way skilled surgeons can contribute to journals and science. Through their scientific societies, often in joined efforts with representatives of sister organisations, they can aim for consensus...
statements and guidelines. Professor Hendrik Terheyden, editor-in-chief of the International Journal of
Implant Dentistry has guided the International Academy for Oral and Facial Rehabilitation (IAOFR) to work
along these lines. The IAOFR, presided by Prof. Dr. Piet Haers, is an international group with more than 30
years of continuous history in the field of oral and facial rehabilitation of patients with innate or acquired
tooth loss or defects of the jaws and the craniofacial region. This group has an international composition,
high scientific expertise and independence. Consensus Statements and Guidelines can target a worldwide
audience of practitioners, clinicians and patients. The methodology used is in accordance with the
GIN-McMaster Guideline Development Checklist, the AWMF Guidance Manual and Rules for Guideline
Development, and the policies of the Guidelines International Network. All this information is freely accessible
on the internet. Consensus Statements and Guidelines allow for a corridor of accepted clinical treatment or
pathways, excluding under-therapy, over-therapy, false therapy, obsolete therapy. Consensus Statements
and Guidelines try to identify a standard of care and have the character of a recommendation to clinicians
in standard clinical situations and a standard clinical environment without any legal force. Consequently,
clinicians can deviate from recommendations in specific cases and situations. Consensus Statements and
Guidelines can also be of help for informed patients for participative therapeutic decisions. Guidelines also
provide tools for policymakers.
Conflicts of interest need to be addressed in a transparent way. The policy of an independent guideline
group requires a declaration, evaluation and management of conflicts of interest of every participant of
the guideline group because the guideline should not be vulnerable to competing interests of industry
companies or competing societies afterwards. A listing of possible conflicts of interest of the participants
should be forwarded to all participants in advance of the consensus meeting.
Since medicine is a quickly evolving field each statement and guideline expires 3 years after publication. The
‘Terheyden-Haers doctrine’ not only allows seasoned and skilled surgeons to combine surgical experience
with common sense and scientific rigor but to translate the surgeon’s group-knowledge into answers to
questions which are relevant to patients and society at large.
Journals will remain necessary for those who pursue academic careers and are in need of citations, h-index
scores to advance in the academic ranking. The perverse side-effect however is that Universities and
Academic Institutions in so-doing make publishers of scientific journals with paid ‘open access’ filthy rich,
while at the same time depriving a mass of interested parties of scientific information. It is high time that
universities embrace unpaid open access and look for alternatives beyond the h-indexes and citation indices
to appreciate the scientific value of young academics.

Sincerely yours,

Constantinus Politis
MD, DDS, MM, MHA, PhD
Professor & Chairperson
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EFFICACY OF PERSONAL PROTECTIVE EQUIPMENT AGAINST CORONAVIRUS TRANSMISSION VIA DENTAL HANDPIECES

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https://jada.ada.org/article/S0002-8177(21)00166-5/fulltext

This article has an accompanying online continuing education activity available at:
https://doi.org/10.1016/10.1016/j.adaj.2021.03.007

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PMCID: PMC7997726
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MAXILLARY SINUS VOLUME IN CLEFT LIP AND PALATE PATIENTS WITH AND WITHOUT AN ORONASAL FISTULA USING CBCT

Bita Kiaee¹* , Ladan Hafezi²b , Mahshid Karani¹c , Faezeh Amiri¹d , Abdolreza Jamilian¹c ³

¹Department of Orthodontic, Dental School, Tehran University of Medical Sciences, Tehran, Iran
²Maxillofacial Radiology Department, Faculty of Dentistry, Tehran Medical Sciences, Islamic Azad University, Tehran, Iran
³DDS, MS, Assistant Professor; e-mail: dr.bitakia@gmail.com; ORCIDID: https://orcid.org/0000-0002-9117-3593
⁴DDS, MS, Assistant Professor; e-mail: Lhafezi@yahoo.com; ORCIDID: https://orcid.org/0000-0002-1727-2665
⁵DDS; e-mail: dr.mahkm96@gmail.com; ORCIDID: https://orcid.org/0000-0002-8586-3846
⁶DDS; e-mail: dr.faerehhamir1989@gmail.com; ORCIDID: https://orcid.org/0000-0003-0184-3061
⁷DDS, MS, Professor; e-mail: info@jamilian.net; ORCIDID: https://orcid.org/0000-0002-8841-0447

ABSTRACT

Introduction Formation of oronasal fistula is a common complication after surgical closure of cleft lip and palate (CLP). This study aimed to compare the maxillary sinus volume in 9-12-year-old CLP patients with and without an oronasal fistula who had undergone surgical closure of the cleft at 1 year of age, using cone-beam computed tomography (CBCT).

Methodology This descriptive, cross-sectional, analytical study was conducted on CBCT scans of 50 patients with unilateral CLP who were between 9-12 years and had undergone surgical closure of the cleft at 1 year of age in two groups with and without an oronasal fistula (n=50). The patients were selected among those presenting to a private orthodontic office between 2001-2009 and already had CBCT scans taken for orthodontic treatment. The 3D CBCT scans were reconstructed with Mimics software, and the volume of the maxillary sinuses was measured on the images. Data were compared using t-test.

Results The maxillary sinus volume was significantly smaller in patients with oronasal fistula compared with those without it (9510.7±492 mm³ vs. 10278.2±512 mm³, P<0.000). The maxillary sinus of the affected side was smaller than that of the unaffected side in both groups of patients with and without an oronasal fistula (P<0.05).

Conclusion Immature patients with unilateral CLP and oronasal fistula have a smaller maxillary sinus than unilateral CLP patients without an oronasal fistula, and may be at higher risk of respiratory infections.

KEYWORDS
Cone-Beam Computed Tomography; Orofacial Cleft; Fistula; Maxillary Sinus.

1. INTRODUCTION

The failed fusion of the medial nasal and maxillary processes would result in the occurrence of cleft lip while failed fusion of the palatine prominences would lead to the formation of a cleft palate [1,2]. Cleft lip and palate (CLP) has a prevalence of 1 per 500 live births [3]. Surgical management of CLP was first performed approximately 150 years ago [4]. At present, CLP patients often undergo surgery before the 1st year of age. However, an oronasal fistula may develop postoperatively due to the infection of the palate or tension of the flap, and cause problems for the patient [5]. The oronasal fistula is a common complication of surgical management of CLP with a prevalence rate of 9-50%. The rate of recurrence of the fistula after surgery is as high as 35-70% [6,7]. Development of an oronasal fistula indicates failure of the surgical closure of the palate to obstruct the communication between the oral and the nasal cavity.

According to the classification by Pittsburg, seven types of fistula are present [8], which can be symptomatic or asymptomatic. Symptomatic fistula can cause several complications such as leakage of foods and drinks from the oral cavity into the nasal cavity, bad odor, rhinitis, impaired hearing, hypernasality, infection, and speech problems [7,9,10].

CLP patients often suffer from decreased maxillary sinus volume and significant esthetic impairments due to the maxillary deficiency at the midface, where the maxillary sinuses are located. These patients often develop recurrent sinusitis for no clear reason.
Also, they have smaller sinuses due to a different developmental process during the embryonic stage, surgical scars, recurrence of fistula, leakage of foods and liquids into the nasal cavity, frequent infections, and different pattern of air circulation in the nose and sinuses [1,8,11-14]. Several studies have been conducted on CLP patients using 2D lateral cephalometry, which has high diagnostic accuracy for clinical applications, despite simplicity and low cost [15-20]. However, cone-beam computed tomography (CBCT) has become increasingly popular in the recent years due to its higher accuracy at a comparable cost.

Controversy exists regarding the maxillary sinus volume in CLP patients such that some studies reported a significantly smaller volume of the maxillary sinuses in CLP patients compared with normal individuals [15,21-23] while some others found no significant difference in this respect [8,11,24-26]. Considering the existing controversy in this respect, and the gap of information regarding the maxillary sinus volume in patients who developed an oronasal fistula after surgery compared with those who did not, this study aimed to compare the maxillary sinus volume in 9-12-year-old CLP patients with and without an oronasal fistula who had undergone the surgical closure of the cleft at 1 year of age using CBCT. The null hypothesis was that no significant difference would be found in the maxillary sinus volume between CLP patients with and without oronasal fistula.

2. MATERIALS AND METHODS

This descriptive, cross-sectional, analytical study was conducted on 50 unilateral CLP patients between 9-12 years who had undergone surgical closure of the cleft at 1 year of age in two groups with and without oronasal fistula (n=50). The patients were selected from among those presenting to a private orthodontic office in Tehran between 2010-2019 and who already had CBCT scans taken for orthodontic treatment. The study was approved by the ethics committee of School of Dentistry (IR.IAU.DENTAL.REC.1399.19).

The sample size was calculated to be 25 for each group according to the results of a pilot study on 10 patients from each group considering α=0.05, β=0.2, mean maxillary sinus volume of 10671 mm³ and 10081 mm³ in the two groups and standard deviation of 715 mm³ using two-sample t-test, assuming equal variances in PASS 15.

The CBCT scans of unilateral CLP patients between 9-12 years who had undergone surgical closure of the cleft at 1 year of age were retrieved from the archives of a private orthodontic office from 2010-2019 by convenience sampling, and assigned to two groups with and without oronasal fistula.

The inclusion criteria were age between 9-12 years, history of surgical closure of the cleft before 1 year of age, and cervical vertebral stage (CVS) 2 or 3 (on sagittal CBCT scans). The CVS of each patient was determined by two examiners after reaching a consensus. The exclusion criteria were history of previous orthodontic treatment, orthognathic surgery, trauma, syndromes, frequent colds (more than 6 times in 1 year), medication intake at the time of CBCT, inflammatory diseases of the upper airways at the time of CBCT, and systemic conditions.

All CBCT images had been obtained in standard upright position with maximum intercuspation. Also, all images had been taken with NewTom 5G CBCT scanner (NEWTOM | CEFLA S.C., Imola, Italy) with a total scanning time of 14-18 s, 3.4 s exposure time, and 0.3 mm³ voxel size. Three-dimensional reconstruction of images was performed according to the Demirtas method [11]. After standardization of images, the maxillary sinus volume was quantified. For this purpose, first the skeletal borders adjacent to the sinus structure were traced.

Figure 1. Quantification of the maxillary sinus volume on axial, sagittal and coronal CBCT sections using the Mimics software.
Next, the sinus area between the bones and the area between the infundibulum and the uncinate process was measured (Figs 1 and 2). Then, a 3D model was prepared to assess the sinus volume. After image reconstruction and standardization of orientation in axial, coronal and sagittal planes, the Mimics software suite-20 (Materialise, 3001 Leuven, Belgium) was used for the measurements. The data were analyzed by SPSS version 22 using t-test. All measurements were repeated on 20 randomly selected CBCT scans after a 2-week interval by another examiner, and the reliability of the measurements was ensured by test-retest reliability. Since R was found to be >0.8, the results were found to be adequately reliable.

3. RESULTS

This study evaluated 50 patients including 25 with and 25 without oronasal fistula. The group with oronasal fistula included 17 females (66%) and 8 males (34%) with a mean age of 10±1 years. Of all, 30 patients (80%) were in CVS II (15 from each group) and 10 (20%) were in CVS III (5 from each group). The control groups were matched with the test group in terms of age, CVS and gender.

Table 1 presents the mean maxillary sinus volume in the two groups of patients. As shown, the maxillary sinus volume at the cleft side of patients with oronasal fistula was significantly lower than that at the cleft side of patients without fistula (P<0.000). The maxillary sinus volume at the non-cleft side of patients with oronasal fistula was also significantly lower than that at the non-cleft side of patients without fistula (P<0.000). The maxillary sinus volume at the cleft side was significantly smaller than that at the non-cleft side in patients with (P<0.000) and without (P<0.000) oronasal fistula.

4. DISCUSSION

This study compared the maxillary sinus volume in 9-12-year-old CLP patients with and without oronasal fistula who had undergone surgical closure of the cleft at 1 year of age using CBCT. The null hypothesis was that no significant difference would be found in the maxillary sinus volume between CLP patients with and without oronasal fistula. The results showed that the maxillary sinus volume was significantly smaller in patients with oronasal fistula compared with those without it. Also, the maxillary sinus volume in the cleft side was significantly smaller than that in the non-cleft side in both groups. Thus, the null hypothesis of the study was rejected. The smaller size of the maxillary sinus at the cleft side can be due to different developmental processes during the embryonic stage, maxillary deficiency, surgical scars, recurrence of fistula, leakage of foods and liquids into the nasal cavity and frequent infections, and different patterns of air circulation in the nose and sinuses. The present results were in agreement with those of Demirtas et al [11]. Our methodology was also similar to that of Demirtas et al, [11] although they did not assess the effect of the presence of oronasal fistula on the maxillary sinus volume; however, they assessed patients with a mean age of 13.5 years while we evaluated patients between 9-12 years. The assessment of patients in this age range was an advantage since evidence shows airway growth and development in two periods of 6-9 and 12-15 years, with an interval between 9-12 years [27]. Also, CBCT images are not often obtained from patients younger than 9 years of age (CBCT is often first requested for grafting prior to canine eruption). Moreover, the soft tissue becomes more stable after 9 years of age. Erdura et al. [8] evaluated the maxillary sinus volume of

<table>
<thead>
<tr>
<th>Maxillary sinus volume</th>
<th>Sinus volume at the cleft side</th>
<th>Sinus volume at the non-cleft side</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oronasal fistula</td>
<td>Mean± std. deviation</td>
<td>Mean± std. deviation</td>
<td></td>
</tr>
<tr>
<td>Present (n=5)</td>
<td>9510.78±492</td>
<td>10282.8±483</td>
<td>p&lt;0.0001</td>
</tr>
<tr>
<td>Absent (n=5)</td>
<td>10278.2±512</td>
<td>10932.9±554</td>
<td>p&lt;0.0001</td>
</tr>
<tr>
<td>FP value</td>
<td>Fp&lt;0.0001</td>
<td>Fp&lt;0.0001</td>
<td></td>
</tr>
</tbody>
</table>
unilateral CLP patients of approximately 13 years of age. They found no significant difference in the maxillary sinus volume between the cleft and non-cleft sides, which was different from the present results, and may be attributed to the different age range of patients. Hikosaka et al. [18] measured the maxillary sinus volume in patients with CLP. They assessed the computed tomography (CT) scans of 109 CLP and 100 non-CLP patients and found no significant difference between the two groups, which was in contrast to our findings. Also, they found no significant difference in the maxillary sinus volume of the cleft and non-cleft sides, which was different from the present results. The difference between the two studies may be due to the use of different imaging modalities (CBCT vs. CT). Also, they did not specify the patients’ age. Agarwal et al. [16] evaluated the differences in maxillary sinuses of the cleft and non-cleft sides. They made the measurements on the maxilla using a combination of reconstructed axial, coronal and lateral CT images. The maxillary sinus volume was calculated on 3D reconstructed images. They found significant reduction of length, width, height, depth and volume of the maxillary sinus at the cleft side, which supported the present results. However, they did not mention the patients’ age range.

The assessment of patients between 9-12 years was a strength of this study since this age range is ideal for assessment of the size of maxillary sinuses [27]. The use of CBCT was another strength of this study since this age range is ideal for accurate data regarding the dimensions of anatomical structures, and has high measurement accuracy. Also, the effect of the presence of the fistula on the maxillary sinus dimensions was evaluated in this study, which has not been addressed before. Not evaluating bilateral CLP patients and small sample size were among the limitations of this study. Future studies with a larger sample size are required on bilateral CLP patients. Another limitation was that, patients evaluated in this study had been operated by different surgeons at 1 year of age, and different techniques had been used for cleft closure, which could have different effects. Due to the small number of patients, they could not be standardized in this respect. Future studies should address this topic and preferably enroll patients operated by the same surgeon and with the same surgical technique for cleft closure. Moreover, the effects of the surgical technique and time of surgery on the recurrence of the fistula are important topics that need to be scrupulously studied in further studies.

5. CONCLUSION

Immature patients with unilateral CLP and oronasal fistula have a smaller maxillary sinus than unilateral CLP patients without an oronasal fistula, and may be at higher risk of respiratory infections. Also, the maxillary sinus at the cleft side is smaller than that at the non-cleft side in unilateral CLP patients.

ACKNOWLEDGMENTS

None.

AUTHOR CONTRIBUTIONS

AJ: Study concept and design; critical revision of the manuscript for important intellectual content; administrative, technical, and material support; study supervision. LH: Acquisition of data. BK: AJ: Analysis and interpretation of data. FA: Drafting of the manuscript. MK: Statistical analysis.

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COMPETING INTERESTS

The authors declare that they have no competing interests.

REFERENCES

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Bita KIAEE
DDS, MSc, Assistant Professor
Department of Orthodontics
Dental School
Tehran University of Medical Sciences
Tehran, Iran

Dr. Kiaee received her DDS (2013) and MSc in Orthodontics (2017) from Tehran University in Tehran, Iran. Since 2017, she has been working as an Assistant Professor at the Department of Orthodontics within the Faculty of Dentistry of Tehran University. Her research areas of interest are mostly clinical projects.
Questions

1. Which item was among the exclusion criteria stated in this article?
   - a. History of surgical closure of the cleft before 1 year of age;
   - b. Orthognathic surgery;
   - c. Cervical vertebral stage (CVS) 2 or 3;
   - d. Age between 9-12 years.

2. Which statement is NOT TRUE based on the findings of this article?
   - a. The maxillary sinus volume at the cleft side of patients with oronasal fistula was significantly lower than that at the cleft side of patients without fistula;
   - b. The maxillary sinus volume at the non-cleft side of patients with oronasal fistula was significantly lower than that at the non-cleft side of patients without fistula;
   - c. The maxillary sinus volume at the cleft side was significantly smaller than that at the non-cleft side in patients with and without oronasal fistula;
   - d. The maxillary sinus volume at the cleft side of patients without oronasal fistula was significantly lower than that at the cleft side of patients with fistula.

3. Which of the following statements is True based on the findings of this article?
   - a. Immature patients with unilateral CLP and oronasal fistula have a smaller maxillary sinus than unilateral CLP patients without an oronasal fistula;
   - b. Immature patients with unilateral CLP and oronasal fistula may be at lower risk of respiratory infections;
   - c. The maxillary sinus at the non-cleft side is smaller than that at the cleft side in unilateral CLP patients;
   - d. Adult patients with bilateral CLP and oronasal fistula have a smaller maxillary sinus than unilateral CLP patients without an oronasal fistula.

4. Which one is the prevalence of cleft lip and palate patients based on the present study?
   - a. 1 per 700 live births;
   - b. 1 per 1000 live births;
   - c. 1 per 500 live births;
   - d. 2.3 per 1000 live births.
ON THE TRACK OF BRUXISM: QUANTITATIVE, QUALITATIVE AND INTRAINDIVIDUAL ANALYSES OF THE BRUXCHECKER® IN DAILY CLINICAL ROUTINE

Gregor Slavicek¹,²,*, David Grimmer³, Anastasia Novitskaya¹,⁴, Florian Slavicek¹,²,b

¹Steinbeis Transfer Institute Biomedical Interdisciplinary Dentistry, Steinbeis University Berlin, DE-12489 Berlin, Germany
²Orehab Minds GmbH, DE-70567 Stuttgart, Germany
³Zahntechnik Baltz GbR, DE-73728 Esslingen am Neckar, Germany
⁴Dental Clinic Smiletime, RU-14106 Podolsk, Podolsky District, Russia

ABSTRACT

Introduction Bruxism is a relevant topic in daily dental routine. Bruxism has to be confirmed by instrumental procedures. The BruxChecker® (BC) is an inexpensive instrument that does not affect the stomatognathic system while used and is suitable for routine use in diagnostics and follow-ups. A novel digital approach for analyzing BC is described, based on first standard values.

Material and Method Within this pilot study, 30 participants (15 males, 15 females) used an upper BC for one night and a lower BC during another night. A standardized digitalization process and a unique software application measured all Tooth Contact Areas (TCAs) on the BC: number and size of each TCAs for each occlusal segment.

