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ERO-Plenary Session Spring 2021
the FDI World Dental Federation objectives

Michael Frank
DDS, PhD
ERO President
Editor-in-Chief Section

Dear Readers,
It gives me great pleasure to address you once again as President of the European Regional Organization (ERO) of the FDI World Dental Federation. As a follow-up to our General Assembly, which took place online as a live stream with simultaneous interpretation on Saturday 17 April 2021, I would like to give you an insight into the topics and decisions of this important meeting.
The Corona pandemic has changed many things, but nothing as much as the way we meet each other. Distance and social distancing determine our everyday life and our work. Although it is difficult for us dentists to keep our distance from our patients, we have discovered that many things can also work well over long distances - especially in the field of professional politics.
In short, our online General Assembly was a huge success and showed that ERO is fully capable of taking decisions even under pandemic conditions. Delegates from dental organizations from 34 European countries took part in the virtual meeting. It will certainly be possible to hold larger meetings again in the near future, but Corona has also shown us alternatives that help save resources.
At the beginning, the FDI President Dr. Gerhard Seeberger and the President of the European Dental Students Association (EDSA) James Coughlan addressed the meeting. For me personally, it was a great pleasure to welcome our guests of honour in the form of former World Dental Federation President Michèle Aerden (Belgium) and my esteemed predecessor in office, Anna Lella from Poland.
The dominant theme of my report was the pandemic and its consequences for the dental practice in the ERO member states. I was happy to give the delegates an insight into the work of the Executive Board under pandemic conditions, and I would like to share these insights with you.
Infection incidence
The ERO survey on the consequences of the Corona pandemic in cooperation with the Council of European Dentists (CED) unfortunately did not produce the large response we had hoped for. Nevertheless, the various surveys on Corona in general and on the incidence of infection in Europe and worldwide showed that dental practices were and are not places of increased risk of infection, either for patients or for the entire practice team; and this despite the very different general situation in the various countries, especially at the beginning of the pandemic.

WHO message
Another issue was the temporary confusion caused by the World Health Organization's (WHO) announcement in August 2020 that all unnecessary treatments should be postponed due to infection control. Thanks to a timely intervention by the FDI and substantial support from the ERO, this was corrected by the WHO.

Vaccination campaigns
It is incomprehensible that in two thirds of all ERO member countries dentists are still excluded from participating in national vaccination campaigns. One of the declared goals of the ERO Board and the ERO member states is to continue to work towards changes in this area.
Voting and candidatures
The necessary votes, which are part of every General Assembly, could be carried out electronically thanks to a new procedure. The presentation of the candidates for the positions of Council members and Speakers in the ranks of the World Dental Federation also took place online this time. Prof. Paulo Melo (Portugal), Dr. Michael Sereny (Germany), Dr. Sophie Dartevelle (France), Dr. Duygu Ilhan (Turkey), Dr. Anna Lella (Poland), Dr. Susie Sanderson and Dr. Victor Chan (United Kingdom) each introduced themselves in short statements for the aforementioned positions in the FDI.
In addition to the reports of the Executive Board and the votes, the ERO working groups also presented their results on topics such as dental education, the ageing population, digitalization and artificial intelligence, the dental team, liberal practice, science and dental practice or the cooperation with the Council of European Dentists (CED) in the field of antimicrobial resistance. The reports from the member states as well as the reports of the individual working groups and much more information can be found on our website (https://www.erodental.org/).

Dear Readers,
The pandemic and the associated restrictions are not over, but even though we should continue to exercise caution and restraint and many people are still falling ill, the proverbial light at the end of the tunnel is visible. Some of the ERO countries have already returned to a certain normality, not least thanks to the vaccination campaigns, and this positive trend will - we all hope - continue in the coming months. Let us continue to meet this historic challenge with discipline and vision, and thus master it with confidence. I wish this for all of us, our families, friends and, of course, our patients.