Results The mean number of TCAs on upper BC is 28.17 (sd +/-7.84), for lower BC 27.70 (sd +/-7.41). The mean size (mm²) of TCAs on upper BC is 71.81 (sd +/-51.27), for lower BC 68.11 (sd +/-42.64). There are only minor, not significant, gender differences regarding the number and size of TCAs. The transversal right-leftTCAs distribution is almost symmetrical; a slightly increased difference can be observed for the size of TCAs right and left. The sagittal distribution of the TCAs shows the dominance of the posterior contacts, while the intermediate segments are least involved.

Conclusion Within the limits of this pilot study and based on the digital analyses of TCAs on BC, the paper presents first standard values and a two-step systematic individual BC analysis.

KEYWORDS

Bruxism; Occlusal Functions; Oral Rehabilitation; Parafunction; Tooth Contact Areas.

1. INTRODUCTION

BC visualizes the contacts between teeth that occur during unconscious teeth grinding or clenching during awake and sleep bruxism. The BC is fabricated for the individual patient using the pressure molding technique. Comparing the actual bruxing scheme on the BC with a so-called optimal centric and eccentric occlusal situation is one suggested possibility to analyze the BC. However, understanding the optimal occlusion does not make it easier to work with the suggested classification scheme. In any case, the BC analyses must consider the laterotrusive and the mediotrusive side contacts during bruxing [1].

A paradigm shift in the assessment of sleep bruxism (SB) took place in recent years. SB is no longer understood solely as a harmful movement disorder. But the majority of clinicians focus primarily on the possible negative consequences of bruxism: chipping, occlusal trauma, tooth migration, temporomandibular disorder [2]. The issue of the significance of teeth grinding in humans is controversially discussed in medicine. Is it an abnormal function, a movement disorder [3]? Or, in contrast, can SB be assessed as a relevant physiological occlusal function [4]? If one takes this view, then parafunction represents a secondary function beside primary occlusal functions. The increasing acceptance of considering SB as a physiologic function modifies the fundamental methodical approach. Today SB is graduated in possible (based on patient’s self-reports), probable (determined by clinical inspection), and definite (verified by an instrumental analysis) [5].
Dentists are interested in the best possible care for their (bruxing) patients. All diagnostics have impacts on the therapeutic decisions. Expert opinions regarding the best therapeutic concepts of SB differ substantially. Instead of the term "therapy" the phrase “management” is often utilized [6]; however, both terms exclusively refer to the negative consequences of teeth grinding. Based on today’s knowledge, there is no indication to treat a most probably physiological oral function. Management recommendations include, among others, behavioral advice, medication, physiotherapy, or physical intervention [7]. The therapeutic goal of “stop bruxing” can never be achieved [8]. Such therapeutic concepts must be regarded as meaningless [9]. Dentists find themselves constricted between these points of view: is a management strategy necessary? Or are occlusal measures to influence/stop bruxism? Are occlusal therapeutic changes indicated or contraindicated in bruxing patients? It must be understood that awake and sleep bruxism will still be executed after occlusal therapy, but maybe with less muscular strength and minor eccentric mandibular movements. The ability and the necessity to influence bruxism by occlusal parameters is still a matter of controversy. Occlusal factors such as the inclination of occlusal guiding structures in the anterior and posterior occlusal segments seem to play an important role in muscle recruitment during bruxism [10]. In silico simulation demonstrated that both the direction and the size of the bruxing force vectors adapt and change due to the position and the inclination of occlusal guiding structures [10]. Grinding areas and occlusal parameters such as anterior occlusal plane and overbite are closely related [11]. The need of an oral Rehabilitation of bruxing patients is a common situation in daily dentistry. Patients present with impaired chewing surface morphology, the risk of increased mechanical and technical complications in prosthodontic Rehabilitation rises. Prosthetic intervention in a patient with (heavy) bruxism without taking into consideration heavy occlusal loading on materials and constructions will end in a breakdown. "Failure to do so may indicate earlier failure than is the norm." [12]. Successful oral Rehabilitation in patients with severely worn teeth seems to be independent of the materials of choice. Direct or indirect materials may be feasible options to restore severely worn teeth [13]. From a clinician’s point of view, more clinical studies are required, with a clear focus on the clinical impact on oral structures of bruxism. The decision-making process for successful interventions in bruxing patients requires more detailed and focused studies [14]. As soon as patients recognize symptoms, they demand clarification. A link to awake or sleep bruxism is often not reported by the patient in this stage. The clarification of bruxism using instruments is required to confirm the subjective report of the patient [4]. The various uses of instrumental analysis are known in dentistry and are routine in many dental clinics. If, however, the use of instruments in bruxing subjects primarily refers to polysomnography [4], the immediate practical implementation is limited by apparent obstacles. Mobile devices that measure the muscle activity of selected masticatory muscles or record the forces on sensors in occlusal devices are available but elude clinical applicability due to missing cut-off values [15]. Devices measuring tooth contacts in centric and eccentric mandibular positions are available and successfully used in restorative dentistry. But such approaches are suitable only to a minimal extent for verifying awake or sleep bruxism, as the measurement takes place in a completely different setting: awake patients, sitting upright in a dental chair, with an invasive measuring instrument placed intraorally, performing artificial mandibular movements trying to simulate unconscious bruxing. The execution of so-called bruxing movements is very different from those performed in various sleeping postures with changing head positions. The BC is a device for such minimally invasive investigation of unconscious tooth contacts during sleep. A classifying evaluation of the BC enables an initial assessment [16]. But occlusion and occlusal structures are core elements in dentistry, and this can be rated as unique proposition of dental clinics. Occlusal Rehabilitation aims to maintain and re-establish oral function such as chewing and bruxing [17]. The BC visualizes functional TCAs. But the interpretation of the BC remains challenging, and many dentists left the use of BC again after their initial enthusiasm. For this reason, the authors of this article suggest a different, systematic approach for the BC analysis based on numerical data. This pilot study aims to determine quantitative and qualitative data of occlusal contacts areas on BruxCheckers for sleep bruxism.

2. MATERIAL AND METHOD

60 already used BC from 30 subjects served as the data source in this exploratory study. Females and males participated in the study. The exclusion criteria comprise persons younger than 16 years and older than 35 years, participants with two or more missing teeth, removable (partial and total) and/or extensive fixed prosthodontic Rehabilitation. This manuscript did not require ethical approval. Each subject signed an informed consent after being informed about the study in detail. The use of the BC followed the guidelines and recommendations of the manufacturer (Scheu Dental, Islohn, Germany). The data analysis uses the BC used by the participants for one night; clinical intervention did not take place. Each participant used two BC for one night, but not simultaneously. Only sleep bruxism TCAs were analyzed in this pilot study. Before evaluation, white silicon reinforced the contrast of the TCAs against the red color of the BC.
A validated procedure was applied to digitize the BC. Reproducibility tests demonstrated the soundness of the digitizing process a priori - a series of 7 recordings of 16 BCs (8 upper and 8 lower BC) were included for that test. A password-protected zip folder guarded the data. Finally, the data set listed the automatically measured key figures number and area of TCAs for each BC. The calculation of the maximal differences and the standard deviations for the differences followed. The formula $[\text{means } \pm (sd*1.96)]$ sets an upper and lower tolerance limit. Bland-Altman Diagrams visualized the results. If all means of record 1 to record 7 for all BC were within the upper and lower tolerance limits, adequate reproducibility can be derived (Fig. 1a,1b). For anonymization, a 7-digit unique identifier tags each BC. A short anonymous questionnaire collected information on gender, age, and subjective symptoms, possibly related to grinding and clenching. Table 1 presents the personal functional status of the study participants. In an automatic evaluation process, using a calibrated software (Orehab Minds GmbH, Germany), the number and size of each TCAs were determined and assigned to a specific segment of the occlusion (right-anterior, left-anterior, right-intermediate, left-intermediate, right-posterior, left-posterior).

For the statistical analysis, IBM SPSS Statistics 25 was used. The outcome measures are continuous data; the measurement parameter is the number of TCAs. Table 1 presents the personal functional status of the study participants. A validated procedure was applied to digitize the BC. Here, the measurement parameter is the number of TCAs on upper BC. 8 BC were included; digitizing was repeated 7 times per BC (56 records in total). The mean difference (1.5) and the tolerance limits [upper: 1.03 and lower: 0.16] were calculated. The mean differences per BC are indicated (i); all are located between the upper and lower limit. No outliers are detectable; the limits are not exceeded. A slight dependence on the number of TCAs may exist.

Figure 1a. Bland-Altman-Diagram to demonstrate the reproducibility of the analytic process for BC. Here, the measurement parameter is the number of TCAs on upper BC. 8 BC were included; digitizing was repeated 7 times per BC (56 records in total). The mean difference (1.5) and the tolerance limits (upper: 4.46 and lower: -1.46) were calculated. The mean differences per BC are indicated (i); all are located between the upper and lower limit. No outliers are detectable; the limits are not exceeded. A slight dependence on the number of TCAs may exist.

Figure 1b. Bland-Altman-Diagram to demonstrate the reproducibility of the analytic process for BC. Here, the measurement parameter is size of TCAs on upper BC. 8 BC were included; digitizing was repeated 7 times per BC (56 records in total). The mean difference (0.6) and the tolerance limits (upper: 1.03 and lower: 0.16) were calculated. The mean differences per BC are indicated (i); all are located between the upper and lower limit. No outliers are detectable; the limits are not exceeded. A slight dependence on the number of TCAs may exist.

3. RESULTS

The mean age of all participants was 27 years (sd +/- 4.98 years). The female participants had an average age of 26 years with a sd of 5.3 years, the male study participants had an average age of 28 years (sd +/- 4.4 years). All participants had a natural occlusion with only minor restorations. 27 (80%) had full dental arches, not considering wisdom teeth. In comparison, 14 (47%) presented one or more of the following findings: lingual retainer of front teeth (4 (13%) upper and 8 (26%) lower); missing teeth (3 (10%) participant, one missing tooth 14, one missing tooth 37 and one missing tooth 47).

Table 1 presents the subjective functional status of the study participants (personal self-assessment via VAS). The symptom pain for different locations appears with a minimum of 1 and a maximum of 4 on the VAS. The different localizations of the pain showed no noticeable deviations. However, the intensity of the pain, including its impact on activities of daily life (AoDL), individual stress levels, and the reported quality of sleep, are widely spread. Although this pilot study aimed not to identify associations between TCAs and symptoms, the collected data will serve as a basis for further studies to determine whether TCAs’ number, size, or distribution are equally related to patients’ symptoms.

All 60 BC (30 upper and 30 lower) from 30 individuals are analyzed. The mean value of the number of TCAs for the upper occlusion is $n = 28.2$ (sd +/- 7.8) with a minimum number of 11 and a maximum number of 39 TCAs (Fig. 2a). The mean value of the number of TCAs for the lower occlusion is $27.7$ (sd +/- 7.4), with
a minimum number of 13 and a maximum number of 43 (Fig. 2b). The mean size of TCAs is 71.8mm² (sd +/- 51.3mm²) for the upper occlusion and 68.1mm² (sd +/- 42.6mm²) for the lower occlusion. The range of TCAs size for upper occlusion encompasses a span from 13mm² to 224mm² or from 11mm² to 194.5mm² for the inferior occlusion (Fig. 2c, 2d), respectively. Table 2a and 2b summarizes these results. Kolmogorov-Smirnov Tests (KS test) tested the null hypotheses "Within this sample, number and size of TCAs are normal-distributed." For the upper BC, a normal distribution for both number (KS test, p=0.019) and size (KS test, p=0.021) of TCAs cannot be assumed; for the lower BC, a normal distribution cannot be assumed for size (KS test, p=0.047), but for the number of TCAs (KS test, p=0.2).

The comparison between females and males shows only minor, not significant differences for number of TCAs: for the males, an average of 29.13 (sd +/- 8.55) TCAs for the upper occlusion; for the females, 27.2 (sd +/- 7.25); for the lower occlusion, an average of 27.13 (sd +/- 6.01) TCAs for males, for the females 28.26 (sd +/- 8.77), respectively. The following data can be described for the size of TCAs: males, upper occlusion: 87.27mm² (sd +/- 57.88mm²), females, upper occlusion: 56.35mm² (sd +/- 39.79mm²); males, lower occlusion: 80.38mm² (sd +/- 46.11mm²), females, lower occlusion: 55.83mm² (sd +/- 36.29mm²) (Tab. 3). The minimal differences between women and men related to TCAs also appear in the direct comparison (Fig. 3a, 3b) [Mann-Whitney U test for size of TCAs: upper BC p=0.09; lower BC p=0.08; Mann-Whitney U test for number of upper BC: p=0.37; independent samples t-test for number of lower BC: p=0.6].

<table>
<thead>
<tr>
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<th>sd</th>
<th>min</th>
<th>max</th>
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Table 1. Overview: reported symptoms of the participants. These data were not collected to analyze correlations of TCAs (number and/or size) with subjective complaints but to check the sample for consistency and to support future sample size calculations.

TCAs Tooth Contact Areas; sd standard deviation, min minimum; max maximum; AoDL Activities of Daily Living; VAS Visual Analog Scale.
Further attention during the analyses of BC has to be paid to the distribution of TCAs right and left, the transversal (lateral) distribution. The number of TCAs is almost identical on the right and left sides (Fig. 4a). There are minor differences in the distribution of the size of TCAs on the right and left (Fig. 4b). Tab. 4a and 4b present these results. The transversal (lateral) distribution seems to be regardless of the number or the size of TCAs (Fig. 4c, 4d). The evaluation of the sagittal distribution weighs three sections: anterior (corresponds largely to anterior teeth including the canine), intermediate (corresponds largely to the premolar region), and posterior (corresponds largely to the molar region). The sagittal distribution of TCAs in the upper jaw is 8.2 (sd +/- 3.3) anterior, 7.5 (sd +/- 2.5) intermediate, and 12.5 (sd +/- 4.8) posterior. The sagittal distribution of TCAs in the lower jaw is 8.3 (sd +/- 3.1) anterior, 6.6 (sd +/- 2.1) intermediate, and 12.8 (sd +/- 4.6) posterior. The following values describe the mean size of TCAs: for the upper occlusion 28.2mm$^2$ (sd +/- 23.7mm$^2$) anterior, 13.9mm$^2$ (sd +/- 10.8mm$^2$) intermediate, 11.0mm$^2$ (sd +/- 7.9mm$^2$) posterior.

### Table 2a.
Key figures for number and size of TCAs of upper BC, male and female participants.

<table>
<thead>
<tr>
<th>TCAs Tooth Contact Areas; BC BruxChecker; sd standard deviation.</th>
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<td>Upper BruxChecker *</td>
</tr>
<tr>
<td>N</td>
</tr>
<tr>
<td>Mean</td>
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<td>sd</td>
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<td>Minimum</td>
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<td>Maximum</td>
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</table>

### Table 2b.
Key figures for number and size of TCAs of lower BC, male and female participants.

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<td>Lower BruxChecker *</td>
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<td>Mean</td>
</tr>
<tr>
<td>sd</td>
</tr>
<tr>
<td>Minimum</td>
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<td>Maximum</td>
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</table>

### Table 3a.
Key figures for number and size of TCAs of upper and lower BC, female participants.

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<td>Females</td>
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<tr>
<td>Upper BruxChecker *</td>
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<td>Lower BruxChecker®</td>
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</table>

### Table 3b.
Key figures for number and size of TCAs of upper and lower BC, male participants.

<table>
<thead>
<tr>
<th>TCAs Tooth Contact Areas; BC BruxChecker; sd standard deviation.</th>
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</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
</tr>
<tr>
<td>Males</td>
</tr>
<tr>
<td>Upper BruxChecker *</td>
</tr>
<tr>
<td>Lower BruxChecker®</td>
</tr>
</tbody>
</table>

### Figure 3a.
Comparison of number of TCAs for females and males, shown for upper and lower BC. Boxes indicate the IQR [Q3-Q1], the lines (-) indicate the median (Q2). The whiskers are limited by minimum and maximum. Outliers (o) are identified if the distance to Q1 or Q3 is bigger than IQR multiplied by 1.5. In such cases, the whiskers are limited by the value that just does not represent an outlier.

TCAs Tooth Contact Areas, IQR Interquartile Range; Q1 First Quartile, Q2 Second Quartile, Q3 Third Quartile.

### Figure 3b.
Comparison of size of TCAs for females and males, shown for upper and lower BC. Boxes indicate the IQR [Q3-Q1], the lines (-) indicate the median (Q2). The whiskers are limited by minimum and maximum. Outliers (o) are identified as such if the distance to Q1 or Q3 is bigger than IQR multiplied by 1.5. In such cases, the whiskers are limited by the value that just does not represent an outlier.

TCAs Tooth Contact Areas, IQR Interquartile Range; Q1 First Quartile, Q2 Second Quartile, Q3 Third Quartile.

### Figure 4a.
Comparison of the transversal (lateral) distribution of number of TCAs for total vs. right vs. left. Total (□), right (◄), and left (►) TCAs are shown for upper and lower BC (males and females).

TCAs Tooth Contact Areas, BC BruxChecker.
Figure 4b. Comparison of the transversal (lateral) distribution of size of TCAs for total vs. right vs. left. Total (□), right (◄), and left (►) TCAs are shown for upper and lower BC (males and females).
TCAs Tooth Contact Areas; BC BruxChecker.

Figure 4c. Scatter plot for size of right vs. left TCAs for the upper BC (males and females). The R² value of 0.873 shows a tendency towards a symmetrical lateral distribution of the number of TCAs.
TCAs Tooth Contact Areas; BC BruxChecker; R² coefficient of determination.

Figure 4d. Scatter plot for size of right vs. left TCAs for the lower BC (males and females). The R² value of 0.704 shows a tendency towards a symmetrical lateral distribution of the size of TCAs.
TCAs Tooth Contact Areas; BC BruxChecker.

and 29.7mm² (sd +/- 24.9 mm²) posterior; for the lower occlusion: 23.7mm² (sd +/- 17.2mm²) anterior, 12.3mm² (sd +/- 8.8mm²) intermediate and posterior 32.2mm² (sd +/- 24.5mm²) posterior. The results are summarized in Tables 5a and 5b and shown in Figures 5a and 5b. A TCAs may exceed the midline (right-left) or the boundaries between sections (anterior-intermediate or intermediate-posterior). In such situations, TCAs are split up and allocated proportionally to both sides of the adjacent sections. The areas are measured per TCAs and summed up for each segment. Rounding errors can lead to minimal inaccuracies in the automatic summation in the decimal places.

Figure 5a. Comparison of the sagittal distribution of the number of TCAs for anterior vs. intermediate vs. posterior. Anterior (▲), intermediate (●), and posterior (♦) number of TCAs are shown for upper and lower BC (males and females). Posterior sections are dominantly involved, while the intermediate sections have the lowest number of TCAs. Similar distributions are shown for upper and lower BC.
TCAs Tooth Contact Areas; BC BruxChecker.

Figure 5b. Comparison of the sagittal distribution of the size of TCAs for anterior vs. intermediate vs. posterior. Anterior (▲), intermediate (●), and posterior (♦) size of TCAs are shown for upper and lower BC (males and females). The dominance of posterior sections can only be seen for lower BC, while the anterior and posterior sections of the upper BC are almost equally involved. The intermediate sections show the smallest sizes of TCAs.
TCAs Tooth Contact Areas; BC BruxChecker.

Based on this pilot study, the authors recommend a two-step procedure for the systematic BC analysis: Step 1 - Quantitative analysis; Step 2 - Qualitative Analysis. In the future, an option of a third step (intra-individual analysis) for individual occlusal planning exists.

Step 1 - Quantitative analysis
The quantitative analysis of a BC: based on the measured critical numbers for number and size; the extent to which the individual uses occlusion when bruxing during sleep, compared to average values (Fig. 6).

Step 2 - Qualitative analysis
Understand the distribution of TCAs on the BC is a crucial element in occlusal functional analysis. The following assumptions facilitate the qualitative analysis of a BC: involvement of all occlusal sections; symmetric transversal distribution; the sagittal distribution shows the dominance of the posterior occlusal segments, both for the number and the size of TCAs, followed by the anterior segments. The intermediate section shows the least participation (Fig. 7).

Typically, the dental focus is on "large" and "eye-catching" grinding spots. However, such a focus inhibits a deeper understanding of the involved
A systematic approach to understand BruxChecker®

occlusion. It is essential to pay attention to those occlusal sections not used in bruxing. In addition, it might be helpful to superimpose the visible TCAs on the BC and the functional structures of the occlusal morphology (Fig. 8).

This quantitative approach to BC enables the clinician not only to focus on adverse effects [1,6,8,12,13] but instead on therapeutic aspects – which occlusal parameters to be changed [10,11,17]. It seems possible to change the muscle recruitment during bruxing activity by modifying occlusal structures [10,11], based on an increased alertness of dentists for TCA’s and their distribution by BC visualization and numerical analyses. In addition, it appears reasonable to alter bruxing patterns by the design of occlusal parameters such as canine guidance concerning the temporomandibular joint movement pattern [17].

The BC constitutes a clinically suitable instrument for long-time observation and a functional recall after Rehabilitation. It is up to the supervising team whether other diagnostic methods should be used [1,2,4,11].

Missing teeth may influence the quantitative analysis of a BC. The number of the OCA’s on the upper BC of participant with missing teeth are close to the sample mean (missing first premolar: 36 TCAs; missing first lower molar: 29 TCAs; missing second lower molar: 30 TCAs). The size of the OCA’s on the upper BC of these participant are close to the sample mean (missing first premolar: 96.7 mm² TCAs; missing first lower molar: 69.2 mm² TCAs; missing second lower molar: 80.82 mm² TCAs). The number of the OCA’s on the lower BC of these participant are close to the sample mean (missing first premolar: 36 TCAs; missing first lower molar: 22 TCAs; missing second lower molar: 15 TCAs). The size of the OCA’s on the upper BC of these participant are still high and close to the sample mean (missing first premolar: 92.4 mm² TCAs; missing first lower molar: 63.2 mm² TCAs; missing second lower molar: 38.9 mm² TCAs). Missing teeth have to be considered in the BC analyses. The effect of absent teeth on the key figures of BC analysis has to be evaluated in future studies.

4. DISCUSSION

From the authors’ point of view, the quantitative approach is an advantage to understand the BC, and thus for tooth grinding pattern of the individual patient. The claim for instrumental confirmation by the SB is fulfilled [4]. The key figures support the possibility to compare the individual situation with standard values and expectations for optimized occlusion [3,16,17,19]. The distribution of TCAs for the upper and lower occlusion is symmetric for the transversal (lateral) distribution and well-adjusted in the sagittal distribution. The following concepts may explain the quantitative differences between upper and lower BC: a) different nights: bruxing activity varies from night to night; b) The lower dental arch is smaller than the upper dental arch. c) Grinding of teeth has different effects on the upper and lower teeth, especially on anterior teeth: while the lower front teeth will contact with a relatively small area during the entire bruxing movement, the upper front teeth will be “used” widely – from centric occlusion contact points up to the incisal edge. In the premolar and molar regions, these differences are less significant.

5. CONCLUSION

- The average size of TCAs in this study population shows a high variance (72 mm² +/-51 mm²).
- The average number of TCAs in this study population is 28 with a sd of +/-8.
- There is only a not significant gender-specific difference.
- The lateral distribution of TCAs is symmetrical for both number and size.
- The sagittal distribution shows a dominance of the posterior occlusion.
- Based on the quantitative analysis, the clinician has the option to assess occlusion with the number and size of TCAs and thus perform a functional-occlusal analysis: all sections of occlusal seems to be involved in bruxing.
- In the future, dentists’ attention can be focused more on the number of TCAs in combination with the size of TCAs: few but large TCAs should be seen differently compared to many but small TCAs.
• Occlusal segments without any TCAs have to be seen as critical as those with huge TCAs
• Based on the knowledge of the distribution of number and size of TCAs, a qualitative analysis of the BC serves as a valuable element in the functional assessment of the individual occlusion.

AUTHOR CONTRIBUTIONS
GS: contributed to the concept, protocol, data gathering and analysis, their interpretation and critically revising the manuscript.
DG: contributed to the concept, protocol, data gathering and analysis and critically revising the manuscript.
AN: contributed to the gathering and analysis, their interpretation and critically revising the manuscript.
FS: contributed to the data analysis, their interpretation and critically revising the manuscript.

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CONFLICT OF INTEREST
Gregor Slavicek and Florian Slavicek are CEO's of Orehab Minds GmbH, DE-70567 Stuttgart, Germany.

REFERENCES

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Gregor SLAVICEK
MD, DDS, MSc
CEO, Head & Director
Steinbeis Transfer Institute Biomedical Interdisciplinary Dentistry
Steinbeis University Berlin
DE-12489 Berlin, Germany

Dr. Slavicek is an MD, specialized in Dentistry. He is currently Director of the Steinbeis Transfer Institute Biomedical Interdisciplinary Dentistry, Steinbeis University Berlin. Since 2019, he has been CEO of Orehab Minds GmbH in Stuttgart, Germany. He graduated from the University Vienna (medicine and dentistry), also specializing in Clinical Research at the same university (Master of Science). He attended additional postgraduate orthodontic training at University Aarhus (Denmark), Prof. B. Melsen, and postgraduate gnathological training at University of Florida (USA), Prof. H. Lundeen and Prof. C. Gibbs. He is an honorary member of the Italian Gnathological Society. He was awarded an honorary professorship by the Ukrainian Dental Society. He was visiting professor at the first medical state University in Moscow Sechenov (2014-2018).
**Questions**

1. **How can bruxism be graduated according to the actual international consensus?**
   - a. Possible, confirmed, severe;
   - b. Possible, probable, definite;
   - c. Confirmed and not definite;
   - d. Possible, harmless, sometimes.

2. **Which number of tooth contact areas to expect on an upper BruxCheckers® (males and females)?**
   - a. Number: 8 +/- 2;
   - b. Number: 71 +/- 51;
   - c. Number: 28 +/- 8;
   - d. Number: 101 +/- 51.

3. **Which size of tooth contact areas to expect on an upper BruxCheckers® (males and females)?**
   - a. Size: 71 mm² +/- 51 mm²
   - b. Size: 7,1 mm² +/- 5,1 mm²
   - c. Size: 17 mm² +/- 15 mm²
   - d. Size: 171 mm² +/- 151 mm².

4. **Which answer is correct?**
   - a. The lateral distribution of tooth contact areas on BruxCheckers® is almost symmetrical;
   - b. The posterior segments are dominant in the sagittal distribution of tooth contact areas on BruxCheckers®;
   - c. There are only minor differences between females and males regarding tooth contact areas;
   - d. Answers 1-3 are correct.

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THE USE OF ER:YAG LASER FOR DENTAL CARIES REMOVAL

Geise dos Santos Marcelino¹, José Humberto Ribeiro Lopes², Juliana Jendiroba Faraoni², Pâmella Coelho Dias², José Humberto Ribeiro Lopes¹, Juliana Jendiroba Faraoni², Pâmella Coelho Dias²

¹School of Dentistry, Faculdade Morgana Potrich (FAMP), Mineiros, Goiás, Brazil
²Restorative Dentistry Department, School of Dentistry, University of São Paulo (USP), Ribeirão Preto, São Paulo, Brazil

ABSTRACT

Background: Carious tissue removal in enamel and dentin requires the use of sharp and resistant instruments. New tools have appeared to optimize/facilitate dental treatment, among them the laser. Regarding laser application for dental caries removal, the use of erbium laser doped with yttrium, aluminum, and garnet (Er:YAG) stands out. The Er:YAG laser is excellent for hard tissues ablation since its wavelength of 2.940nm is highly absorbed by water and hydroxyapatite.

Objective: To review the application of the Er:YAG laser in dental caries removal, to present its advantages and limitations in clinical practice, as well as to describe its action mechanism, and to compare its effectiveness with different methods used to remove caries.

Data sources: The search for articles to compose this literature review was carried out in the PubMed and Embase databases.

Study selection: Articles in English published between 2006 and 2021. The manual search included additional articles and books; a total of 39 references were selected.

Data extraction: Information from studies that evaluated the use of the Er:YAG laser to remove caries or related this type of laser to other methods. Articles that evaluated characteristics of the dental structure, or the influence of restorative materials after caries removal with the Er:YAG laser, were also considered.

Study selection: Based on studies results, the Er:YAG laser presents itself as an alternative for caries removal since it can remove demineralized tissue (selective ablation) without causing damage to the dental element.

KEYWORDS

Cariology; Dental Caries; Dental Caries Removal; Dentin; Lasers.

1. INTRODUCTION

Contemporary dentistry is based on early diagnosis, adequacy of the oral environment, and prevention of oral diseases. In recent years, new tools have emerged to optimize/facilitate dental treatment, including laser. Studies carried out over the years have proven the effectiveness of laser therapy for hard and soft tissues manipulation [1-3]. The word LASER comes from the English acronym Light Amplification by Stimulated Emission of Radiation. Its mechanism of action is based on the emission of a collimated light beam of high energy intensity and can be stimulated by solid, liquid, or gaseous active medium. Lasers have different wavelengths, and this implies the variable phenomena that they can present: absorption, penetration, transmission, and diffusion. In dentistry, the most desirable phenomenon is absorption, as it will interact with living tissue, effectively exercising its different functions [4].

Lasers can be classified, according to their application, in low and high-power lasers [4]. Low-power lasers can aid analgesia, reduce inflammation and stimulate tissue repair [3,5], while high-powered ones are used in surgery, ablation of decayed tissue, and orthodontics [2,4,5]. There are also lasers used for photodynamic therapy and tissue fluorescence diagnosis [4].

Regarding the application of laser for dental caries removal, the use of erbium-doped yttrium, aluminum, and garnet laser (Er:YAG laser) stands out. This laser operates in a pulsed mode, and the handpiece includes a spray of water to prevent tissue dryness and heat build-up, allowing energy to be absorbed efficiently [6]. Several types of research have evaluated the use of lasers in dentistry, highlighting the erbium laser in hard tissues [1,2,7,8]. This study aimed to perform a literature review about the application of the Er:YAG laser in dental caries removal and to present its advantages and limitations in clinical practice.
2. METHODOLOGY

The article search for this literature review utilized the PubMed and Embase databases, and the selection included articles published between 2006 and 2021. The terms used were “Er:YAG laser” AND “dental caries removal”. The inclusion criteria included articles in English published between 2006 and 2021 that evaluated the use of the Er:YAG laser to remove caries or related this type of laser to other methods. Articles that evaluated characteristics of the dental structure, or the influence of restorative materials after removal of caries with Er:YAG laser, were also considered. The search excluded: literature reviews, monographs, case reports, studies with bovine teeth, and studies with artificial or induced demineralization. The manual search included ten studies: three books, four original articles, and three reviews as they contained viable information to structure this literature review. Figure 1 shows the flowchart detailing the selection of articles. In total, this review included 39 references.

3. LITERATURE REVIEW

Dental caries is described in the literature as a multifactorial disease influenced by genetic, environmental, and behavioral characteristics, being a complex disease resulting from the accumulation of specific acidogenic bacterial colonies present in the dental biofilm, capable of adhering to the tooth. These, in turn, produce acids from their metabolism using fermentable carbohydrates responsible for decreasing the pH on the dental surface, promoting the reduction of hydroxyapatite crystals and the widening of the intercrystalline spaces, leading to an increase in porosity and, consequently, the emergence of the disease [9].

Clinically, the active initial caries lesion appears on enamel as a white spot with a rough and opaque appearance. With the progression of demineralization, this lesion forms a cavity that can progress to reach the dentin, which then starts to show generally a yellow color, moist aspect, and softened consistency [9].

The removal of decayed enamel and dentin tissue requires the use of strong and sharp instruments to allow the proper preparation of the cavity. There are several instruments used for cavity preparation, such as hand instruments (chisels, dentin scoop) and rotary instruments (carbide burs with different types of active tip, diamond tips) [10]. Previous studies have shown that chemical-mechanical methods like Carisol® and Papacarie® are also effective in removing caries [11,12].

The laser is another alternative that has been used in the dental field as an effective method for removing decayed tissue, being considered a conservative method since such removal is selective. Besides, laser treatment promotes greater comfort during the surgical procedure and without causing pulpal damage [13-15]. The type of laser most used for this purpose is the yttrium-aluminum-garnet erbium laser (Er:YAG).

The Er:YAG laser is excellent for the ablation of hard tissues, as it has a wavelength of 2.940nm, which is highly absorbed in water and hydroxyapatite. The erbium laser creates microexplosions in the hydroxyapatite by vaporizing the water molecules present in the hard tissues, which leads to the breakdown of this tissue during the ablation process. This laser operates in a pulsed mode, and the handpiece includes a spray of water to prevent tissue dryness and heat accumulation, allowing the energy to be absorbed efficiently. Thus, its action occurs without tissue carbonization and with minimal generation of heat [6]. Its use was approved for these purposes by the Food and Drug Administration (FDA) in May 1997 [14].

Research that used scanning electron microscopy (SEM) and thermographic study to evaluate the pulp temperature during the use of Er:YAG laser in deciduous and permanent teeth showed that in the same pulse of energy, ablation in dentin was more effective than in enamel and that ablation and caries removal values were significantly higher in primary teeth when comparing to permanent teeth, but without exceeding the temperature of 5.5°C [7].

Eberhard et al. (2008) analyzed extracted decayed permanent molars in which they were sectioned and treated with fluorescence-feedback controlled (FFC) Er:YAG laser or diamond tips. The use of the FCC Er:YAG laser at a threshold of 7U (units) resulted in less dentin loss when compared to the use of diamond tips [16].

A randomized clinical trial compared the efficacy of the fluorescence-controlled Er:YAG laser and the low-speed bur in removing decayed tissue in adults. The results showed that the use of the FCC laser at a threshold of 7 and 8U promotes the same effectiveness of the bur, presenting insignificant numbers of remaining bacteria [17]. One research evaluated different techniques for caries removal and found no selectivity for demineralized tissue using the Er:YAG laser. In this study, the laser showed significant variability in the results, where several samples remained with amounts of remaining caries and others had tooth structure removed in excess [18].

A study evaluating the rate of ablation and selectivity of healthy and demineralized enamel and dentin promoted by a 30W (watts) diode-pumped Er:YAG laser operating on a pulse of 20-30µs (microseconds)
showed that this laser has considerable potential for selective removal of dental caries [19].

Analysis of the removal of demineralized dentin using the FFC Er:YAG laser showed that dentin ablation occurred effectively at fluorescence control values between 6U and 7U when measured by microCT (computed microtomography). While at a value greater than 8U, the removal of decayed dentin was unsatisfactory [20].

Kornblit et al. (2008) investigated the effectiveness of the Er:YAG laser in removing caries in deciduous and permanent molars and observed that ablation in areas infected by caries promoted maximum maintenance of the remaining structure. According to these authors, the laser provided decontamination of the affected area and improved retention of the composite resin to the surface prepared with laser, promoting better marginal enamel sealing [21].

Yonemoto et al. (2006) evaluated the DIAGNODent® as a guide for caries removal using the Er:YAG laser. Values set at 11-20 were able to remove caries preserving the affected dentin in vitro [21].

An in vivo study used 120 primary teeth from children aged 5 to 9 years, divided into four groups: air rotor, Carisolv®, Papacarie®, and Er:YAG laser. The results were visually and tactile observed, besides having the values of the DIAGNODent® pen and the FLACC scale (Face, Legs, Activity, Cry, Consolability) to measure pain during the procedure. Air rotor and laser were the most effective and efficient methods, and laser and chemical-mechanical methods were considered more comfortable [13].

Another in vivo study evaluated the FFC Er:YAG laser for caries removal in pediatric patients. S. mutans and Lactobacilli were found in 33.33% of the lesions. In a total of 79 lesions, 14 contained S. mutans and 15 contained Lactobacilli. The average log of colony-forming units (CFU) per sample was 0 for S. mutans and Lactobacilli. The average time to perform the procedure was 2.3±1.2min. Regarding pain, 93.8% of children considered laser usage comfortable [15].

One research biochemically analyzed decayed and healthy teeth treated by the fluorescence-controlled Er:YAG laser, where a layer of dentin was removed from the bottom of the preparation to determine the presence of hydroxylsylpyridinoline (HP) and lysylpyridinoline (LP) collagen cross-links using high-performance liquid chromatography. 100% HP and LP were found in decayed dentin and 0.33% HP and 0.68% LP in healthy dentin. After caries removal, 0.84% HP and 1.26% LP were found at the 5U fluorescence-control threshold and 1.56% HP and 2.48% LP at 10U. The Er:YAG laser proved to be a viable method for removing the irreversibly denatured collagen present in decayed dentin [1].

Scanning electron microscopy was used to investigate the morphological changes in the hard dental tissues after caries removal and cavity preparation using different methods: Er:YAG laser, Carisolv® gel, high-speed diamond burs, and low-speed micromotor steel burs. The dental surface after using the laser remained highly retentive, without smear layer residues and with the presence of exposed dentinal tubules. The samples treated with Carisolv® gel presented a rough retentive surface and some dentinal tubules obliterated by denatured collagen and surface contaminants; surfaces prepared with low and high-speed burs showed a thick smear layer and no micro retentions [22].

An in vitro study evaluated marginal microleakage of cavities restored with glass ionomer, comparing Er:YAG laser with Apacarie gel and atraumatic restorative technique (ART), and found a higher level of infiltration with the use of the laser to remove caries compared to the other methods [23].

Studies show that different techniques for removing decayed tissue influence the bond strength of adhesive systems [24-27]. The study of Yıldız et al. (2013) concluded that the chemical-mechanical method or use of burs at low rotation compared to the Er:YAG laser show better results in terms of bond strength for both self-etch and total-etch adhesives [27]. In another study, using a 2-step self-etch adhesive system, the dentin surface prepared by the Er:YAG laser showed lower micro-tensile bond strength (μTBS) values compared to healthy dentin [24]. In the study of Sattabanasuk et al. (2006), the bond strength values of a total-etch adhesive system were similar for the Er:YAG laser and steel bur [25].

Sirin Karaarslan et al. (2012) evaluated the micro-tensile bond strength of 3 types of adhesive systems - Clearfil® SE Bond (2-step self-etch), G-Bond® (single-step self-etch), and Adper® Single Bond 2 (2-step total-etch) after caries removal using a spherical steel bur at low-speed, Carisolv® gel or the Er:YAG laser. Based on the results, the techniques used to remove decayed tissue showed significant differences in bond strength between the adhesive systems. There was no significant difference in the bond strength of total-etch adhesive systems comparing laser and bur groups. Using the laser, Adper® Single Bond 2 was superior to the other adhesive systems, indicating that total-etch adhesives are the best option in this type of caries removal method [26].

The microhardness and chemical composition of dentin vary according to the applied caries removal method. The chemical-mechanical technique (Carisolv®) showed lower microhardness of the remaining dentin and a considerable number of samples with residual caries (20%) when compared to the carbide bur and the Er:YAG laser (both 5%). There was no significant difference in calcium and phosphorus rates of the three evaluated groups [28].

A comparative clinical study between the bur and the Er:YAG laser to remove caries from primary molars showed that the laser was less efficient than the bur to remove caries. Regarding effectiveness, the two treatments were similar to remove caries in the pulp wall, and the bur was better in the surrounding walls. The composite resin restorations for both groups remained satisfactory after one year of treatment [8].

A double-blind clinical study, performed in children aged 7-10 years, evaluated composite resin restorations in primary teeth performed after selective removal of necrotic dentin using an Er:YAG laser and a carbide bur. Adhesive restorations did not suffer laser interference, and the SEM analysis showed that laser group restorations showed a 10% gap in its extension, and the group treated with a bur showed...
a 20% gap in the cavosurface margin after 12 months of follow-up [29].

A longitudinal clinical study with four years of follow-up evaluated the clinical longevity of composite resin restorations after selective caries removal in permanent molars using the Er:YAG laser or bur preparation with chlorhexidine as dentin biomodifier. The Er:YAG laser group biomodified with chlorhexidine presented a statistically significant difference for marginal adaptation criteria compared to the other groups; for secondary caries criteria and clinical and radiographic evaluation of pulp vitality, there was no statistically significant difference between the evaluated groups. The authors concluded that the method of caries removal and dentin biomodification did not influence the survival rate of composite resin restorations [30].