And now, enjoy reading the rest of the Stomatology Edu Journal!
Yours,

Michael Frank
DDS, PhD
ERO President
Editor-in-Chief Section

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June 01, 2021

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A CLINICAL INVESTIGATION OF DENTAL EVACUATION SYSTEMS IN REDUCING AEROSOLS

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EFFICACY OF BIOFLAVONOIDS OF FLAVOBAC™ AGAINST SEVERE ACUTE RESPIRATORY SYNDROME-Coronavirus 2 IN VITRO

Abdelahhad Barbour1a, Lynda Gail Darlington2b, Michelle Mendenhall3c, Henriette Lerner4d, Michael Glogauer5,6,e,1,5

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*Corresponding author: Prof. Dr. Michael Glogauer, DDS, PhD; e-mail: michael.glogauer@utoronto.ca

ABSTRACT

Introduction The Severe Acute Respiratory Syndrome-Coronavirus 2 (SARS-CoV-2) is responsible for the global pandemic of Coronavirus disease-2019 (COVID-19). Human-to-human transmission occurs mainly through the aerosolization of respiratory droplets. Improved antisepsis of human and non-human surfaces has been identified as a key feature of transmission reduction. Flavobac, a complex of soluble bioflavonoids and hydroxylated phenolic structures used in oral care products, has demonstrated efficacy to act against microorganisms. This study evaluated nasal and oral antiseptic formulations of FLAVOBAC for the virucidal activity against SARS-CoV-2.

Methodology FLAVOBAC nasal antiseptic formulations and FLAVOBAC oral rinse antiseptic formulations from 1-10% concentrations were assayed for virucidal efficacy against the SARS-CoV-2 virus. SARS-CoV-2 was exposed directly to the test compound for 60 seconds or 5 minutes. Compounds were then neutralized, and the surviving virus was quantified.

Results All concentrations of nasal antiseptics and oral rinse antiseptics evaluated completely inactivated the SARS-CoV-2 virus.

Conclusion Nasal and oral FLAVOBAC solutions are effective at inactivating the SARS-CoV-2 virus at a variety of concentrations after 60-second or 5-minute exposure times. The formulations tested have the potential to reduce the transmission of SARS-CoV-2 if used for nasal/oral decontamination, or surface decontamination in known or suspected cases of COVID-19.

KEYWORDS

Bioflavonoid; COVID-19; Flavobac, SARS-COV-2; Virucidal Activity.

1. INTRODUCTION

The emergence of the novel human Severe Acute Respiratory Syndrome CoronaVirus-2 (SARS-CoV-2) has caused drastic damage to the globe with a dramatic loss of human life worldwide. To date, approximately 172 million cases have been confirmed with over 3.7 million deaths according to WHO [1]. Previous studies confirmed that viral loads are high in the nasal cavity, nasopharynx, and oropharynx [2-5]. SARS-CoV-2 viral RNA levels (measured in saliva, throat and nasal swabs) are highest at the time of, soon after, or before symptoms and SARS-CoV-2 RNA are detected in saliva and throat swab specimens in recovered patients 5 to >40 days following hospital discharge [6]. Furthermore, live SARS-CoV-2 was isolated from throat swab specimens, indicating viral replication and shedding are active in tissues of the upper respiratory tract where SARS-CoV-2 is not thought to replicate [7]. SARS-CoV-2 appears to remain viable while suspended in aerosols for ~3h and on surfaces for days possibly indicating disease spread might occur even at considerable distances and in enclosed spaces with poor ventilation [8].

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Furthermore, among genetically related coronaviruses, SARS-CoV-2 is predicted to have the hardest protective outer shell against degradative enzymes thus contributing to its high resilience in saliva, other body fluids, and outside the body [9]. Despite many clinical trials that have been conducted for the treatment of COVID-19, no antiviral has been verified to be effective for COVID-19. Conventional antiviral drugs including ribavirin and favipiravir and other anti-inflammatory agents are currently used in clinical settings against the severe cases of SARS-CoV-2 infections [10]. On the other hand, increased interests in plant-based natural products belonging to the flavonoids class have emerged as an attractive option of treatment. The low cytotoxicity and synergy with other effective drugs make flavonoids an ideal candidate to interfere with the life cycle of the virus. Several flavonoids have been shown to exhibit significant antiviral properties in in vitro and in vivo studies [11-13]. Bioflavonoids are naturally present in plants, fruit, and vegetables, there are over 6000 identified having a wide range of uses including antioxidants & food ingredients. Flavonoids comprise a group of naturally occurring compounds that are among the most ubiquitous in the plant kingdom [14]. They are found in every family and nearly every species of the higher plants and they have extensive biological properties that promote human health and help reduce the risk of diseases. Bioflavonoids have demonstrated their capacity to act against bacteria, fungi, and viruses [12,15,16]. Flavobac (Trademark of Citrox Bioscience Ltd) is a natural product extracted from bitter oranges and composed of soluble bioflavonoids and hydroxylated phenolic structures. Flavobac is developed as nasal and oral rinse antiseptic formulations and besides its potent antibacterial activity against a tandem array of bacterial pathogens [15], it showed to have a strong virucidal efficacy against many viruses in vitro (unpublished data).