Prabhakar et al. (2018) evaluated morphological changes and the presence of bacterial deposits in primary decayed molars submitted to carious tissue removal by Carie-Care (chemical-mechanical method), Er:YAG laser, and tungsten carbide spherical bur. The results showed that the laser group was the most effective of the three, with fewer bacterial deposits and no smear layer formation [31]. A meta-analysis evaluated the Er:YAG laser to remove caries and for cavity preparation in children compared to the traditional mechanical method. This study evaluated seven randomized clinical trials and found that the laser requires more operative time but is less painful. There were no statistically significant differences between the two types of treatment concerning retention, marginal adaptation, and marginal discoloration of restorations [32].

A recent systematic review showed that the use of burs, chemomechanical method, and the Er:YAG laser are efficient for caries removal, reduction of bacteria in the tooth cavity, and do not compromise the clinical performance of restorations [33].

An in vitro study compared the FFC Er:YAG laser with the Er:YAG laser in three different pulses (super short, medium short, and short pulse) regarding the efficiency of removing cariogenic bacteria and carious dentin and dentin temperature during ablation. The results showed that no experimental group had bacterial contamination after treatment. In the groups with varied pulses of laser energy, the dentin temperature was significantly higher than the FFC laser [34].

A study that evaluated and compared the Er:YAG laser, the tungsten bur, and the polymer bur in caries removal showed no difference between the treatment time comparing the three methods. Histological analysis showed that all groups effectively removed the infected dentin and the laser group showed a regular 5µm thick layer of denatured collagen. The group treated by the tungsten bur presented a smear layer, and the polymer bur group showed an affected dentin surface layer [35].

Matsumoto et al. (2007) clinically evaluated the applicability of the Er:YAG laser on 95 decayed teeth from 45 patients. No adverse reactions and no or little pain were reported in most treated teeth (89.5%). Tooth preparation was successfully performed exclusively by laser in 94.7% of the cases, and the operative time was on average 49 seconds [36].

4. DISCUSSION

The Er:YAG laser to remove caries has been widely studied in recent years, showing that it is a safe and comfortable method for the patient, minimizing the use of local anesthesia and maintaining pulp vitality [2,7,13,17]. Studies comparing different methods of caries removal found that the Er:YAG laser, together with the chemical-mechanical method, provided greater comfort and satisfaction for both the operator and the patient as they were less traumatic [13]. According to a systematic review, chemomechanical methods are the best option for a minimally invasive treatment [33]. In an in vitro study, the hand excavator was the most effective technique to remove caries in deciduous teeth [37].

Comparing caries removal effectiveness (capacity) between laser and carbide bur at low rotation, the results of the two methods were similar for removing caries from the pulpal wall; the bur was more effective on the surrounding walls of primary molars [8]. Both techniques showed similar results regarding the presence of residual caries [28].

The adjusted value in lasers with fluorescence-feedback control influenced selectivity for carious tissue in the studies evaluated in this literature review. Schwass et al. (2013) showed that the Er:YAG laser with fluorescence control selected between 7U and 8U was effective for removing demineralized dentin [20], as well as studies by Dommsch et al. (2008) [17] and Eberhard et al. (2008) [16], where the Er:YAG laser with fluorescence control at levels of 7U and 8U promoted caries removal similar to that obtained with the conventional bur, generating greater comfort and wellness to the patient. The use of a laser with fluorescence control set to 9U and 10U did not remove all decayed tissue [17]. Contrasting these results, Neves et al. (2011) did not find selectivity when analyzing samples prepared with the FFC Er:YAG laser at the threshold of 7U, where some specimens were overprepared, and others continued with decayed tissue. In this study, the laser was the evaluated method that presented the least minimally invasive potential [18].

Regarding the morphological changes generated on the treated dental surface, the laser did not promote thermal damage and also left the surface highly retentive and without the presence of a smear layer; while the use of burs in both high and low rotation promoted surfaces with a thick smear layer and absence of microretentions; the use of polymer burs left an affected dentin layer [22,35].

Despite the advantages of using laser as a method of removing decayed tissue, clinical studies have
shown variation in clinical time, with laser consuming about 3x more time than the use of burs [17] with an average treatment duration of 2.3±1.2min [15]. Other studies have also shown a longer average treatment time with the use of laser, but with a minor difference: 110s [8] or 49s [36] for the Er:YAG laser and 55s [8] for the low-speed carbide bur. Another disadvantage found in one of the selected studies was the presence of marginal infiltration in decayed teeth ablated by laser and restored with glass ionomer [23].

The bond strength of adhesive systems influenced the method used to remove caries [26]. According to the results, the authors suggest choosing a conventional adhesive system after caries removal by the Er:YAG laser and a self-etch adhesive system after using a chemical-mechanical method. These results corroborate the study by Neves et al. (2011) that found lower micro-tensile bond strength using a 2-step self-etch adhesive after caries removal by the Er:YAG laser compared to the chemical-mechanical method and the use of conventional burs [24]. In another study, the use of a chemical-mechanical technique or usage of burs at low-speed compared to Er:YAG laser showed better results in terms of bond strength for both self-etch and total-etch adhesive systems [27]. Other studies showed that the Er:YAG does not influence the bond strength value of a total-etch adhesive system [25, 38]; however, the study of Sattabanasuk et al. (2006) showed higher bond strength values for Er:YAG laser compared to steel bur evaluating a self-etch adhesive system (Cleargil Protect Bond) [25].

A 12-month follow-up of a randomized clinical trial with a split-mouth design showed that teeth with decayed tissue removed by both laser and bur and restored with a 2-step total-etch adhesive system and composite resin maintained satisfactory restorative treatment [8]. In a double-blind clinical study, the restorations of the laser group showed a lower percentage of a gap than the group treated by bur in the analysis performed by SEM at the same follow-up time [29].

In a biochemical analysis of dentin collagen on decayed surfaces treated with erbium laser through SEM, the percentage of dehydrated collagen and decayed dentin reduced after laser treatment, becoming similar to healthy dentin [1]. In the study of Krause et al. (2008), 42.9% of the samples had bacterial residues, but in only 7.1%, the bacterial count was greater than 100 CFU (colony forming units) [15].

The pulp response to the application of external heat was evaluated in an in vivo study using rhesus monkeys [39]. The results showed that a temperature increase of 2.2°C does not cause pulp changes and that increase of 5.5°C allowed pulp repair for most specimens (75%). In several studies, the use of the Er:YAG laser has proven not to generate thermal damage to the dental structure, not exceeding the temperature increase above the threshold tolerated by the dental pulp [2,7,19,34].

Table 1 summarizes the 29 studies selected by Pubmed and Embase.

<table>
<thead>
<tr>
<th>Author (Year)</th>
<th>Substrate</th>
<th>Type of study</th>
<th>Evaluated parameters</th>
<th>Er:YAG laser specifications</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al-Batayneh et al. (2014) [7]</td>
<td>Sound and carious enamel and dentin from 40 primary and 40 permanent extracted teeth</td>
<td>In vitro comparative study</td>
<td>Laser ablation in sound enamel and dentin</td>
<td>- Wavelength: 2.94µm</td>
<td>Laser creates greater crater depths in dentin than enamel for both types of teeth</td>
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<td></td>
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<td>- Comparison between the Er:YAG laser and the rotary bur for carious removal</td>
<td>- Pulse energy: 200µJ</td>
<td>- Laser is more efficient than the rotary bur to remove caries in primary teeth</td>
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<td>- Surfaces changes through SEM</td>
<td>- Pulse duration: 250µs</td>
<td>- There was no significant difference between both methods regarding permanent teeth</td>
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<td>- Frequency: 10Hz</td>
<td>- Dental ablation did not exceed 5.5°C</td>
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<td></td>
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<td>- Power output: 6W</td>
<td>- SEM: dentin ablation with no smear layer</td>
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<tr>
<td>Baraba et al. (2018) [34]</td>
<td>60 teeth with dentin caries and 12 teeth without caries lesion.</td>
<td>In vitro comparative study</td>
<td>Caries removal efficiency of the FFC Er:YAG laser and different pulses of the Er:YAG laser</td>
<td>FCC laser:</td>
<td>-Ablated specimens were bacteria-free</td>
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<td>-PCR analysis -Thermal alterations</td>
<td>-Pulse energy: 350µJ (enamel) and 250µJ (dentin)</td>
<td>-All laser evaluated were efficient for caries removal</td>
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<td>-Pulse duration: 400µs</td>
<td>-FCC laser group presented the lowest average temperature</td>
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<td>-Frequency: 4Hz</td>
<td>-Threshold: 7U</td>
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<td>Laser with different pulses:</td>
<td>-Pulsed: 50µs, 100µs, and 300µs</td>
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<td>120 carious primary teeth from children aged 5 to 9</td>
<td>Carious primary teeth</td>
<td>10 permanent molars with proximal caries</td>
<td>80 deciduous molars with dentin caries</td>
<td>102 teeth with active caries from 26 adult patients</td>
<td>165 permanent molars with dentin caries</td>
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<tr>
<td>In vivo comparative study</td>
<td>Systematic review</td>
<td>In vitro comparative study</td>
<td>In vitro comparative study</td>
<td>Randomized clinical trial</td>
<td>In vitro comparative study</td>
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<tr>
<td>-Wavelength: 2.94µm -Pulse energy: 200mJ -Frequency: 20Hz -Power output: 4W -Contact mode</td>
<td>-Wavelength: 2.94µm -Power output: 3.5W -Pulse duration: 300µs (short pulse mode) -Frequency: 10Hz -1mm distance -Energy density: 44J/cm²</td>
<td>-Wavelength: 2.94µm -Pulse energy: 200mJ -Frequency: 4Hz -Non-contact mode -Working distance: 12mm</td>
<td>-Wavelength: 2.94µm -Pulse energy: 250mJ -Frequency: 4Hz -Non-contact mode -Working distance: 10-20mm -Threshold: 7, 8, 9, and 10U</td>
<td>-FCC laser at the threshold of 7 and 8U and carbide burs showed similar results regarding S. mutans and Lactobacill CFU -FCC laser was more comfortable but significantly more time consuming compared to carbide burs</td>
<td>-Cavity extension after caries removal from 2 methods: bur and FCC laser in contact and non-contact mode</td>
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<td>-Air rotor and laser were faster and more efficient -Carisolv®, Papacarie®, and laser were less painful</td>
<td>-All methods are efficient in reducing CFU count and in removing caries -Chemomechanical methods showed to be the best option for minimally invasive treatments -Conventional methods promote faster treatment, and Er:YAG is faster than Carisolv® and Papacarie® -Chemomechanical and laser require less anesthesia and are also less painful -Restorations were not affected by any of the caries removal methods</td>
<td>-The Er:YAG laser did not impair the bond strength of a total-etch adhesive system</td>
<td>-Carbide bur was the fastest and the Er:YAG laser the slowest technique -Polymer bur and laser left large amounts of underprepared areas -Carbide bur was the least conservative method -Hand excavator was the most effective technique to remove caries in deciduous teeth</td>
<td>-FCC laser at the threshold of 7 and 8U and carbide burs showed similar results regarding S. mutans and Lactobacill CFU -FCC laser was more comfortable but significantly more time consuming compared to carbide burs</td>
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### Review Articles

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<tr>
<th>Study</th>
<th>Description</th>
<th>Parameters</th>
<th>Results</th>
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</thead>
<tbody>
<tr>
<td>Juntavee et al. (2013) [23]</td>
<td>Primary second molars with occlusal caries</td>
<td>In vitro comparative study</td>
<td>- Influence of Apacaries gel, Er:YAG laser, and spoon excavator as caries removal methods in the marginal microleakage of glass ionomer restorations</td>
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<tr>
<td></td>
<td></td>
<td>- Pulse energy: 260mJ</td>
<td>- the Er:YAG laser promoted significant higher microleakage than Apacaries and spoon excavator in ionomer restorations</td>
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<tr>
<td>Katirci et al. (2016) [28]</td>
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<td>- Efficacy of the FCC Er:YAG laser for caries removal - Pain, discomfort, ample efficacy - the Er:YAG laser had a similar outcome regarding caries removal</td>
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<td></td>
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<td>- Pulse energy: 250mJ</td>
<td>- Carbide bur and Er:YAG laser showed: low rate of no pain or sensitivity 7 and 28 days after the treatment</td>
</tr>
<tr>
<td>Kornblit et al. (2008) [2]</td>
<td>30 carious teeth from children aged 4 to 12s</td>
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<td>- Possible postoperative complications after caries removal with the Er:YAG laser</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Wavelength: 2.94µm</td>
<td>- Children treated with Er:YAG laser did not show any pain or sensitivity 7 and 28 days after the treatment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Wavelength: 2.94µm</td>
<td>- Treatment duration was 2.3±1.2 min - 93.8% of the children considered the laser treatment comfortable</td>
</tr>
<tr>
<td>Li et al. (2019) [32]</td>
<td>Carious teeth from children</td>
<td>Meta-analysis</td>
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<td>- Caries removal with laser is more time consuming than the use of bur - the Er:YAG laser is less painful than the bur - There were no statistical differences in complete restoration retention, marginal discoloration, and marginal adaptation between Er:YAG laser and bur</td>
</tr>
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<td>Matsumoto et al. (2007) [36]</td>
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<td>Clinical trial</td>
<td>- Pain, discomfort, assessment during cavity preparation, prognosis factor, and overall clinical evaluation</td>
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<tr>
<td></td>
<td></td>
<td>- Wavelength: 2.94µm</td>
<td>- Laser showed: low rate of pain during treatment, no discomfort, ample efficacy, substantial efficiency, good prognosis after three months of follow-up, and mean of treatment duration of 49s</td>
</tr>
<tr>
<td>Medioni et al. (2016) [35]</td>
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<td>In vitro comparative study</td>
<td>- Effectiveness of the Er:YAG laser, carbide bur, and polymer bur for caries removal</td>
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<td></td>
<td></td>
<td>- Wavelength: 2.94µm</td>
<td>- Procedure time was similar for all the three methods - Histological analysis showed smear layer in the specimens treated with carbide bur, denatured collagen in the laser group, and a layer of affected dentin in the polymer bur group - All methods removed the infected dentin</td>
</tr>
<tr>
<td>Neves et al. (2011) [24]</td>
<td>Carious molars</td>
<td>In vitro comparative study</td>
<td>- Influence of the 7 methods for caries removal in the bonding capacity of the remaining dentin</td>
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<td></td>
<td></td>
<td>- Pulse energy: 250mJ</td>
<td>- Remaining denting from the FCC Er:YAG laser group showed lower μTBS values - Carisolv® showed the best results regarding μTBS, followed by carbide bur + caries detector</td>
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<td>Review Articles</td>
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<tr>
<td>Neves et al. (2011) [18]</td>
<td>Carious molars</td>
<td>In vitro comparative study</td>
<td>- Caries removal effectiveness and minimally invasive potential of 9 methods for caries removal by microCT</td>
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<td></td>
<td></td>
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<td>- Pulse energy: 250mJ</td>
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<td></td>
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<td>- Pulse repetition rate: 4 pulses/s</td>
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<td>- Non-contact mode</td>
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<td>- Threshold: 7U</td>
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<td></td>
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<td></td>
<td>- Chemomechanical methods</td>
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<td></td>
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<td>+ metal excavators showed the best results</td>
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<td>- the FCC Er:YAG laser showed the most variable results: specimens with over and others with under preparation</td>
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<td>- the FCC Er:YAG laser did not prove to be a selective method for caries removal</td>
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<tr>
<td>Polizeli et al. (2019) [29]</td>
<td>48 primary molars with occlusal and proximal caries from children aged 7 to 10</td>
<td>Double-blind, randomized clinical trial</td>
<td>- Salivary cortisol levels and clinical performance of restorations after caries removal by the Er:YAG laser compared to carbide bur</td>
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<td></td>
<td></td>
<td></td>
<td>- Medium short pulse mode</td>
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<td>- Pulse energy: 250mJ</td>
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<td></td>
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<td>- Frequency: 4Hz</td>
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<td>- non-contact mode</td>
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<td></td>
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<td>- Working distance: 7cm</td>
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<td>- Salivary cortisol levels were similar for laser and bur</td>
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<td></td>
<td>- There was no difference regarding marginal adaptation, retention, discoloration, and secondary caries for restorations from both groups after one year of follow-up</td>
</tr>
<tr>
<td>Prabhakar et al. (2018) [31]</td>
<td>Carious primary molars</td>
<td>In vitro comparative study</td>
<td>- Morphological changes/Bacterial deposits</td>
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<td></td>
<td></td>
<td></td>
<td>- Wavelength: 2.94µm</td>
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<td>- Pulse energy: 200mJ</td>
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<td></td>
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<td></td>
<td>- Energy density: 22.5 J/cm² for 10 pulse/s</td>
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<td>- Non-contact mode</td>
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<td>- the Er:YAG laser showed a minor quantity of bacterial deposits compared to Carie-Carie and carbide bur; Carie-Carie presented greatly bacterial deposits</td>
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<tr>
<td></td>
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<td></td>
<td>- Morphological changes: Carbide bur – thin smear layer and few open tubules; Er:YAG laser: irregular rugged surface, no smear layer, opened tubules; Carie-Carie – rough surface, smear layer, obliterated tubules</td>
</tr>
<tr>
<td>Sattabanasuk et al. (2006) [25]</td>
<td>Carious third molars</td>
<td>In vitro comparative study</td>
<td>- Influence of 3 methods for caries removal and two types of adhesive systems in the bonding capacity of the remaining dentin</td>
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<td></td>
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<td>- Pulse energy: 180mJ</td>
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<td>- Frequency: 2Hz</td>
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<td>- Non-contact mode</td>
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<tr>
<td></td>
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<td></td>
<td>- The total-etch adhesive system (OptiBond Solo Plus) showed similar results in all groups (steel bur, laser, and SiC paper)</td>
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<td>- The self-etch adhesive system (Clearfil Protect Bond) showed lower bond strength in dentin treated with steel bur</td>
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<td>- Only the laser group showed similar bond strength for the two tested adhesive systems</td>
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<td>- Pulse energy: 600mJ (enamel) and 250mJ (dentin)</td>
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<td>- Frequency: 10Hz (enamel) and 4Hz (dentin)</td>
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<td>- Pulse duration: 400µs</td>
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<td>- Threshold: 4, 5, 6, 7, 8, 9, 10, 12, 16, and 20U</td>
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<td>- Non-contact mode</td>
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<td>- Feedback control values higher than 8U did not remove infected caries efficiently</td>
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<td></td>
<td>- Threshold for conservative caries removal lies between 7 and 8U</td>
</tr>
<tr>
<td>Sirin Karaarslan et al. (2012) [26]</td>
<td>Carious molars</td>
<td>In vitro comparative study</td>
<td>- Influence of 3 methods for caries removal and three adhesive systems in the bonding capacity of the remaining dentin</td>
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<td></td>
<td></td>
<td></td>
<td>- Wavelength: 2.94µm</td>
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<td></td>
<td>- Power output: 3.5W</td>
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<td></td>
<td>- Pulse duration: 300µs (short pulse mode)</td>
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<td>- Frequency: 10Hz</td>
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<td></td>
<td>- 1mm distance</td>
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<td></td>
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<td>- Energy density: 44 J/cm²</td>
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<td></td>
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<td></td>
<td>- The total-etch adhesive system: similar bond strength values for steel bur and laser and lower for Carisolv®</td>
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<td>- One-step and two-step self-etch adhesive systems: similar bond strength values for all three methods</td>
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<td>- the bur group: all adhesive systems had the same behavior</td>
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<td>- the laser group: total-etch adhesive showed the higher µTBS values</td>
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<td>- Carisolv®: two-step self-etch adhesive showed the best results</td>
</tr>
</tbody>
</table>
5. CONCLUSION

The Er:YAG laser is a viable alternative for the treatment of caries since it can remove demineralized tissue without causing damage to the dental element, in addition to providing greater comfort for the patient due to the absence of noise, vibrations, and pressures during removal of decayed tissue and less need for anesthetic administration in most cases.

Despite the advantages, its use requires more clinical time compared to the use of burs. Furthermore, the cost of the equipment, despite not having been addressed in the review, can also be considered a limiting factor. In general, the Er:YAG laser is as effective as the conventional and chemical-mechanical methods for selective caries removal.

ACKNOWLEDGMENTS

None.

REFERENCES


Review Articles


CV

Geise dos Santos Marcelino graduated from FAMP, Mineiros, Goiás, Brazil, and is a student of the Specialization course in Orthodontics at the Graduate Center in Dentistry – CIOG, Goiânia, Goiás. Her academic interests include Hospital Dentistry and Pediatric Dentistry. She works as a general dentist in a private practice in Senador Canedo, Goiás and at the PSF in Taquaral de Goiás, Goiás, Brazil.

Questions

1. Which caries removal method is the least conservative?
   - a. Mechanical removal with dentin scoop;
   - b. Diamond tips and air rotor;
   - c. Er:YAG laser;
   - d. Use of a chemical-mechanical method.

2. Which is the Er:YAG laser wavelength?
   - a. 2.940nm;
   - b. 2.840nm;
   - c. 2.490nm;
   - d. 2.480nm.

3. Which sentence is correct?
   - a. Er:YAG is a selective method for caries removal;
   - b. Chemical-mechanical methods cause more pain for the patients;
   - c. Er:YAG can affect pulp vitality;
   - d. Carbide burs cannot be used in children.

4. In dentistry, which one is the most desirable phenomenon of the laser?
   - a. Diffusion;
   - b. Transmission;
   - c. Absorption;
   - d. Penetration.
CONTRIBUTION OF PIEZOCISION IN ORAL SURGERY: THE EXAMPLE OF THE ACCELERATION OF ORTHODONTIC MOVEMENTS

Thonnart François¹*, Systermans Simon²b, Gilon Yves²c

¹Department of Plastic and Maxillofacial Surgery, CHU Liège, Belgium
²Department of Maxillofacial Surgery, ZOL Genk, Belgium

ABSTRACT

Introduction Patients are more demanding of short or less invasive interventions. Piezocision responds well to this demand, particularly in the case of piezo-guided corticotomy to accelerate orthodontic movements. Different surgical approaches are described to shorten orthodontic procedures. Corticotomy is a surgical process where osteotomies are realized at the level of the cortical part of the bone.

Objective The aim of this work is to review the contribution of piezocision in oral surgery, using as example a review over the current results of piezocision on the acceleration of orthodontic movements.

Data sources The articles referenced and used in this article come from the PubMed database. The searched keywords were “piezocision” alone or in combination with “orthodontics”.

Study selection This search resulted in 44 available articles. Subsequently, 6 randomized controlled trials were selected based on relevance, journal, and publication date. Four Randomized Controlled Trials and two Controlled Clinical Trials were studied.

Data extraction The reviewer assessed each article for their relevance and methodology. The 6 studies compared the time savings between conventional orthodontic treatment (control group) and orthodontic treatment combined with piezocision surgery (test group).

Data synthesis Piezocision corticotomy reduces the operation and the postoperative period and increases the acceptance of corticotomies and their indications.

KEYWORDS

Piezocision; Orthodontics; Corticotomy; Oral Surgery; Minimally Invasive.

1. INTRODUCTION

Originally, piezosurgery was developed to allow cutting hard structures without affecting soft structures, with an ultrasound instrumentation. Bone cutting is performed by high frequency micromovements generated by the piezoelectric handpiece, the piezotome. The back and forth motion transmitted to a cutting insert creates a cutting effect. Over the past decades, numerous scientific articles have illustrated the numerous indications of piezocision in oral surgery, implant surgery, cranio-maxillofacial surgery and other surgical disciplines. The main advantages and characteristics of piezocision are the selective cutting of the bone without damaging adjacent soft tissues such as vessels, nerves, mucous membranes, but also to reach difficult access areas via angled inserts compared to conventional instrumentation, and to cut without generating significant exothermic reaction. The use of angled inserts improves the visibility of the operating field. Therefore, piezoelectric surgery is a safe, precise and atraumatic technique.

In our oral and maxillofacial surgery practice, the piezotome is currently taking an important place. It is particularly used in our department in pre-implant surgery for maxillary ridge expansion, opening the bone windows during the sinus lift, during rami, symphyseal, tuberosal or cranial parietal harvesting and during the lateralization surgery of the inferior alveolar nerve. The piezotome is also used in maxillofacial surgery for mandibullectomy and costochondral harvesting (temporomandibular ankylosis treatment, rhinoplasties), and for free fibula flaps. It is also used for condylectomies and complicated mandibular sagittal osteotomies with malposition of the inferior alveolar nerve. In oral surgery, the piezotome is used in our practice for retrograde
3. RESULTS

Four Randomized Controlled Trials and two Controlled Clinical Trials were studied. The 6 studies compared the time savings between conventional orthodontic treatment (control group) and orthodontic treatment combined with piezocision surgery (test group).

3.1. Characteristics of the studies

The general information from the studies is summarized in Table 1. Of the 6 articles, 4 are RCT [3-4-6-8] and 2 are CCT [5-7]. All studies included 131 patients. Each study presented a group treated with electric piezocision and another "control" group with conventional orthodontic movement. One study [5] compared the efficacy of conventional corticotomy to piezocision. The studies by Uribe, Gibreal, and Charavet focus on tooth alignment, while the studies by Abbas and Aksakalli investigate canine distalization in premolar extraction.

3.2. Orthodontic movements

The study by Charavet et al [6] showed a decrease of 43% in orthodontic time in the piezocision group compared to the control group, compared to 59% in the study [4]. The differences between the two groups in study [6] increased in time until full alignment but decreased for final adjustments. Study [3] showed no significant difference between the two groups. The duration of canine distalization in study [7] is reduced in the piezocision group. In addition, the study by Abbas et al [5] found a higher rate of movement in the corticotomy group compared with the piezocision group during weeks 2,4,10,12 after surgery. The 2019 study by Charavet et al [8] shows a 36% acceleration of treatment for the piezocision group compared with the control group.

Table 3. Studies descriptions.
3.3. Surgical approach

The surgical protocol is based on a flapless piezocision procedure. This technique consists in making vertical interproximal microincisions 4mm above each papilla. The length of the incisions varies according to the studies from 5 to 8mm [6-8] and 4mm [3]. After the incisions, the gingiva is elevated to visualize the bone and adjacent roots. A corticotomy line is then made with a piezoelectric instrument. The line also varies according to the studies, from 5mm long and 3mm deep for Charavet et al. [6-8] and 1mm deep for Uribe et al [3]. The incisions are sutured with absorbable suture.

3.4. Periodontal parameters

All periodontal parameters were comparable between the piezocision and test groups at the end of the treatment in the studies [5-6-7-8]. For 3 patients (2 in the control group and 1 in the test group) in the study [6], a non-significant increase in recession was observed between the interval at the beginning of the treatment and the end of the treatment.

The studies by Charavet et al [6-8] investigated the visibility of vertical scars in the piezocision groups. Study [6] observed persistent scarring in 50% of patients with piezocision. In 33% of cases, the scar was as a punt and in 17% of cases, in the form of a line. The 2019 study shows a visible scar in 66% of the patients treated with piezocision.

3.5. Root resorptions

Abbas et al [5] showed that there were no differences in root resorptions between the corticotomy group and the piezocision group. However, the contralateral control group shows greater root resorptions of the canine than the experimental groups (piezocision and corticotomy).

Studies [6-8] do not show an increase in root resorptions in each group.

3.6. Patient-centered outcomes

Study [6] did not show any significant differences between the two groups consumption of paracetamol. The level of satisfaction was significantly higher in the piezocision group compared to the control group.

4. DISCUSSION

The analysis of the results shows an acceleration of orthodontic treatment in 5 of the 6 clinical trials analyzed, ranging from 36 to 63% (Table 2). According to Uribe et al. [3], the results of his study do not show a significant difference in the time required to correct a mandibular anterior crowding between the two groups. The lack of significant time savings in orthodontic treatment in the Uribe et al. [3] study is probably related to the surgical technique. Indeed, the corticotomy is only 1mm deep and 3mm high, compared to the 3mm and 5mm found in the studies of Charavet [6-8] and Gibreal [4].

In addition, the studies by Charavet et al. and Gibreal et al. perform 5 vertical incisions up to the canine-premolar interdental space while Uribe et al. perform 3 vertical incisions, stopping between the canine and lateral incisor. The difference between the two RCTs by Charavet et al. may be explained by the use of different Brackets system, CAD/CAM for the 2019 study.

The study by Gibreal et al. shows a greater time gain than the 2 studies by Charavet et al. The improvement in time gain for orthodontic tooth movements observed is probably related to the severity of the anterior crowding. In the Gibreal et al. study, severe anterior crowding required prior extraction, which probably increased the RAP effect.

Based on the results of the studies above and the literature cited above, the effectiveness of bone decortication in accelerating tooth movement is progressive and effective for 3 months after surgery, with greater effectiveness in the maxilla. This effectiveness of piezocision is observed when the first arch is placed 1 to 2 weeks before surgery and when the corticotomy is at least 3mm deep and 5 to 8mm long. In addition, the patient should be recalled every 2 weeks to activate the fixed appliance if possible because of the limited effect of the RAP [4].

A review of the literature by Mertens et al. [9] shows interesting results of corticotomies depending on the indications. All of them seem to go in the direction of an acceleration of dental movements. However, few studies have been performed with a control group treated with fixed orthodontics, without surgery. Therefore, the number of reviews supporting that the use of corticotomies reduces orthodontic treatment time is limited.

According to Charavet et al. [6-8], there is a visible scar (either punctiform or linear) in 50 to 66% of the subjects who have undergone piezocision. Therefore, upper jaw piezocision is not recommended for patients with a gummy smile.

Furthermore, an interradicular proximity of less than 2mm is a contraindication to corticotomy.6. Means such as CBCT, surgical guides [10] or retroalveolar radiographs with opaque interradicular wires can be used to avoid root effraction. These tools can also be
used to prevent damage to anatomical structures such as the maxillary sinus or the mental foramen. All periodontal parameters appeared to be stable in the different studies. However, 3 patients with pre-existing oral recessions showed an increase in recessions [8]. Therefore, mucogingival techniques combined or not with piezocision may be interesting to prevent gingival recession. A bone grafting technique associated with piezocision was performed in a study by Charavat and Lecloux [11]. This technique has allowed a thickening of the vestibular bone in a class II patient and thus prevented the aggravation of bone dehiscence and the appearance of gingival recession. According to the study by Angelo Troedban [12], the use of surgical ultrasound devices in reduction rhinoplasty has shown a decrease in postsurgical morbidity and significantly increases overall patient satisfaction. Piezotome rhinoplasty could reduce the need for secondary corrective rhinoplasties, and piezotomes could be the surgical instrument of choice in facial hard tissue cosmetic surgery as they already are in oral surgery. Relating to preimplant sinus surgery, numerous studies [13-14] have shown a lower rate of Schneider’s sinus membrane perforation using piezoelectric instruments compared with conventional rotary instrumentation. In orthognathic surgery, most surgical trauma occurs especially during osteotomy. Therefore, any surgical tool such as the piezotome that can provide a safe and precise cut is an excellent option. It has several disadvantages: reduced ability to cut dense bone, increased time to perform an osteotomy [15] and additional cost [16]. The neurosensory effect of the piezotome is the main factor studied by several authors [16], especially on the inferior alveolar nerve during sagittal osteotomy of the lower jaw. Most studies report little or no nerve damage using piezocision surgery. Only one comparative study finds less nerve disruption after inferior sagittal osteotomy using conventional rotary handpiece instrumentation [16].

5. CONCLUSION

Piezocision corticotomy seems to be an attractive technique to reduce the time of orthodontic treatments. Compared to corticotomy, it reduces the operation and the postoperative period and increases the acceptance of corticotomies and their indications. However, given the presence of vertical scars in more than 50% of cases, it remains contraindicated in patients with a gummy smile. These examples confirm the interest of piezosurgery in oral and maxillofacial surgery, at a time when the demand for less invasive treatments is growing. The indications for the piezotome are becoming more and more extensive, which makes it an instrument of choice, indispensable in our practice.

ACKNOWLEDGMENTS

There are no conflicts of interest and no financial interests to be disclosed.

AUTHOR CONTRIBUTIONS

FT, SS: wrote the manuscript in consultation with YG. All authors provided critical feedback and helped shape the research and the manuscript. YG: aided in interpreting the results.

REFERENCES


Questions

**1. The effectiveness of piezocision is observed when:**
- a. The first arch is placed 3 weeks after the surgery;
- b. The corticotomy is 3-4 mm long;
- c. The corticotomy is minimum 3 mm deep;
- d. The corticotomy is 1-2 mm deep.

**2. In Charavet’s study, there is a visible scar after piezocision in:**
- a. 50 to 66%;
- b. 35 to 45%;
- c. 0 to 10%;
- d. 95 to 100%.

**3. The use of surgical ultrasound devices has shown:**
- a. A higher rate of Schneider’s sinus membrane perforation;
- b. No increase in patient satisfaction for rhinoplasty;
- c. A decrease in postsurgical morbidity;
- d. It can increase the need for secondary corrective rhinoplasties.

**4. Piezotome:**
- a. Is not able to cut dense bone;
- b. Reduces the risk of nerve damage;
- c. Decreases the time to perform an osteotomy;
- d. Increases the time of orthodontic treatments.
SELECTING AN APPROPRIATE OCCLUSAL SCHEME WHEN FABRICATING IMPLANT-SUPPORTED FIXED DENTAL PROSTHESES: A SYSTEMATIC REVIEW

Mariam Margvelashvili-Malament, Kenneth Albert Malament, Steven E. Eckert

1Department of Prosthodontics, School of Dental Medicine, Tufts University, Boston, MA, USA
2College of Medicine, Mayo Clinic, Rochester, MN, USA

ABSTRACT

Background Dental implants are ankylosed in the bone without a periodontal ligament resulting in a lack of micro-mobility during chewing. Consequently, occlusion with dental implants may be at greater risk, specifically when the teeth come into contact in lateral excursive movements.

Objective A systematic review of the literature was performed to identify occlusal concepts that were most favorable for implant-retained fixed restorations.

Data Sources A search of the literature was conducted using PubMed and EndNote literature online software databases. Keywords were used to assist in the identification of the literature.

Study Selection The literature search identified 49 articles using PubMed and 33 articles using the author-created EndNote database.

Data Extraction Two occlusal concepts were identified, namely mutually protected occlusion and group function unilateral occlusion. None of the articles demonstrated clear scientific evidence to identify superiority of one concept over the other.

Data Synthesis Based upon the systematic review of the literature, no scientific evidence was identified favoring any specific occlusal concept.

KEYWORDS

Occlusion; Dental Implants; Implant Supported Fixed Restoration; Mutually Protected; Group Function.

1. INTRODUCTION

The primary purpose of teeth is to prepare food for ingestion. Processing food demands the actions of trituration, manipulation, and deglutition. When teeth are lost, the function is compromised [1]. The replacement of missing teeth is accomplished using dental prostheses. These prostheses may be used to replace all the teeth with complete dental prostheses, or some of the teeth with partial dental prostheses. Replacement teeth may gain support using remaining natural teeth, dental implants, residual alveolar ridges, or a combination of these structures. Studies clearly indicate that removable prostheses are not as effective in restoring function, esthetics, and patient self-esteem. In fact, multiple nutritional deficiencies, associated comorbidities, and loss of self-confidence have been reported with removable prostheses [2-4]. Implants may provide single tooth replacement, or they could support the entire dentition with fixed dental prostheses. Although natural teeth and dental implants may provide similar support for dental prostheses, there are substantial differences between the two. The implant is an alloplastic device that replaces the natural tooth root and supports the prosthesis. Although implants may provide aesthetic and comfortable tooth replacement, there are characteristics associated with the use of dental implants that must be considered [5]. Perhaps the most obvious is the lack of a periodontal ligament around implants and thus a lack of micro-mobility during chewing. Consequently, occlusion with dental implants may be at greater risk, especially when teeth contact in lateral excursions [6]. The aim of this review was to identify the most harmonious relationship of prosthetic teeth when supported by dental implants and describe occlusal theories using a systematic review.
2. MATERIALS AND METHODS

The research question for this review was formulated following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines using the Population, Intervention, Comparison and Outcome (PICO) tool.

**POPULATION:** The patient group receiving fixed dental prostheses supported by implants.

**INTERVENTION:** The patient group receiving a specific form of treatment. Unilateral group function lateral occlusion with multiple posterior teeth guiding lateral movements.

**COMPARISON:** The patient group receiving an alternative form of treatment. Mutual protection placing lateral contacts on anterior teeth thereby separating the posterior teeth during mandibular movements.

**OUTCOME:** The results obtained from the two compared treatments. In partially and/or completely edentulous patients restored with implant-supported fixed dental prostheses either a mutually protected occlusion, whereby the anterior teeth separate the posterior teeth in laterotrusion, or a group function occlusion, where the anterior and posterior teeth contact simultaneously on the working side result in fewer complications? The dental literature was to be evaluated to determine the relative superiority of one occlusal scheme over the other to answer the PICO question.

An electronic search was conducted utilizing the following database and Software: PubMed and EndNote using the search strategy "(dental implants OR implants) AND Occlusion AND implant restoration AND "dental implants"[Mesh]" and "Dental Occlusion and Dental Implant and Fixed Prosthesis or Occlusion or Group Function and Mutually Protected" respectively. No language or journal type restrictions were applied to the search. A supplemental hand search was also conducted. Search strategy and outcomes for each source are provided in Table 1.

To meet the eligibility requirements, the selected studies had to meet the following inclusion criteria:

1. Human studies.
2. Randomized controlled clinical trials (RCT), clinical trials, systematic reviews.
3. If multiple publications on the same cohort to be found, only the publication with the longest follow-up time was included.

The exclusion criteria included the following:

1. Not meeting inclusion criteria.
2. Duplicate publications.
3. Full-text not available in English.
4. Full-text unavailable.
5. No information available about occlusal concepts applied.

### Table 1. Search strategy.

<table>
<thead>
<tr>
<th>Database/Software</th>
<th>Search terms</th>
<th>Filters used</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>PubMed</td>
<td>&quot;(dental implants OR implants) AND Occlusion AND implant restoration AND &quot;dental implants&quot;[Mesh]&quot;</td>
<td>Humans, Randomized Controlled Trial, Clinical Trial, Systematic Review</td>
<td>49</td>
</tr>
<tr>
<td>EndNote</td>
<td>&quot;Dental Occlusion and Dental Implant and Fixed Prosthesis or Occlusion or Group Function and Mutually Protected&quot;</td>
<td></td>
<td>33</td>
</tr>
<tr>
<td>Hand search</td>
<td>N/A</td>
<td>N/A</td>
<td>3</td>
</tr>
</tbody>
</table>

2.1. Screening Process

A total of 49 (PubMed) and 33 (EndNote) articles were selected by two of the authors (M.M.M. and S.E) as being of potential interest to the reader on the topic of dental occlusion. These articles were assessed by reviewing the titles and then by reading the abstracts. Any disagreement regarding the quality of the article was managed through discussion and eventually by the inclusion of the third author (K.A.M) if necessary.

The authors, after compilation and assessment of the articles, extracted the available data from the articles and compiled the gathered data. The articles were evaluated relative to the use of natural tooth support or dental implant support of the final prostheses.

3. RESULTS

Using the literature search described, no studies were identified to answer the PICO question. There were subjective descriptions of different techniques that were used in the management of clinical patients relative to the posterior fixed occlusal scheme. The PubMed search was linked with 49 articles. After screening the titles, 39 were assessed as irrelevant, 7 as potentially relevant, 2 as hypothetical designs and 1 as relevant. The EndNote search was linked with 33 articles, 23 were reviewed as irrelevant, 7 potentially relevant, 3 represented hypothetical designs (Fig. 1).
Dental occlusion described as mutually protected occlusion was identified as the most common method of management of lateral articulation of the teeth. Group function was identified in three articles, although no scientific studies were performed. Due to an inability to identify a study, or studies, that answer the PICO question or provided conceptual homogeneity, no Meta-Analysis or risk of bias assessment could be conducted. The following opinion-based and clinical articles were identified and are summarized in Table 2.