In the current study, we hypothesized that bioflavonoids as active ingredients in the Flavobac may have virucidal activities against SARS-CoV-2 which may enable a new application for protection against COVID-19. We report for the first time the virucidal activity of commercially available 2-5% Flavobac solutions against the human novel SARS-CoV-2 strain SARS-CoV-2, USA-WA1/2020. We report here the first anti-SARS-CoV-2 evaluation of a nasal and oral rinse antiseptic containing Flavobac which has been developed specifically for routine intranasal or oral use.

2. METHODS

2.1. Virus culture and biosafety and test compounds

SARS-CoV-2, USA-WA1/2020 strain obtained from the World Reference Center for Emerging Viruses and Arboviruses (WRCEVA), was used in this study for the virucidal activity of Flavobac. The virus stock was prepared by passaging three times in Vero 76 (ATCC, CRL-1587) cells. The media was MEM supplemented with 2% fetal bovine serum (FBS, Cytvia) and 50 μg/mL gentamicin (Sigma). Viral cultures were carried out in a biosafety level 3 (BSL-3) following standard operating procedures approved by the USU Biohazards Committee, Institute for Antiviral Research, Utah State University, USA. Nasal antiseptic solutions and oral rinse antiseptic solutions consisting of aqueous Flavobac BCL concentrate as the sole active ingredient and OSI-20210203 oropharyngeal spray solution consisting of aqueous Flavobac 2% (A) and 5% (B) and other natural ingredients were supplied by Oral Science International (Montreal, Canada).

2.2. Virucidal Assay

Flavobac BCL concentrate was diluted to 10%, 5%, 2%, or 1% in the test media and OSI-20210203 samples were tested at full strength. Prepared test compounds were mixed with the virus stock solution (approximately 5.5 log10 CCID50 per 0.1 mL) at a volume ratio of 9:1 (v/v). Each concentration was tested in triplicate. The Test media was added to one tube of each prepared concentration to serve as toxicity controls. Water was tested in parallel as a negative control. The prepared test compound and the virus solution mixtures were incubated at room temperature for 5 min. Neutralization control indicates the highest dilution of the endpoint titer where compound inhibited virus CPE in the wells after neutralization. Cytotoxicity indicates the highest dilution of the endpoint titer where full (80-100%) cytotoxicity was observed.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Contact Time</th>
<th>Cytotoxicity</th>
<th>Neut. Ctrl.</th>
<th>Virus Titer</th>
<th>Virus Titer</th>
<th>LRV</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLAVOBAC BCL 10%</td>
<td>1 min</td>
<td>1/100</td>
<td>None</td>
<td>&lt;2.7</td>
<td>4.6</td>
<td>&gt;1.9</td>
</tr>
<tr>
<td>FLAVOBAC BCL 5%</td>
<td>1 min</td>
<td>1/100</td>
<td>None</td>
<td>&lt;2.7</td>
<td>4.6</td>
<td>&gt;1.9</td>
</tr>
<tr>
<td>FLAVOBAC BCL 2%</td>
<td>1 min</td>
<td>1/10n</td>
<td>None</td>
<td>&lt;1.7</td>
<td>14.6</td>
<td>&gt;2.9</td>
</tr>
<tr>
<td>FLAVOBAC BCL 1%</td>
<td>1 min</td>
<td>1/10</td>
<td>None</td>
<td>&lt;1.7</td>
<td>4.6</td>
<td>&gt;2.9</td>
</tr>
<tr>
<td>OSI-20210203A</td>
<td>5 min</td>
<td>1/10</td>
<td>None</td>
<td>&lt;1.7</td>
<td>4.7</td>
<td>3.0</td>
</tr>
<tr>
<td>OSI-20210203B</td>
<td>5 min</td>
<td>1/10</td>
<td>None</td>
<td>&lt;1.7</td>
<td>4.7</td>
<td>3.0</td>
</tr>
</tbody>
</table>

1. Cytotoxicity indicates the highest dilution of the endpoint titer where full (80-100%) cytotoxicity was observed.
   2. Neutralization control indicates the highest dilution of the endpoint titer where compound inhibited virus CPE in the wells after neutralization.
   3. Virus titers of the test sample or virus control (VC) in log10 CCID50 of virus per 0.1 ml.
   4. LRV (log reduction value) is the reduction of virus in the test sample compared to the virus control.
temperature (22 ± 2°C) for 1 or 5 minutes as indicated in Tab. 1. The assay was neutralized by a 1/10 dilution in MEM 2% FBS, 50 µg/mL gentamicin. For quantification, the surviving virus from each sample was quantified by standard end-point dilution assay. Briefly, the neutralized samples were pooled and serially diluted using eight log_{10} dilutions in a test medium. Then 100 µL of each dilution was plated into quadruplicate wells of 96-well plates containing 80-90% confluent Vero E6 cells (ATCC CRL-1586). The toxicity controls were added to an additional 4 wells of Vero E6 cells and 2 of those wells at each dilution were infected with the virus to serve as neutralization controls, ensuring that residual sample in the titer assay plate did not inhibit growth and detection of the surviving virus. Plates were incubated at 37 ± 2°C with 5% CO2 for 5 days. Each well was then scored for the presence or absence of an infectious virus. The titers were determined using the Reed-Muench (1948) equation [17] and the log reduction value (LRV) of each compound compared to the negative (water) control was calculated.

3. RESULTS

Flavobac BCL aqueous solution showed to have potent antiviral activities by reducing SARS-CoV-2 viral titer below the limit of detection (LoD) at all concentrations tested in vitro. We have tested various concentrations to ensure that we identify the optimal concentration of Flavobac BCL against SARS-CoV-2. Flavobac BCL is a key ingredient of the formulation OSI-20210203. The latter is the commercialized product (Cold & Flu Guard). Because of differences in cytotoxicity, the lower concentrations had higher LRV values with LRV>2.9 at 2% and 1% and LRV>1.9 at 5% and 10%, respectively (Table 1). Furthermore, Virus titers and LRV of SARS-CoV-2 after incubation with Flavobac commercial solutions OSI-20210203A and OSI-20210203B reduced the virus below the limit of detection (LRV>3.0). Each Flavobac containing solution evaluated was effective at reducing >3 log_{10} CCID50/mL for Flavobac 1 and 2% of infectious virus, from 4.7 log_{10} CCID50/0.1 mL to <1.7 log_{10} CCID50/0.1 mL. A consistent reduction in virus titre was observed for SARS-CoV-2 viruses at all concentrations of Flavobac solution tested and with a contact time of 1 or 5 minutes. The reductions in virus titre were >1.9 log_{10} CCID50/mL for Flavobac 5 and 10%, equating to >98.7% reduction; >2.9 log_{10} CCID50/mL for Flavobac 1 and 2%, equating to >99.8% reduction; and >3.0 log_{10} CCID50/mL, equating to >99.9% reduction for OSI-202103, the commercial formulation of Flavobac.

4. DISCUSSION

In this era of emerging infectious diseases caused by respiratory tract viruses especially SARS-CoV-2, finding new alternative biomedical tools based on natural products is important to suppress viral spread especially in high-risk disease transmission settings e.g., hospitals, long-term care facilities, and vulnerable populations. One viable approach is to reduce viral loads in the oral and nasal cavities, which can be achieved by locally neutralizing viruses that have entered these cavities with over-the-counter oral and/or nasal sprays with virucidal properties. In our current study, Flavobac based products exhibited excellent virucidal activities towards SARS-CoV-2 when tested in vitro. These products can be used as supplementary preventative measures to reduce exposure to infectious droplets, thus potentially reducing the person-to-person transmission risk in close contact situations. Nasal and oral antisepsis has been recommended as part of a comprehensive plan to reduce the likelihood of virus transmission by reducing the number of active aerosolized virus particles from the nasal passages and oral cavity [9,18,19].