Wismeijer et al. [7] described implant reconstruction in the edentulous mandibular arch opposing an edentulous maxilla as being treated using bilateral balanced occlusion. Mutually protected occlusion or group function was suggested when the maxilla was den- tate. In an article that was primarily describing the use of short implants in the posterior areas, Misch et al. [8] suggested that cantilevers should be eliminated, and the patient should be restored with a mutually protected or canine guided occlusal concept.

In 2016, Sheridan et al. [9] performed a systematic review that failed to identify evidence in favor of any specific occlusal management. Once again, these authors suggested mutually protected occlusion with anterior guidance with wide freedom in centric and avoidance of cantilevers. Considering the descriptors, specifically with “wide freedom in centric,” the readers may have interpreted the terms as fulfilling the description of group function. Esquivel-Upshaw et al. [10] studied the effect of direction and magnitude of occlusal loading on implant supported FDPs. The authors provided group function to the treated patients and identified these lateral excursive contacts as not being associated with a higher fracture occurrence. Conversely, the strong centric contacts resulted in higher porcelain fracture rate. None of the treated patients received mutually protected occlusion. The authors suggested that due to the absence of a periodontal ligament, implant supported fixed dental prostheses should have lighter maximum intercuspation contacts.

4. DISCUSSION

This systematic review of the literature failed to identify randomized controlled clinical trials or cohort studies that would promote one specific occlusal design concept over another. Even from the standpoint of descriptive studies there is no clear recommendation. The lack of a periodontal ligament limits the micromotion and proprioceptive capability of implant-supported fixed restorations making them potentially more susceptible to technical complications. Therefore, it is of paramount importance to provide optimal occlusion to hopefully generate higher survival rates for implant-supported fixed restorations. However, the question remains as to what is the optimal occlusal scheme. Although this systematic review failed to identify studies that would answer the question directly, suggestions derived from the included articles as well as the factors that may be considered confounding variables are further discussed.

Two occlusal concepts that are currently applied to fixed restorations on implants are: group function occlusion and mutually protected occlusion.

Both occlusal approaches share the concept of simultaneous, bilateral contact of posterior teeth when the jaws are in maximum intercuspation. The concepts differ in the way that occlusion of the anterior teeth is described with group function exhibiting very light contact of the anterior teeth while mutual protection entails anterior teeth contact in all excursive movements thereby separating the posterior teeth. Mutually protected occlusion is considered by many to be the ideal occlusal scheme for the natural dentition. D’Amico described the size and innervation of the canine tooth as a way to explain the rationale for embracing the mutual protection concept [11-13]. Conversely, group function exhibits unilateral, simultaneous anterior and posterior tooth contact as the jaws move laterally from maximum intercuspation. Primary support for the concept of group function is seen when the dentition exhibits abrasive wear after years of function [14-18]. Although without clear scientific or clinical evidence, three of the selected four studies recommended mutually protected occlusion for implant-supported fixed restorations.

Most of the authors highlight the complexity of biomechanics with implant-supported fixed dental prostheses. Misch et al. suggested decreasing stress through a biomechanical approach, namely: splinting implants and avoiding cantilevers, applying

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Journal</th>
<th>Study Design</th>
<th>Sample Size (number of FDPs)</th>
<th>Occlusal Concept Used</th>
<th>Observation Time</th>
<th>Prostheses’ Survival Rate (%)</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wismeijer, D. et al 1995</td>
<td>Journal of Prosthetic Dentistry</td>
<td>Review</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Recommends mutually protected occlusion</td>
</tr>
<tr>
<td>Misch, C. E. et al 2006</td>
<td>Journal of Periodontology</td>
<td>Retrospective Case Series</td>
<td>338</td>
<td>Mutually protected</td>
<td>Up to 6 years</td>
<td>98.9%</td>
<td>Recommends methods to decrease biomechanical stress (including mutually protected occlusion)</td>
</tr>
<tr>
<td>Sheridan, R. A. et al 2016</td>
<td>Implant Dentistry</td>
<td>Review</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Recommends mutually protected occlusion</td>
</tr>
<tr>
<td>Esquivel-Upshaw, E.H. et al 2014</td>
<td>Journal of Dentistry</td>
<td>RCT</td>
<td>89</td>
<td>Group Function</td>
<td>3 years</td>
<td>85%</td>
<td>Recommends light centric contacts</td>
</tr>
</tbody>
</table>

Table 2. Included studies.
a mutually protected occlusal concept, and selecting an implant design to increase bone-to-implant contact area. Unfortunately, this study lacked a control group utilizing an alternative occlusal concept. Mutually protected occlusion resulted in high survival rates, yet the study does not answer the PICO question of current systematic review. It shows successful application of this occlusal concept but fails to demonstrate its superiority [8]. Esquivel-Upshaw, et al. showed no risk of higher fracture of implant-supported fixed dental prosthesis in excursive contacts (group function). This was true for both metal-ceramic and ceramic-ceramic restorations. However, similarly to Misch there was no control group of the alternative occlusal concept group. Regardless, the authors recommend hypoocclusion in maximum intercuspation on implant-supported fixed restorations [10].

Another concept that should be mentioned is bilateral balanced occlusion. Unlike mutually protected occlusion and group function, bilateral balance provides bilateral contacts in eccentric movements. While this occlusal concept is popular in complete denture prosthetics, it should also be considered when a fixed restoration opposes a removable complete denture. When a prosthodontist considers the alternative occlusal concepts for treating edentulous patients with fixed prostheses, the decision is often made based upon clinical experience and personal and laboratory preferences. However, another important aspect that should be considered is the type of restorative material being used. Normally the material choices are acrylic resin, cast metal, metal-ceramic, and milled or pressed ceramic materials. Over time, the use of acrylic resin has diminished because of unfavorable wear characteristics. Although acrylic resin prostheses usually have a supporting metal substructure, the wear characteristics of acrylic or composite materials as an occlusal material demonstrate moderate to severe wear in a relatively short period of time. The prostheses can be removed and the surface veneering material replaced, but this will require a number of appointments that will incur some cost. In addition, the customization of the occlusal surface of the prosthesis may create an occlusal awareness for the patient that could be unfavorable.

Full cast metal restorations could certainly be considered. The advantage of cast metal is that most cast materials exhibit a hardness and a wear pattern similar to that seen with natural dentition. The disadvantage of cast metal is the appearance and the relatively high cost associated with such prostheses. In today's esthetically conscious society, full cast metal restorations are unlikely to prove acceptable. Metal ceramic restorations have been one of the most popular choices for restorative material for more than 50 years. Metal ceramic is relatively stable over time although it is somewhat prone to chipping and fracture of the veneering ceramic material. The restoration, because of the fabrication process, is built up incrementally. The ability to duplicate a prosthesis sometime after it was made originally will provide a cosmetic benefit for the patient but in terms of full functional replacement, the incremental stacking of porcelain will never be so accurate that it could be used without adjustment. In addition to the abrasive nature of metal ceramic restorations there is also a tendency for the material to lose surface detail over time. The cost of metal ceramic is dependent upon the type of metal alloy that is used. This is a material that was quite popular through the first decades of implant dentistry but it appears to have lost much of the previous popularity of this material. The use of milled, or pressed, all ceramic materials has demonstrated a number of advantages. Since the design of such a prosthesis (milled) can be saved digitally, any future damage in the form of breakage, could be easily restored as long as the fixed dental prosthesis is retrievable. Perhaps a more important advantage is that monolithic all ceramic materials exhibit very little, if any, discernible wear over time. With the advent of lithium disilicate and zirconia materials the aesthetic replacement of posterior teeth should be easy to achieve and reliable and predictable into the future. Assuming that the choice of material will be that of a milled all ceramic material, it is important to remember the unique characteristics of the dental implant that must be duplicated or compensated for in the final prosthesis. Perhaps the most critical factor as it relates to implants is the relative immobility of the individual implants. Unlike natural teeth that exhibit physiologic mobility, implants are, for all intents and purposes, rigid within bone. This rigid device must have a carefully controlled occlusal relationship with the opposing teeth. The patient can advise the clinician of the presence of high occlusal contacts but it is very hard to communicate to the patient the more important factor related to lateral motions and how those must be compensated in the prosthetic design.

5. CONCLUSIONS

Within the limitations of this systematic review the authors agreed on the following conclusions:

- There is lack of information as to which occlusal scheme, mutually protected or group function, is more favorable.
- Based upon clinical preference and experience, group function or mutually protected occlusion, both appear to be acceptable occlusal schemes for implant supported fixed dental prostheses.
- Future clinical studies are needed to assess scientific and clinical evidence of the superiority of one occlusal scheme over another.

AUTHOR CONTRIBUTIONS

MM-M: was responsible for the conceptualization, design, data analyses and writing the manuscript. SE: was responsible for the conceptualization, design, and data analyses, and editing the manuscript. KM: was responsible for editing the manuscript. All the authors gave their final approval and agreed to be accountable for all aspects of the work.
Occlusion on fixed implant restorations

Mariam MARGVELASHVILI-MALAMENT

DMD, MSc, PhD, Assistant Professor
Department of Prosthodontics
School of Dental Medicine
Tufts University - TUSDM
Boston, MA, USA

Dr. Margvelashvili-Malament is an Assistant Professor in the Department of Prosthodontics at Tufts University School of Dental Medicine (TUSDM). She is a Diplomate of the American Board of Prosthodontics and Fellow of the American College of Prosthodontics. She received her DMD from the Tbilisi State University in Georgia, Master of Science and PhD Degrees in Dental Materials from the University of Siena, Italy. She is a co-author of the national residency program in Prosthodontics in Georgia. She was also the Founding Chair of the International Dental Program at the University of Georgia. She is the recipient of an ITI Scholarship. She completed her Advanced Graduate training in Prosthodontics at TUSDM with high honors. She has lectured internationally and published numerous scientific articles and she also serves as a reviewer for international journals.

REFERENCES

Full text links PubMed Google Scholar Scopus WoS

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Google Scholar

Google Scholar Scopus

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Google Scholar

Full text links PubMed Google Scholar Scopus

Full text links PubMed Google Scholar Scopus

Full text links PubMed Google Scholar Scopus
Questions

1. How can mutually protected occlusal concept be described?
   - a. An occlusal scheme in which the posterior teeth prevent excessive contact of the anterior teeth in maximal intercuspal position, and anterior teeth disengage the posterior teeth in all mandibular excursive movements;
   - b. An occlusal scheme in which multiple posterior teeth contact in all mandibular excursive movements on the working side to distribute occlusal forces;
   - c. An occlusal scheme in which the buccal and lingual cusps of the maxillary posterior teeth on working and balancing side contact buccal and lingual cusps of mandibular posterior teeth in all mandibular excursive movements;
   - d. None of the above.

2. How can group function occlusal concept be described?
   - a. An occlusal scheme in which the posterior teeth prevent excessive contact of the anterior teeth in maximal intercuspal position, and anterior teeth disengage the posterior teeth in all mandibular excursive movements;
   - b. An occlusal scheme in which multiple posterior teeth contact in all mandibular excursive movements on the working side to distribute occlusal forces;
   - c. An occlusal scheme in which the buccal and lingual cusps of the maxillary posterior teeth on working and balancing side contact buccal and lingual cusps of mandibular posterior teeth in all mandibular excursive movements;
   - d. None of the above.

3. Slightly hypo-occlusion in maximal intercuspal contacts is recommended for implant-supported fixed restorations because:
   - a. The lack of a periodontal ligament limits the micromotion;
   - b. The lack of a proprioceptive capability of implant-supported fixed restorations;
   - c. Both a. and b. are correct;
   - d. None of the above.

4. Based on the findings of this systematic review, the following is correct:
   - a. There is a lack of information as to which occlusal scheme, mutually protected or group function, is more favorable for implant-supported fixed restorations. Group function or mutually protected occlusion, both appear to be acceptable occlusal schemes;
   - b. There is strong scientific evidence that suggests the use of group function occlusal concept for implant-supported fixed restorations;
   - c. There is strong scientific evidence that suggests the use of mutually protected occlusal concept for implant-supported fixed restorations;
   - d. None of the above.
MECHANISMS LINKING ORAL HEALTH AND FRAILTY IN OLDER ADULTS: A NARRATIVE REVIEW

Kalliopi Konstantopoulou1,*, Anastassia Kossioni1,2

1Department of Prosthodontics, Dental School, National and Kapodistrian University of Athens, Athens, Greece
2DDS, MSc; e-mail: kakonsta@dent.uoa.gr; ORCIDiD: https://orcid.org/0000-0002-4314-9222

ABSTRACT

Background Frailty is a geriatric syndrome in which multiple systems lose their physiological reserves resulting in increased vulnerability to stressors and risk of adverse health-related outcomes. There is an increasing number of studies discussing the association of oral health with frailty through several pathways. Objective The aim of this review was to describe the possible mechanisms linking oral health and frailty. Data Sources A narrative review was performed with literature search in PubMed, Google Scholar and ScienceDirect electronic databases. Reference lists from relevant studies and cited papers were also investigated. Study Selection The review included full papers of any study design, published in peer-reviewed journals in English until July 2021. Data Extraction Current literature indicates four possible mechanisms linking oral health and frailty. Data Synthesis The first mechanism refers to the nutritional pathway. It is reported that poor oral health negatively affects protein and vitamins intake. Malnutrition and decreased energy intake have a dominant role in frailty onset. Inflammation is another mechanism. Periodontal disease causes a systemic increase of pro-inflammatory biomarkers which in turn may lead to muscle strength deterioration. Furthermore, oral health can be related to frailty through neural mechanisms. Specifically, occlusion and proprioception from the periodontal ligament contribute to the control of body balance. Finally, the mechanisms include the psychological pathway, since poor oral health may lead to social isolation and depression which increase the risk of negative general health outcomes. More studies are necessary to clarify the previous associations and reveal any causative effects.

KEYWORDS
Oral Health; Frailty; Malnutrition; Inflammation; Depression.

1. INTRODUCTION

One of the dominant characteristics of the older population is heterogeneity, therefore overall health and function can vary substantially among individuals of the same chronological age. The concept of frailty has come to the forefront of research interest in Geriatric Medicine as a geriatric syndrome characterized by multiple functional impairments trying to explain this diversity among older people [1,2,3]. Frailty is defined as a clinical state of increased vulnerability related to ageing in which multiple systems lose their physiological reserves and the homeostatic balance is disrupted, resulting in an increased risk of adverse health-related outcomes, including functional impairment, dependency, hospital admission, institutionalization, reduced quality of life and mortality, even after exposure to a minor stressor, such as viral infection or the use of a new drug [2,4]. The most common clinical manifestations of frailty are falls, confusion, functional decline and several non-specific signs and symptoms, such as unintentional weight loss, extreme fatigue and frequent infections. Genetic and environmental factors combined with epigenetic mechanisms are closely associated to the cumulative molecular and cellular damage, and pathophysiology of frailty.

As frailty is considered a dynamic and modifiable condition exercise (aerobic, balance and resistance-based), caloric and protein support, vitamin D intake and reducing polypharmacy seem to be effective strategies in its prevention or even reversion [4]. Prevalence of frailty among community-dwelling older adults and nursing home residents is estimated to be approximately 16.7% [5] and 52.3% respectively [6]. Regarding the assessment of frailty, a total of 67 instruments are available in the literature [7]. The Physical Frailty Phenotype has been identified as the most widely used instrument [7].
According to this instrument, frailty is diagnosed when at least three of the following components are met: unintentional weight loss, self-reported exhaustion, low physical activity, weak hand grip strength and slow gait speed, while pre-frailty is defined by the presence of one or two of these criteria [8]. Moreover, the Clinical Frailty Scale and the Frailty Index of Accumulative Deficits are among the nine most-referenced frailty instruments [7]. It was developed as a 7-point ordinal scale and has been modified as a 9-point scale from one (very fit) to nine (terminally ill with a life expectancy of less than six months) based on information about health status derived from medical history and clinical examination; a score of 5 or more indicates frailty [9]. The Frailty Index of Accumulative Deficits is based on the multi-dimensional nature of frailty and is expressed as a ratio of various accumulated health deficits [10].

Frailty has come to the forefront of the research interest in the dental field as well. Poor oral health has a high prevalence among older adults and there is an increasing number of studies which demonstrate cross-sectional, as well as longitudinal associations of oral health indicators with frailty or its components through several suggested pathways [11-13]. A systematic review showed a relationship between aspects of oral health, such as number of teeth, need for and use of dental prostheses, and frailty or pre-frailty, and suggested the existence of various mediators of this association which should be further investigated [11]. In a systematic review of longitudinal studies, the number of teeth, oral function, accumulation of oral health problems and number of dry mouth symptoms were identified as predictors of frailty [12]. The evident associations between oral health and frailty status among older people suggest that the integration of frailty assessment into dental treatment planning might be useful in providing the most appropriate dental care and preventive strategies to older adults who are at a state of increasing vulnerability [13]. Moreover, oral health, and particularly occlusal force and mastication, have been associated with sarcopenia [14], a muscle disease characterized by decreased muscle strength and muscle mass, and/or reduced physical performance, which has many mutual clinical features with frailty and may serve as a precursor of frailty [15,16].

Apart from the various individual oral health indicators that have been investigated in relation to frailty, the term “oral frailty” has been introduced by the Japanese Society describing a condition of decreased articulation, slight choking, or spillage while eating and increased number of unchewable foods [17]. A longitudinal study in Japanese community-dwelling older adults, describing oral frailty as the presence of at least three of the following parameters: less than 21 natural teeth, decreased masticatory performance, decreased oral diadochokinesis for the syllable “ta”, decreased tongue pressure, subjective difficulties in eating tough foods and swallowing tea or soup showed that it may predict new onsets of frailty as defined by the Physical Frailty Phenotype and mortality [18].

As an increasing number of studies has shown an association between oral health and frailty, the purpose of the present narrative review was to describe the possible linking mechanisms.

2. METHODOLOGY

A literature search in PubMed, Google Scholar and ScienceDirect electronic databases was performed. The following keywords were used: (oral health OR oral function) AND (frailty) AND (linking mechanisms OR linking pathways). In addition, reference lists from relevant studies and cited papers were investigated. The titles and abstracts of the retrieved articles were screened to decide whether full-text reading was required, and full texts were retrieved for the selected articles. Included studies should have been published in peer-reviewed journals in English language, while no limits were set on the study design and the year of publication. Articles published until July 2021 were included in the present review.

3. RESULTS

Current literature indicates four possible mechanisms through which oral health is associated to frailty: a) nutritional pathway, b) inflammation, c) neural mechanisms and d) psychological pathway (Fig. 1).
3.1. Nutritional pathway

The first linking mechanism refers to the nutritional pathway and there is an interesting discussion on the association between oral health and nutrition. Malnutrition is associated with frailty [19,20]. A meta-analysis revealed that a total of 68% of community-dwelling older adults with malnutrition had frailty [21].

Another meta-analysis demonstrated the substantial association between malnutrition and frailty or sarcopenia, with the co-occurrence of two or all the afore-mentioned conditions in about 50% of the hospitalized older adults [22].

There are indications that energy intake, as well as nutrient quality have an important role in the onset of frailty and the pathogenesis of sarcopenia [23]. Deficiencies in nutrients have been associated with mitochondrial dysfunction which in turn may cause fatigue and weakness, two elements of Physical Frailty Phenotype [24,25]. Furthermore, a decreased amount of protein intake possibly contributes to the pathogenesis of frailty findings, based on a meta-analysis of observational studies suggesting an association between an increased intake of dietary protein and a lower prevalence of frailty (OR=0.67) [26]. In addition to the quantity of proteins, other parameters, such as protein source and protein distribution across meals, may also have an impact on the development and progression of frailty in older people [18].

Diet quality overall has been associated with a lower incidence of frailty in older adults [27,28]. Regarding the eating patterns in older adults, higher adherence to the Mediterranean Diet, which is characterized by a high intake of plant foods and olive oil and low consumption of red meats, have been inversely correlated to the loss of muscle mass, sarcopenia and frailty [29]; a meta-analysis demonstrated the protective role of the Mediterranean Diet against physical disability (OR=0.75) and frailty (OR=0.42) [30]. It is hypothesized that the Mediterranean Diet has a protective action on skeletal muscle health (myoprotective effect), since it is regarded as a source of bioactive nutrients and has anti-oxidative and anti-inflammatory properties [31]. On the other hand, Westernised dietary patterns, characterized by high consumption of refined cereals, whole dairy products, and processed meat, have a direct relationship with the increased risk of developing several components of physical frailty phenotype, namely weight loss and slow gait speed [32].