The American Dental Association and the Center for Disease Control and Prevention (CDC) guidelines for minimizing the risk of COVID-19 transmission advise the use of effective mouthwash before all procedures [20]. Bioflavonoid-based products like Flavobac are known to be rich in plant polyphenols which have been shown to have good antiviral (including SARS-CoV-2), antioxidant, antibacterial and anti-inflammatory properties [21]. A recent study has suggested that the anti-SARS-CoV-2 activities of plant-derived natural polyphenols can be mediated by RNA dependent RNA polymerase (RdRp) inhibition which may represent an effective therapy for SARS-CoV-2 infections [22]. In a separated study, Jo et al found that many flavonoids were able to block the proteolytic activity of SARS-CoV-2 3CLPro, an essential enzyme controlling the virus replication life cycle [23]. Since Flavobac is a mixture of plant-based bioflavonoids, it is believed to exhibit similar modes of action towards SARS-CoV-2. Hence, scientists are recommending the use of such products to reduce the spread of SARS-CoV-2 [24] while we wait for a broad immunity conferred by the new vaccines.

The limitation of the current study is the lack of key information on whether the tested product can work in an actual in vivo environment and exhibit the same virucidal activities when used by human consumers as a nasal spray. Further research is required by testing Flavobac in clinical trials to assess its biological activities in preventing the spread of the virus, As the world is now inching towards gradually returning routine societal and economic activities to pre-pandemic level, the heightened fear of a post-pandemic outbreak looms as the virus still lurks and relatively little is known about the key parameters that could shape the future course of the pandemic [25].
The challenge in nasal antisepsis is to find effective topical preparations which are safe to use. Oral and nasal solutions infused with Flavobac, a natural bioflavonoid complex, with broad virucidal efficacy, has demonstrated efficacy to kill 99.9% of SARS-CoV-2 and it may provide a safe and protective solution for people within viruses-aerosolized places like workplaces, gym, restaurant, schools or even for people who are at a higher risk of respiratory viral complications due to other health complications

5. CONCLUSION

Current public health recommendations emphasize the need to break the person-to-person viral transmission primarily through social separation, hand hygiene and surface disinfection. Flavobac deactivated SARS-CoV-2 virus tested from 98.8% to > 99.9% when incubated with the virus for 1 to 5 minutes at 22°C. The results indicate that Flavobac oral and nasal spray could potentially be used to neutralize SARS-CoV-2 and reduce viral transmission.

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CONFLICT OF INTEREST

Dr. Glogauer is the Chief Scientific Officer for Oral Sciences. Oral Sciences is the developer of this rinse product. The rest of the authors declare no conflict of interest. Dr. Glogauer is the Chief Scientific Officer for Oral Sciences. Oral Sciences is the developer of this rinse product. The rest of the authors declare no conflict of interest.

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AUTHOR CONTRIBUTIONS

AB, MG contributed to the concept, design, and data analysis of the study and wrote the manuscript. MM performed the experiments. GD, HL contributed to the data analysis and edited the manuscript.

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COMPETING INTERESTS

The authors declare that they have no competing interests.


Dr. Abdelahhad Barbour is a Postdoctoral scientist and research coordinator of the COVID-19 saliva testing project at the Faculty of Dentistry, University of Toronto. The project aims to document rates of COVID-19 infection and immune responses to vaccination among trainees, faculty, and staff in Canadian dental schools. Dr. Barbour obtained his PhD in Molecular Microbiology from the University of Malaya, Malaysia with a thesis entitled “Characterisation and mechanism of action of lantibiotics produced by Streptococcus salivarius”. He is an expert in the fields of antimicrobial peptides, microbial genomics, oral microbiome and probiotics developments. Areas of interest in the research activity: Host-microbiome interactions, neutrophils-pathogens signaling, COVID-19 saliva testing, antibiotic resistance, microbial genomics.

Questions

1. What are bioflavonoids?
   a. Synthetic substance;
   b. Natural products derived from animal origin;
   c. Natural products derived from fruits and vegetables;
   d. Antibiotics produced by soil microorganisms.

2. What are the biological activities of bioflavonoids?
   a. Antimicrobial;
   b. Antiviral;
   c. Antifungal;
   d. All mentioned above.

3. What is the main composition of FLAVOBAC™?
   a. Soluble bioflavonoids and hydroxylated phenolic structures;
   b. Antimicrobial peptides;
   c. Polysaccharides;
   d. Lipids.

4. FLAVOBAC™ deactivated the SARS-CoV-2 virus at the following levels:
   a. 10-20%;
   b. Less than 50%;
   c. Less than 80%;
   d. More than 95%.
TESTING POSSIBILITIES OF MATERIALS USED IN PERIODONTAL THERAPIES ON LABORATORY RATS

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ABSTRACT

Introduction Periodontitis is an oral inflammatory disease of significant importance, that leads to gingival inflammation, alveolar bone loss and has a high impact on the quality of life and general health. There has been a continuous interest in the scientific world to test new therapies and therapeutic materials for periodontal disease. One of the most critical tools to investigate mechanisms of periodontal pathogenesis and test new therapeutic materials are animal models. In addition, there is a wide range of materials used in periodontal therapy, especially in terms of bone augmentation, so choosing the ideal material is often difficult to achieve.

Methodology In this article, we have evaluated two methods for testing artificially induced periodontal defects - intra-orally and extra-orally - the biological adaptation of the materials used in periodontal and bone regeneration techniques on animal models.

Results We have created two protocols for the extra-oral and intra-oral approaches. By following them we have successfully managed to create the periodontal defects and to apply the therapeutic materials. We have also made a comparison between the two methods, and the possibilities of materials that can be used.

Conclusion Tests performed on animal models will remain an important asset for evaluating new approaches for the improvement of tissue regeneration therapies. As there are continuous advances in the study of dental materials, we also have to search for new, easy to perform, ethics-friendly methods to evaluate the biological response of these materials.

KEYWORDS

Periodontal Disease; Animal Models; Alveolar Bone Loss; Bone Augmentation.

1. INTRODUCTION

Periodontal disease is known to have a long history, constantly accompanying the evolution of the human species. New data regarding its prevalence confirm its high value up to 50% around the world, with the highest scores in the older population [1]. It represents one of the major causes of tooth loss which can compromise mastication, esthetics, self-confidence, and quality of life [2]. Microbial dental plaque has been accepted as the primary etiological factor in the occurrence of inflammatory disease. Therefore, the major goal of periodontal therapy was to eliminate the pathological organisms discovered in the dental plaque located on the surface of the tooth [3,4]. Periodontal therapy is complex and it includes: prevention strategies to control the inflammation level and regenerative therapies of all supporting structures and tissues [5]. Root planing leads to clinical improvement by disrupting the subgingival biofilm, which reduces the amount of bacteria, resulting in a delay in the repopulation of pathogenic microorganisms [6,7].
Today many biomaterials are available to use for periodontal regeneration. The vast majority of materials used in periodontal therapies are materials (such as chlorhexidine, tetracycline, metronidazole) used for therapeutic purposes in non-surgical procedures. Lately there has been an increasingly frequent use of materials used in reconstructive surgical therapies. Synthetic bone grafts materials are available in particles with different diameters and can offer the benefits of an unlimited amount, without the risk of transmitting the disease and without the need to create an additional surgical area. Polymers are widely used as a barrier material in guided tissue regeneration applications [8]. The interest of the researchers and the support from the companies allow for an enormous amount of clinical and pre-clinical research to be carried out every day. Generally, the repopulation of cells on the root surface after periodontal surgery determines the nature of the attachment that will form. After surgery and removal of biofilm, the root surface of bone defects can be repopulated by epithelial cells, gingival connective tissue cells, bone cells, or periodontal ligament cells [9].

2. AIM

This study is part of a complex in vivo project that aims to test new materials for gingival inflammation and alveolar bone loss on induced periodontal defects. The aim of the current study is to identify and to compare different approaches in the induction of periodontal disease and bone defects.