Poor dentition, dysphagia and dysgeusia are considered to be among the nine common risk factors (the nine d’s) of malnutrition in older adults [33], but more research is necessary to clarify any causative effects and the role of individual contributors.

Edentulism and the presence of less than 21 natural teeth have been associated with the decreased intake of fruits, vegetables and proteins and the increased consumption of carbohydrates [34]. A meta-analysis showed that a lower number of remaining teeth was associated with poorer nutritional status, while edentulism and the presence of a prosthesis were not found to have a statistically significant effect on malnutrition in older adults [35]. However, a systematic review of longitudinal studies has shown that the evidence of a causative effect between tooth loss and nutritional status and nutrient intake was minor [36]. Also, the results of a randomized controlled trial indicated that both removable partial dental prostheses and the shortened dental arch concept generated equal improvement in partially dentate older adults’ masticatory performance, but the masticatory performance could not predict nutritional status, due to their weak association [37]. Impaired masticatory performance in older adults is affected by a variety of factors and may lead to alteration of dietary choices and, subsequently, to malnutrition [38]. Better masticatory performance among functionally independent older adults, was independently associated with higher adherence to the Mediterranean Diet, in contrast to other dental indicators such as the number of natural teeth and use of removable prostheses [39], while older Greeks were more adherent to the components of the Mediterranean Diet, in contrast to other dental indicators such as the number of natural teeth and use of removable prostheses [39], while older Greeks were more adherent to the Mediterranean Diet compared to younger ones disregarding their dental status [40]. The enhancement of the maximum bite force and masticatory performance has been viewed as a prerequisite for a normal nutritional status in older people [41,42]. Nevertheless, the prosthetic rehabilitation of missing teeth does not seem sufficient for the treatment of malnutrition, and should be accompanied by nutritional advice, as this combination has been shown to lead to alterations in the food intake such as fruits and vegetables and to improvement of older adults’ nutritional status [41-44].

Regarding dysgeusia, taste alteration leads to a diminution of food enjoyment, which in turn may decrease appetite and result in malnutrition [45]. Dysphagia (swallowing problems), which is highly prevalent in older individuals, can alter the oral intake of foods and liquids and, thus, serves as a risk factor of malnutrition [46-48]. According to a systematic review, chewing and swallowing problems were among the factors which were consistently associated with poor nutrition in nursing home residents [31,49]. Furthermore, high Xerostomia Index scores in older adults have been associated with the selective avoidance of foods including raw carrots, whole apples and nuts, lettuce, corn and grilled or fried meats [50].

In a cross-sectional study, community dwelling older adults with oral frailty (based on the definition proposed by Tanaka et al.) were found to have a greater possibility of more severe malnutrition assessed using the Mini Nutritional Assessment – Short Form (OR=2.17) and the level of serum albumin (OR=1.59) [51]. Also, a two-year longitudinal study demonstrated that oral frailty was associated with an increased risk of deterioration of nutritional status (OR=2.24) [52].
There are indications that oral health status is independently associated with malnutrition [53]. However, the findings of a systematic review of prospective studies regarding dental status and swallowing function as determinants of malnutrition in older adults were inconsistent, while moderate quality evidence proposed that periodontal diseases, oral pain and difficulties in mastication are not determinants of malnutrition [54]. Therefore, mastication seems to explain only part of variance in the intake of food and/or nutrients in independent older adults [41], and more high-quality studies are necessary.

3.2. Inflammation
The term “inflammaging” describes an age-related state of low-grade chronic inflammation. It is characterized by both increased levels of proinflammatory cytokines, such as CRP and IL-6 and acute phase proteins, such as CRP, and decreased concentrations of IL-10, which lead to deterioration of immunological homeostasis [55, 56]. Thus, inflammaging has been assumed as an underlying mechanism of frailty. Proinflammatory biomarkers, principally interleukin 6 (IL-6) and tumor necrosis factor-α (TNF-α) can have an effect on the onset of frailty [57]. The results of a meta-analysis demonstrated a cross-sectional association between higher concentrations of CRP and IL-6, and frailty and pre-frailty, while no statistically significant longitudinal relationship emerged [58]. Another meta-analysis revealed a cross-sectional quantitative relationship between immunological biomarkers and frailty among older adults assessed with Physical Frailty Phenotype, which was stronger for CRP and IL-6 and weaker for TNF-α [56]. In a prospective cohort study, elevated serum levels of IL-6 acted as a predictor of walking speed decline among community-dwelling older adults [59]. Also, the findings of a meta-analysis suggested that higher levels of circulating CRP, IL-6 and TNF-α were significantly associated with lower handgrip strength and knee extension strength, and CRP levels were significantly inversely correlated to skeletal muscle mass [60]. A meta-analysis of cross-sectional studies showed that serum levels of CRP were elevated in people with sarcopenia compared to controls, while no statistically significant associations were found between serum IL-6 levels and TNF-α levels, and sarcopenia [61].

There is evidence of strong associations between periodontitis, low-grade inflammation and systemic health. The accumulation of periodontopathogenic bacteria into the gingival sulcus stimulates a local inflammatory response and pro-inflammatory mediators such as interleukin 6 (IL-6) and tumor necrosis factor-α (TNF-α) are produced in periodontal lesions, which may move into the systemic circulation. Also, serum levels of C-reactive protein (CRP), an acute phase reactant produced mainly in the liver in various inflammatory cytokines, are elevated in patients with periodontitis [62].

3.3. Psychological pathway
Late-life depression and frailty have been described as comorbid geriatric syndromes [63]. A meta-analysis supported a reciprocal relationship between depression and frailty in older adults [64]. A systematic review suggested the strong prospective relationship between the presence of depression and greater risk of incident frailty among community-dwelling older adults [65]. Also, a strong correlation between depression and risk of frailty was found in a meta-analysis and this risk was higher for older men compared to older women (OR=4.76 and OR=2.25 respectively) [66]. The findings of another meta-analysis revealed a weak negative correlation between depressive symptomatology and handgrip strength [67]. Furthermore, the results of a longitudinal study demonstrated that both loneliness and social isolation were independently associated with incident frailty [68]. Another prospective cohort study showed a negative association between frequency of laughter and risk of functional disability among older individuals [69]. On the other hand, a longitudinal study showed that high levels of loneliness were associated with increased risk of incident physical frailty, but no relationship was found between loneliness and social isolation, and rate of change in frailty index [70]. Also, the results of a population-based cohort study suggested that depression does not act as a risk factor for the onset of frailty in older people [71]. The bidirectional association between depression and frailty is questioned, but it is indicated that they share some common risk factors in the short and long term [72].

Oral health has an effect on various aspects of older adults’ quality of life among which are appearance and socializing [73]. Poor oral health may have negative consequences on social interaction and self-esteem and may lead to depression, which has an adverse effect on general health and wellbeing [74,75]. Cross-sectional as well as longitudinal associations between oral health related quality of life and loneliness in older adults have been identified [76].

Tooth loss can negatively affect speech and appearance, while denture problems may result in embarrassment due to dislodgement, pain and discomfort [38,77]. Older adults with fewer natural teeth and those who do not use dentures may have a greater possibility of social isolation [78]. In addition, tooth loss and self-reported dry mouth were found to be associated with a higher risk of developing depression among older adults in a longitudinal study [79]. Tooth loss and self-reported oral health problems, such as difficulty in chewing tough foods, may be longitudinally correlated to development or worsening of depression in older adults [80].
Also, a significant association was found between lower GOHAI (Geriatric Oral Health Assessment Index) scores and depression in Greek community-dwelling older adults [81]. A meta-analysis revealed a positive association of edentulism (OR=1.28) and periodontal disease (HR=1.73) with depression in adults and older people [82]. A population-based cross-sectional study indicated a bidirectional association between the number of remaining teeth and the frequency of laughter among community-dwelling older adults [83]. Moreover, the results of a nationwide population-based cohort study demonstrated that periodontitis was associated with the increased risk of subsequent depression [84].

On the other hand, a study in older Greeks has shown that the frequency of eating out was not affected by the dental status, but other biological and social factors played a more significant role indicating the multifactorial nature of human behaviour [85].

3.4. Neural mechanisms
The deterioration of body balance control is one of the most common causes of falls among older people [86]. Evidence has shown the existence of a positive association between postural instability and frailty or pre-frailty [87,88]. In a meta-analysis, an association between falls and frailty (OR=1.80) was found [89]. Moreover, a systematic review and meta-analysis provided a significant association between frailty and the future risk of falls among community-dwelling older adults, greater in males [90]. Another systematic review and meta-analysis with similar findings showed that community-dwelling older adults with frailty and prefrailty were at higher risk for falls and, also, those with frailty were more prone to recurrent falls [91].

Oral health may be related to postural stability through neural mechanisms. The stomatognathic system plays a role in the control of body posture [92]. Dental occlusion, trigeminal afferents and proprioception from the periodontal ligament may contribute to the control of postural stability, therefore tooth loss is a possible risk factor for postural instability [92,93].

A case-control study showed that edentulous older adults had statistically significantly less body balance activity and higher body oscillation compared to those who maintained their dentition, while the use of complete denture(s) was not associated with body balance control [93]. However, in another study, complete dentures were found to have a positive effect on static and dynamic stability among edentulous older individuals [94]. In a longitudinal study, the complete loss of occlusion with natural teeth (Eichner index C) was associated with decreased one-leg standing time with eyes open (OR=4.27) [95]. Furthermore, a prospective study disclosed an independent association of maximum occlusal force with one-leg standing time among men aged 85 and older [96]. The results of a cohort study showed a strong relationship between occlusal status and postural stability [97]. According to a prospective cohort study, older adults with fewer than 20 teeth and those not using dentures were at higher risk for incident falls (OR=2.5) [98].

Also, the presence of teeth (OR=0.59) and dentures (OR=0.66) was significantly associated with decreased risk of falls in older adults with dementia [99]. On the other hand, the findings of a cross-sectional study demonstrated that the use of dentures was correlated to decreased balance in both static and dynamic conditions and the duration of denture use was negatively associated with dynamic balance [100].

4. DISCUSSION
Current evidence supports both the cross-sectional and the longitudinal association between oral health and frailty [11-13], but more studies are necessary to confirm the evidence and clarify any causative effects. The majority of studies investigating this relationship were conducted in community dwelling older adults in Japan and the most commonly used frailty assessment instrument was the Physical Frailty Phenotype. This review has also identified four potential pathways which may link oral health and frailty that also need further investigation: the nutritional pathway, inflammation, the psychological pathway and neural mechanisms.

Oral health indicators, such as the number of teeth, masticatory performance, swallowing problems and dysgeusia seem to contribute to the nutritional status in older adults [33-35,38,45-52]. However, robust evidence on the association between oral health and malnutrition is still lacking as various confounding factors are implicated [41,42,54]. Malnutrition and decreased energy intake, in turn, are considered to have a dominant role in the onset of frailty and the pathogenesis of sarcopenia [23-26]. The multifactorial nature of nutritional status and food choices has been acknowledged, therefore, the interdisciplinary collaboration between dental professionals, dietetics practitioners, and primary care providers is necessary for treatment and prevention of malnutrition [42].

Regarding the pathway of inflammation, periodontitis may lead to systemic increase of inflammatory mediators, which may serve as an underlying mechanism of frailty. Nevertheless, the findings regarding the association of periodontitis with frailty are contradictory and evidence which supports inflammation as a linking mechanism between oral health and frailty is weak [12].

There are indications that poor oral health, namely tooth loss, periodontitis and self-assessed oral health status negatively influences older adults’ quality of life and is associated with an increased risk of depression in older adults [78-82,84].
Reciprocal, as well as prospective associations between depressive symptomatology and frailty in older adults have been reported [64,65], while it is suggested that depression and frailty are affected by common causes such as biological, psychosocial, behavioral, and environmental factors [72]. As far as the neural mechanisms are concerned, the literature supports the existence of a relationship between the stomatognathic system and body posture; the loss of proprioception from periodontal ligament may have a negative impact on the head position and contribute to postural instability [92,93]; posture; the loss of proprioception from periodontal ligament may have a negative impact on the head position and contribute to postural instability [92,93].

Deterioration in control of body balance is one of the leading causes of falls in older people [86]. Falls, in turn, are associated with frailty [87-89] and are among the most common clinical manifestations of frailty [90,91]. This narrative review has revealed the need for further research including case-control and randomized controlled trials to thoroughly explore the association between oral health and frailty and also the specific role of oral health as a predictor and marker of frailty. Moreover, more studies are necessary to explore the potential linking mechanisms including nutrition, inflammation, psychological, and neural pathways. Studies in community-dwelling older individuals and nursing home residents should also examine the possible protective effect of systematic oral care provision against frailty. Statistically significant results on these parameters may lead to the integration of markers of oral health in the frailty assessment instruments and to the development of appropriate preventive strategies in the context of oral health promotion.

5. CONCLUSIONS

Oral health and frailty may be linked through nutritional, inflammatory, psychological and neural mechanisms. Further studies are necessary to thoroughly elucidate the role of these pathways as mediators of the latter association and, subsequently, to determine the most effective preventive strategies.

AUTHOR CONTRIBUTIONS

KK: protocol, data gathering, data analysis, authoring the draft. AK: concept, protocol, critically revising the manuscript.

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Mechanisms linking oral health and frailty

Kalliopi KONSTANTOPOULOU

DPS, MSc

Department of Prosthodontics
School of Dentistry
National and Kapodistrian University of Athens
Athens, Greece

Kalliopi Konstantopoulou graduated from the Dental School of National and Kapodistrian University of Athens, Athens, Greece in 2016. In 2019, she obtained her master’s degree in Health Promotion and Education from the Medical School of National and Kapodistrian University of Athens and is currently a postgraduate student at the Department of Prosthodontics, Dental School, National and Kapodistrian University of Athens, Athens, Greece. She is also a Board member at the European College of Gerodontology.
Questions
1. The most widely used instrument to assess frailty is:
   - a. Physical Frailty Phenotype;
   - b. Frailty Index;
   - c. Clinical Frailty Scale;
   - d. Short Physical Performance Battery.
2. Oral health is linked to frailty through:
   - a. Nutrition;
   - b. Inflammation;
   - c. Psychological and neural pathways;
   - d. All of the above are correct.
3. Which of the following sentences is correct?
   - a. Oral health is the dominant determinant of malnutrition;
   - b. Nutritional status and food selection have a multifactorial nature;
   - c. Malnutrition can be reversed solely by prosthodontic rehabilitation;
   - d. Westernized dietary patterns may prevent frailty.
4. Which of the following sentences is correct?
   - a. No prospective associations exist between depression and frailty;
   - b. No reciprocal associations exist between depression and frailty;
   - c. Depression and frailty seem to be affected by common causes;
   - d. None of the above.
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A MULTIDISCIPLINARY APPROACH FOR THE REHABILITATION OF A PATIENT WITH CHONDROSARCOMA: PROSTHETICALLY-DRIVEN DIGITAL WORKFLOW FOR MAXILLARY RECONSTRUCTION AND IMPLANT TREATMENT

Yanjun Ge1,1a, Danni Guo2,2b, Xiaofeng Shan2,2c, Lei Zhang3,3d, Ruifang Lu4,4e, Pan Shaoxia4,4f, Yongsheng Zhou5,5g*

1Department of Prosthodontics, Peking University School and Hospital of Stomatology & National Center of Stomatology & National Clinical Research Center for Oral Diseases & National Engineering Laboratory for Digital and Material Technology of Stomatology & Beijing Key Laboratory of Digital Stomatology & Research Center of Engineering and Technology for Computerized Dentistry Ministry of Health & NMPA Key Laboratory for Dental Materials, Beijing 100081, China
2Department of Oral-Maxillofacial Surgery, Peking University School and Hospital of Stomatology & National Center of Stomatology & National Clinical Research Center for Oral Diseases & National Engineering Laboratory for Digital and Material Technology of Stomatology, Beijing 100081, China
3Department of Periodontology, Peking University School and Hospital of Stomatology & National Center of Stomatology & National Clinical Research Center for Oral Diseases & National Engineering Laboratory for Digital and Material Technology of Stomatology & Beijing Key Laboratory of Digital Stomatology & Research Center of Engineering and Technology for Computerized Dentistry Ministry of Health & NMPA Key Laboratory for Dental Materials, Beijing 100081, China

ABSTRACT

Aim To describe a comprehensive digital therapy oriented towards the final restoration for treating an oral maxillofacial defect caused by maxillary chondrosarcoma.

Summary The prosthetically-driven multidisciplinary approach was applied to achieve perfectly functional-aesthetic reconstruction for a male patient with maxillary chondrosarcoma. The complete tumor resection was ensured by the design of virtual osteotomy and surgical guide plate. A reverse engineering technique was used to reconstruct the bone defect in the maxillary aesthetic area, which offered reference for a three-dimensional printing guide plate to shape and fix the free vascularized iliac bone flap. On the solid basis of previous treatment, the implant placement was performed under the guidance of the prosthetic-driven implant plate. Vestibular extension and tissue graft were performed to increase keratinized gingiva width to improve implant-supported fixed prosthesis effect.

Key learning points 1. A multidisciplinary approach including maxillofacial surgery, prosthodontic and periodontal treatment can provide better esthetic and functional results for complex rehabilitation of a patient with oral maxillofacial defect. 2. Predictability of maxillary reconstruction and implant restoration can be increased with prosthetic-driven treatment plan. 3. Applying preoperative virtual design and personalized guide plate is beneficial to achieve an ideal outline of reconstructed upper jaw. 4. Obtaining comprehensive aesthetic parameters of the expected restoration is one of the key principles of upper anterior teeth rehabilitation. 5. Digital technology provides an opportunity for consistency between the primary treatment design and the final restoration outcome.

KEYWORDS

Digital; Surgical guide; Implant supported restoration; Oral-maxillofacial defect; Multidisciplinary approach
1. INTRODUCTION

Tumors, trauma or congenital factors mostly lead to an oral-maxillofacial defect. The maxillary defect, especially in the anterior teeth area, has a serious impact on patients from both physiological and psychological aspects, including bite, pronunciation and aesthetic functions [1,2]. Therefore, as a complex functional and aesthetic reconstruction, the multidisciplinary approach is urgently needed to make a comprehensive diagnosis and optimal treatment plan, which may consist in periodontal, prostodontic, maxillofacial and implant treatment [3].

Conventional rehabilitation workflow for patients with oral cancer completes the following steps in sequence [4]. Surgery is performed to remove the affected area. The bone defect is reconstructed with a bone flap or prosthesis. When feasible, the implant and fixed restoration are used to improve the effect. Obviously, there are disadvantages of the conventional workflow to be optimized. Discontinuous procedures are difficult to ensure the treatment consistency. The diagnosis and treatment standards of different specialties are diversified and rely heavily on their experience. In summary, the complex treatment process reduces the predictability of the rehabilitation [5].

The development of digital technology provides a variety of means for the optimization of the oral-maxillofacial defect treatment, such as virtual surgery, personalized model made by rapid prototyping technique, static plate or dynamic navigation-guided surgery [6]. The application of the novel digital technology can achieve higher time efficiency and better quality of outcomes for prosthetic treatment [7]. The implant guide plate significantly reduces the error of implant surgery [8]. Precious registration of multi-source data can realize virtual aesthetic design before surgery. Most of the current scientific evidence of applying digital technique for oral-maxillofacial rehabilitation focuses on mandible reconstruction and shaping of vascularized fibular flap [5,9-12]. Literature on maxillary reconstruction in aesthetic high-risk area rehabilitated with a free vascularized iliac bone flap assisted by digital technique was rare.

In this article, a maxillary chondrosarcoma case is reported to propose a multidisciplinary approach and prosthetically-driven digital workflow for the oral-maxillofacial rehabilitation.