We have studied, developed and compared two different protocols for inducing periodontal defects on animal models. The two methods consist in two different approaches to the periodontium and alveolar bone – through an intra-oral and extra-oral approach, which will allow the further studies of different materials used for periodontal disease.

This paper aimed to evaluate the different methods of addressing artificially induced periodontal defects through a study performed on laboratory animals. The study is part of a multidisciplinary project, as it integrates the clinical surgical field, and biomaterials science as well. By developing these protocols, we hope to bring our contribution to the field of dental materials and oral tissues in vivo studies.

3. MATERIALS AND METHODS

The working methodology consisted in a series of steps starting from the creation of periodontal defects in the mandible of laboratory animals, clinical evaluation of the evolution of inflammation in the periodontium, application of materials studied in defects.

3.1. Study Population

We have performed the tests on male Wistar rats. The animals were then kept in separate cages and marked in batches. The cages were well ventilated, with an alternation of 12 hours of light / dark, being maintained at a temperature of about 25°C. The animals were fed with standard fodder combined with granulate, and ad libitum water. Each animal was registered and the data of the experiment were kept in a single register.

3.2. Working methodology

After studying the specialized literature, we selected two types of protocols that we adapted to be used in our project [10,11]. Thus, the testing methods of the materials used in this study were performed through an intraoral and extraoral approach. The whole operation took place in the animal research facility of the university. The surgical area was equipped correspondingly and located in the same living unit as the animals, so that the stress could be limited as well as the potential danger to the animals health. The surgery room was well disinfected before the operation with disinfectants such as sodium hypochlorite, chlorine dioxide or glutaraldehyde solutions and the animals and instruments were prepared so as to prevent contamination and ensure the success of surgery.

These interventions were performed under general anesthesia with ketamine and narcoxide using Ketamidor 100mg / ml 20 IU (0.2 ml) and Xilazyn Bio 2% 0.3 ml. The injection was made slightly to the right of the white abdominal line.

All experiments were conducted in accordance with local guidelines on the welfare of experimental animals and with the approval of the Ethics Committee of the Research Facility (No. 80/16.04.2019 and No. 101/23.09.2019).

4. RESULTS

We have created both procedures for both intra-oral and extra-oral approaches. Both procedures have managed to induce periodontal defects, and they have proved to be reproduced successfully.

The procedure for the intraoral approach was performed on the lower incisors of the animal models.

As shown in Fig. 1, the depth of the gingival groove measured with the help of a periodontal probe at the level of each tooth in six points MV, V, DV, ML, L, DL. The procedure for the intraoral approach was performed on the lower incisors of the animal models. As shown in Fig. 1, the depth of the gingival groove measured with the help of a periodontal probe at the level of each tooth in six points MV, V, DV, ML, L, DL.
After that, we have inserted a piece of a silk thread used for gingival retraction, size 00, into the gingival sulcus, and performed sutures with a 5/0 suture of sterile non-absorbable silk to hold in place the gingival chord. (Fig. 2)

After 7 days, the rats in the study groups were again anesthetized and the sutures and gingival retraction threads were reoved. The periodontal defect obtained in each animal was quantified by noting the depth of the periodontal pocket measured using a periodontal probe at the level of each tooth in six points (MV, V, DV, DL, L, ML), but also the presence and location of inflammation areas. After performing the mechanical scaling and root planning, the materials studied were applied to the corresponding study group by inserting them directly into the periodontal defect from the depth of the periodontal pocket until it was completely filled (Figs. 3, 4).

The method used in this study to create a periodontal space in the vestibular area of the lower incisors and placement of a gingival retraction thread, followed by the suture allowed us to obtain the periodontal defect after one week by maintaining the mechanical irritating factor at this level.

For the extra-oral approach we chose as the initial site the mandibular side and the bone defect to be made on the mandibular molar level. After preparing the animal for surgery, the correct identification of the epithelium and hard tissue should guide the operator for the initial incision. A superficial incision is made for the first time to expose the masseter muscle (Figs. 13, 14) and to have access to the ligament marks that extend in a posterior-anterior direction, approaching the basilar edge of the mandible. An incision can be made below the ligament line at the masseter muscle to expose the mandible.

A distinct ligament usually covers the lateral area at the level of the first molar; it should be dissected to ensure efficient flap take-off and proper surgical access.