2. CASE PRESENTATION

A 46-year-old male patient required examination and treatment with the chief complaint of a mass on the front of the maxillary and accompanied by loose upper anterior teeth for several months, and he had no relevant medical history. The general examination showed no abnormalities. The patient visited the Department of Prosthodontics, Peking University School and Hospital of Stomatology in February 2018. There was a tough mass with a diameter of about 3 cm and smooth surface on the labial side of the maxilla central and lateral incisors (Fig. 1). The vestibular sulcus was swollen without bleeding and tenderness. Intraoral examination revealed tooth space among upper anterior teeth, which were I degree loose and drifted towards the mesial direction. Deep overjet and overbite were shown on anterior teeth. The first and second right maxilla premolars were missing. The relative position of the upper and lower jaws was basically normal. This patient had lots of dental calculus and poor oral hygiene. The contour of the nasal base and upper lip was obviously raised, the skin color of the lesion looking normal. There were no abnormalities in the region of the neurological lymph nodes and bilateral temporomandibular joint.

Cone beam computed tomography (CBCT) showed one circular area in the maxilla with reduced bone density and unclear boundaries closely adhering to the anterior teeth. The range of this lesion was about 5cmX4cmX3cm, in which spot and flake-like calcification were visible. The radiographic film revealed neither root canal treatment nor peri-apical resorption of upper anterior teeth (Fig. 2).

According to the clinical and radiographic examination, multidisciplinary experts consulted and gave a comprehensive diagnosis and sequential treatment plan. Firstly, the systematic periodontal treatment was performed by the periodontist.
The oral and maxillofacial surgeons would remove the maxillary tumor and reconstruct the maxilla for implant restoration. Free gingival grafts would be performed where required. Subsequently, implant-supported fixed partial denture would be accomplished.

The current condition, treatment plan, cost and prognosis were communicated in detail to the patient. Signed informed consent, with the aid of digital technique, virtual surgical planning (VSP) and rapid prototyping technology (RP) were applied for maxillary chondrosarcoma resection and reconstruction. The free vascularized iliac bone graft surgery was performed. The CT dataset of maxillofacial and iliac were used to simulate the osteotomy operation and construct a three-dimensional maxillary defect model through reverse engineering software. Based on digital design, surgical guide plates and personalized models were made to assist in the osteotomy operation and flap fixation (Fig. 3). A full-thickness flap was raised through intraoral incision under general anesthesia. The tooth-supported maxillary surgical guide was completed in place. According to the preoperative design, the maxillary lesion was excised (Fig. 4). Taking pathology analysis and examination together, the results confirmed the diagnosis of well-differentiated chondrosarcoma. According to the pathological results of frozen sections, there were no tumor cells at the margin. The free vascularized iliac bone flap was prepared and shaped under the guidance of the personalized plate and maxillary model. The bone flap was adequately positioned at the maxillary defect area and firmly fixed by titanium nails and plate. A vascular anastomosis was completed under the microscope for the successful reconstruction (Fig. 5). One week, three months and twelve months after surgery, a clinical examination was performed at each follow-up visit. Panoramic radiograph and CBCT showed no recurrence (Fig. 6).

After healing, plaster models were made from primary impressions. A characteristic occlusal rim was made to record the maxillo-mandibular relationship and key aesthetic parameters with radiopaque material. The Digital Imaging and Communications in Medicine (DICOM) data from CBCT and model scanning data were registered accurately. Based on the aesthetic principle, the expected restoration and implant treatment were virtually designed (Fig. 7). An implant surgical guide supported by natural teeth and lateral retention nails was made through the RP technique. A full-thickness flap was raised under local anesthesia (Primacaine adrenaline 1:100,000, Dentaires Pierre Rolland), and four implants (15, 13 NobelActive® RP, 11, 21 NobelActive® NP, Institut Nobel Biocare AG) were inserted with the guidance of the template (Fig. 8). Before suturing, the healing screws were connected to the implant. Ten days after surgery, the sutures were removed. The examination revealed a favorable healing process of the implant and soft tissue.
A multidisciplinary approach for oral rehabilitation

Figure 4. Resection of maxillary chondrosarcoma with the guidance of tooth-supported surgical guide. (a) The surgical guide plate was in place. (b) The maxillary lesion was excised as pre-operative design. (c) The maxillary defect after maxillofacial surgery.

Figure 5. Maxillary reconstruction with vascularized iliac bone flap graft surgery. (a) Preparation of free vascularized iliac bone flap. (b) Shaping and fixation of flap with the personalized 3D printed model as reference. (c) The bone flap was adequately positioned at the maxillary defect area and firmly fixed. (d) Completion of vascular anastomosis.
Figure 6. Panoramic radiograph showed adequate bone for implant placement.

Figure 7. A prosthetically-driven virtual design for implant placement. (a) Registration of multi-source data. (b) Implant type and position were virtually designed according to the optimal restoration.

Figure 8. A restoration-oriented digital workflow for implant surgery. (a) Implant treatment was virtually designed using precious registered dataset. (b) Implant surgical guide was made by rapid prototyping technology. (c) The implant guide plate was stabilized through transverse retention nails and residual teeth. (d) Optimal implant placement under the guidance of the plate.
Four months after surgery, the implants showed good osseointegration. Further intraoral examination showed less keratinized gingiva on the buccal side of the right upper jaw. Vestibular extension and tissue graft were performed to increase keratinized gingiva width. During the second-stage operation, the 4mm buccal keratinized gingival was retained through apically repositioned flap surgery (Fig. 9). The screws were unscrewed, and the healing abutments were connected to the implants (Fig. 10).

Communicating with the patient, the final restoration was screw-retained zirconia base with labial porcelain fixed bridge. For the upper jaw, an open-tray splint implant impression was taken with a polyether material (Impregum Penta, 3M ESPE GmbH). A conventional impression of the opposing jaw was taken with alginate material (Alginoplast, Heraeus Kulzer GmbH). Temporary resin restoration was milled with a 5-axis CNC machine. Trying in the temporary restoration, passive fit and appropriate upper lip fullness were achieved (Fig. 11). Referred to the pupil line and smile line, minus adjustment of the denture was performed on the restoration to obtain coordinated midline and incisal curve. After three months, the patient did not express discomfort. The maxillo-mandibular relationship was re-determined and transferred to the articulator by face-bow. The final zirconium restoration was made with the reference of the temporary restoration. At delivery, the interproximal contact points were assessed for a strong contact using dental floss. Occlusal contact points were checked for light occlusal contacts without lateral occlusal disturbance (Arti-Fol shimstock foil, Dr. Jean Bausch GmbH & Co.). With a small amount of modified occlusal contact, the patient showed high satisfaction for the effect and comfort (Fig. 12). The panoramic radiograph showed good marginal adaptation of final restoration (Fig. 13). Twelve months after delivery, the follow-up examination revealed restoration in good condition. Oral hygiene maintenance and regular recheck were instructed (Fig. 14).
3. DISCUSSION

In this case, the patient was diagnosed with maxillary chondrosarcoma, which is a rare malignant neoplasm [13]. Chondrosarcoma (CHS) usually occurs in the pelvis, chest wall, and scapula. Maxillary chondrosarcoma is more common in men, average age range from 35 to 45 years old [14]. Maxillary chondrosarcoma may originate from the embryonic cartilage precursors of turbinate and nasal septum. According to the characteristics of the cells under the microscope, this patient is pathologically diagnosed as highly differentiated chondrosarcoma, classified as Grade I. The 5-year survival rate for patients with grade I is 89%, according to WHO data [13,15]. Therefore, it is necessary to provide complete treatment and a rehabilitation plan for this patient to improve his survival life quality.
Implant restoration can effectively improve the rehabilitation outcome of patients with maxillofacial defects. It is reported that the cumulative survival rate of implants placed in bone flaps in jaw rehabilitation can reach 93.2% [20]. It should be noted that the long-term good prognosis of implant restoration is closely related to the dentist’s treatment as well as the patient’s maintenance. A reasonable preoperative design ensures a good self-cleaning for the patient. Hygiene maintenance and regular review effectively reduce complications. The limitation of this case report is that the temporary denture does not use digital preoperative design. The application of the fully digital workflow can further ensure the guiding role of the final restoration. The conventional workflow used in this case report is a time-saving and mature method. The long-term repair effect needs to be further tracked.

4. CONCLUSION

In this case, a new concept of multidisciplinary diagnosis and treatment approach is used to complete the maxillary reconstruction and implant supported fixed restoration for the maxillary chondrosarcoma patient. The prosthetic-driven workflow can achieve the consistency of complex treatment standards and improve the predictability of the restoration. The accuracy and efficiency of the treatment are improved with digital technology.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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None

AUTHOR CONTRIBUTIONS

*Yanjun Ge and Dannii Guo have equally contributed as first authors. DG and YG collected data and wrote the original draft. YG, XS, LZ, and RL performed the clinical treatment. SP and YZ lead the writing and revised the manuscript.

REFERENCE


Dr. Ge, DDS, has been a prosthodontist and lecturer at Peking University School and Hospital of Stomatology since 2009. As an ITI member, he carried out a large number of implant treatments using digital technology. He is good at and responsible for treating prosthetic patients, especially complex case treated with the multidisciplinary approach.

Questions

1. What is the average age range of male patients with maxillary chondrosarcoma?
   - a. 40 to 55;
   - b. 35 to 45;
   - c. 25 to 36;
   - d. 65 to 75.

2. Which of the following options is not a method for maxillofacial surgery to reconstruct the maxilla?
   - a. Distraction osteogenesis;
   - b. Vascularized bone flap graft;
   - c. GBR;
   - d. Obturator.

3. Which is the digital method commonly used in computer-assisted surgery?
   - a. Navigation surgery;
   - b. Surgical guide plate;
   - c. Virtual surgical planning;
   - d. All of the above.

4. What is the retention survival rate of implants on the bone flap (jaw reconstruction)?
   - a. 78.5%;
   - b. 93.2%;
   - c. 96.8%;
   - d. 89.7%.

Yanjun GE
DDS, PhD

Department of Prosthodontics; Peking University School and Hospital of Stomatology National Center of Stomatology; National Clinical Research Center for Oral Diseases; National Engineering Laboratory for Digital and Material Technology of Stomatology; Beijing Key Laboratory of Digital Stomatology Research Center of Engineering and Technology for Computerized Dentistry; Ministry of Health; NMPA Key Laboratory for Dental Materials, Beijing 100081, China
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The use of infrared laser light contributes to an improved reduction of germs in endo, perio and implantation treatments. In endodontics, the laser is used after preparing and washing the root canal to effectively reduce germs and bacteria in areas where an irrigation fluid can never reach, leading to a better long-term prognosis. In periodontics and implantology, within the sanitization procedure, the laser supplements the descaling, contributing to the improvement of the periodontium condition, without surgery and with minimal discomfort. It also ensures the exposure of the implant, decontamination and the realization of clear preparation margins for fingerprints and scans.

**Red wavelength - 660 nm**
The red laser light is used for Photobiomodulation (PBM), also known as Low-Level-Laser-Therapy (LLLT). Photobiomodulation works by applying the photonic energy of the light to the tissue. It penetrates the skin barrier and is absorbed by cells, where it initiates physiological reactions with mitochondria. Photobiomodulation can be used in clinical cases of temporomandibular joint dysfunction (TMJD), TMJ pain, muscle masseter pain, mouth opening limitation, burning mouth-syndrome, dentin hypersensitivity, wound healing.

The technical possibilities provided by SiroLaser Blue, the world’s first diode laser with three different colors, allows the practitioner to use a versatile tool that provides comfort for the appropriate laser treatment for over 20 different dental applications.

**Here are the technical data of the SiroLaser Blue:**

<table>
<thead>
<tr>
<th>Wavelength and operating performance</th>
<th>445 nm +/− 5 nm / 0.2 – 3.0 W (CW)</th>
<th>660 nm +/− 5 nm / 25, 50 and 100 mW (CW)</th>
<th>970 nm −10/+15 nm / 0.2 – 2.0 W (CW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser operating mode</td>
<td>Continuous Wave</td>
<td>Chopped Mode</td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>1 – 10,000 Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duty cycle</td>
<td>Variable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>≈ 1.3 kg (incl. handpiece and battery)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimensions</td>
<td>≈ 19.7 cm x 18.2 cm x 18.9 cm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

https://doi.org/10.25241/stomaeduj.2021.8(3).prodnews.1
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The Vertical Dimension in prosthesis and orthognathodontics
Integration between function and aesthetics

Author: Nazzareno Bassetti
Publisher: Edra S.p.A., Italy
Language: English
ISBN: 978-8-821-45039-6
Edition: 1/e
Publish Year: 2019
Pages: 224, illustrated
Price: € 109,00

Forever interested in perfecting his dental art, Dr. Nazzareno Bassetti attended the courses of Profs. Slavicek, Sato and Mehta from Donau University in Krems, Austria to obtain a master’s degree in science (M.Sc.) in “Therapy of Masticatory Organ’s Dysfunctions”. The theoretical knowledge accumulated is rigorously applied in his current practice both for cases that required dental prosthesis treatments, orthognathodontics, implant-prosthetic approach, and for complex cases that required a multidisciplinary approach. “The Vertical Dimension in prosthesis and orthognathodontics” follows the approach to the patient as seen by the Vienna School of Interdisciplinary Dentistry (VieSID), so the author presents successful treatments using an individualized diagnosis and therapeutic process, finding the vertical dimension and mandibular repositioning that restore the correct combination between aesthetics and the function of the stomatognathic system.

The book is divided in eight chapters and ends with three case reports convincingly described and illustrated. Starting from the transversality of gnathologic principles, the analog and digital gnathologic diagnostic flow are presented in detail. A separate chapter analyzes facial macroaesthetics related to the mandibular position. After approaching the occlusal plane and craniofacial development, dentition development is presented from the perspective of occlusal concepts. Digital functional smile design (DFSD), three-dimensional management of the vertical dimension and gnathologically-guided implantology concepts are described in the vertical dimension project according to VieSID.

The key to the success of oral rehabilitation is knowledge of the mandibular repositioning techniques, Occlusal Mandibular Repositioning Technique - OMRT (Bassetti), Therapeutic Provisional and Rehabilitative Orthodontics Technique - MEAW (Sato) or Early Mandibular Repositioning Technique - EMRT. The last chapter makes a sequential presentation of the ten key points that ensure the success of the treatment plan. Through this book accompanied by a vast iconography (approximately 700 images) Dr. Bassetti manages to successfully put into practice the theories developed for the last fifteen years by Prof. Dr. Rudolf Slavicek within VieSID.

The book addresses all practitioners concerned with oral rehabilitation, orthodontists, prosthodontists, implantologists and dental technicians, as they all need a motivated gnathological evaluation of their interventions.

https://doi.org/10.25241/stomaeduj.2021.8(3).bookreview.1

The Books Review is drafted in the reviewer’s sole wording and illustrates his opinions.
**Regenerative Approaches in Dentistry**
An Evidence-Based Perspective

Editors: Sepanta Hosseinpour, Laurence J. Walsh, Keyvan Moharamzadeh  
Publisher: Springer Nature, Switzerland  
Language: English  
ISBN: 978-3-030-59808-2  
Edition: 1/e  
Publish Year: 2021  
Pages: 267, Illustrated  
Price: € 171,19

Dr. Sepanta Hosseinpour, PhD Student at The University of Queensland, Australia, Laurence J. Walsh, Professor of Dental Science at the School of Dentistry, University of Queensland, Australia, and Keyvan Moharamzadeh, Professor of Endodontics at Hamdan Bin Mohammed College of Dental Medicine (HBMCDM), Mohammed Bin Rashid University of Medicine and Health Sciences (MBRU) in Dubai, United Arab Emirates (UAE), as editors together with 34 international contributors provides us with the latest evidence-based information in the field of regenerative dentistry.

"Regenerative Approaches in Dentistry" is divided in 10 chapters, with a special focus on current and potential future clinical applications. This book manages to collect and compare what has been done to provide evidence-based information on this emerging field of dentistry. The book aims to educate readers about the different therapeutic methods used in the reconstruction of hard and soft tissues in the maxillofacial region. It covers the regeneration of the alveolar bone, the dentin-pulp complex, the enamel, the periodontium and the tissues associated with the oral cavity. It provides a complete description of regenerative approaches in dentistry, namely in regenerative endodontics and dental repair, regenerative periodontics, regenerative assisted orthodontics, regenerative approaches in oral medicine and stem cells derived from dental tissue and their potential applications.

The book, written by an international team of renowned experts, provides evidence-based information in the field of regenerative dentistry and is aimed at students (at both undergraduate and postgraduate levels), practitioners and researchers in the fields of endodontics, periodontics and implantology.
New Trends in Myofunctional Therapy
Occlusion, Muscle and Posture

Authors: Sabina Saccomanno, Licia Coceani Paskay
Publisher: Edi.Ermes, Italy
Language: English
ISBN: 978-88-7051-629-6
Edition: 1/e
Publish Year: 2020
Pages: 330, illustrated
Price: € 68,00

In orthodontics and dento-facial orthopedics, a priority role is given to the oral function in both craniofacial growth and development, as well as in dental occlusion. Everyone is convinced that a young patient benefits from the orthodontist working in a medical team with specialists from different disciplines who follow the oral function evolution.

However, in current practice a young patient does not benefit from a holistic, inter and multi-disciplinary evaluation, as a result of a concrete collaboration between doctors, dentists, orthodontists, speech therapists, myofunctional therapists, osteopaths and otorhinolaryngologists. The book entitled "New Trends in Myofunctional Therapy" covers the experience of two editors, an orthodontist, Sabina Saccomanno, Professor Master in Clinical Orthodontics at the Catholic University of the Sacred Heart, Rome, Italy and a speech therapist Licia Coceani Paskay, Speech-Language Pathologist, with private practice, in Los Angeles, CA, USA, with 20 coauthors and 10 collaborators.

The volume has 15 chapters which approach the correlations between orofacial functions, occlusion and posture to better understand the appropriate diagnostic and therapeutic procedures that can be followed by the multidisciplinary medical team, addressing a young patient's global myofunctional disorders.

After an enumeration of medical records and multidisciplinary examination in holistic approach, an identification of malocclusion and a clinical and instrumental diagnosis of orofacial dysfunctions is made. Myofunctional therapy exercises and home-based myofunctional therapy and diary are presented in detail together with a myofunctional therapy protocol in alterations of the lingual frenulum. Orthodontic appliances in myofunctional therapy are eloquently illustrated by age groups. The book further focuses on unrelated topics in the field of orthodontics, such as orofacial pain, otitis media with effusion, obstructive sleep apnea syndrome, Down syndrome, and gloss-postural syndrome.

The book also provides practical tools, namely the Myofunctional Therapy Diary and Tongue Diary, as guides for a wide range of exercises, along with a video series explaining myofunctional therapy exercises.

The book confirms the validity of the Oro Myo Functional Therapy, proving to be a useful guide for understanding the importance of the functional balance between the craniofacial region and posture for doctors, dentists, orthodontists, speech therapists, myofunctional therapists, osteopaths and otorhinolaryngologists.

Dr. Piero Silvestrini Biavati has recently provided the readers with a book in Italian [Simplified Treatment in Gnathology: The Global Occlusion Method]. This book is the author’s plea for gnathology based on a practical, fast, manual and not very instrumental method: the Global Occlusion method. The book is divided in 13 chapters. The first two chapters present the simplified anatomy and physiology of the stomatognathic system and the etiology of gnathological problems. The next chapter recalls the ideal functions of the stomatognathic system. These fundamental notions contribute to a consistent functional analysis eloquently exemplified by a multitude of clinical signs, which makes up chapter four.

The fifth chapter details the gnathological examination in its complexity. Therapeutic reasoning (chapter 6), as the basis for ensuring therapeutic success is addressed in detail in separate successive chapters: the centric method and its verification (chapter 7), the therapeutic process: rehabilitation method (chapter 8), the custom bite method - SilveSplint (chapter 9), rational use of articulators (chapter 10), postural adaptation and head-neck correlation (chapter 11) and differentiated postural analysis (chapter 12).

The last chapter is a synthesis of the aim of the Global Occlusion method in order to bring each gnathology practitioner closer to include it in the routine of working with their patients. The book is clearly written, convincingly illustrated to support the author’s method. To increase the number of the more and more frequently encountered patients with gnatho-postural problems benefiting from this book, Dr. Piero Silvestrini Biavati’s “Trattamento semplificato in Gnatologia: Il metodo Global Occlusion” must be translated into English.
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