After exposing the bone we identified the first molar and the opaquer area of bone in the form of a "tear" that is a characteristic of the vestibular cortex.
The area of creation of the defect was located at the distal root of the first mandibular molar. Using a surgical 4mm spherical drill, we created a bone defect measuring 8 mm length 4mm wide and 2mm depth. (Fig. 5)

After the test materials were applied to the created defect (Figs. 6,7), the muscle tissue was first repositioned using absorbable sutures. Once the proper muscle closure and the closure were ensured, the skin was repositioned with non-absorbable sutures. (Fig. 8)

5. DISCUSSION

This study aimed to evaluate the testing methods of materials that can be used in periodontal therapies. The laboratory rats proved to have similar anatomy of the periodontal tissues with those of humans [12]. Laboratory animals have a significant advantage because they can copy the cellular complexities that occur in humans in vivo and are often more accurate than in vitro studies that take place on plastic surfaces with a limited number of cell types present [13]. Animal models are highly susceptible to periodontal disease, as the gingival tissues go through different stages once the plaque occurs.

The gingival tissues become swollen, with pocket formation, accumulation of debris, and ulceration at about 3 months of age. Alveolar bone resorption underneath the gingiva causes the teeth to slide apart and eventually to exfoliate [12]. Alveolar bone is constantly renewed by modelling and remodelling mechanisms in response to functional demands, local and systemic factors. Nutritional deficiencies in animals have been shown to affect the periodontal tissues. One study determined that dietary boron deprivation alters periodontal alveolar bone modelling and remodelling by inhibiting bone formation [14]. Animal models have been frequently used in wound healing studies primarily because of cost considerations. Wound contraction is considered to be the primary healing method of rats as opposed to re-epithelialisation seen in humans. Since wound contraction is rapid the overall healing time of rats is substantially reduced, unlike re-epithelialisation which involves the creation of new skin tissue. The reduced healing time in rodent burn models allows researchers to quickly study the mechanics of wound healing [15].
Studies have proposed many protocols for inducing gingival inflammation leading to periodontal destruction, such as the placement of a retentive silk or ligature in the gingival sulcus of the molars or incisors [10,12,16] or by the injection of lipopolysaccharides or various periodontal pathogens such as Porphyromonas gingivalis, Aggregatibacter actinomycetemcomitans, [12,17,18].

Both the method of inserting an interdental floss and the repeated intra-gingival injection of bacteria are suitable to analyse the pathogenesis of periodontal disease and therapeutic strategies to modulate the progression of the disease. However, studies of reconstructive therapies require surgically created periodontal defects [11].

The testing methods of the materials used in this study were performed through an intraoral and extra-oral approach. The intraoral approach was achieved by initially creating the periodontal defect by applying a retraction thread maintained in the gingival groove maintained by means of sutures, followed by the mechanical cleaning procedure and the insertion of the tissue regeneration material. The extra-oral surgical approach was performed by creating cavities in the mandible of laboratory animals, followed by the application of tissue regeneration material.

The intraoral approach has the advantage of an easier application for both materials in both surgical and non-surgical procedures, but is limited to the incisor group. The method used in this study to create a periodontal defect on the lower incisors by placing a gingival retraction thread, helped us obtain the periodontal defect after one week. We found that the insertion in the gingival sulcus of a small retraction chord combined with the placement of a ligature acted as a continuous source of irritation to the tissue and led to a more aggressive result.

Complex surgical procedures limit its use, excluding testing of materials used in non-surgical therapies. The extra-oral approach in order to test the materials used in periodontal surgery has the advantage of easier access to the distal area of the arch, but complex surgical procedures limit its use, excluding testing of materials used in non-surgical therapies.

5. CONCLUSIONS
Tests performed on laboratory animals will remain one important way to evaluate new approaches that improve modalities tissue regeneration currents. For the materials used in periodontal therapies to be optimally effective, doctors and researchers should have sufficient knowledge of both the ways of applying the materials, as well as their properties and also advantages and disadvantages.

In our study, the intraoral approach allowed us to easily obtain periodontal defects, but which can be maintained only for a short period of time. The extra-oral approach allows access to the lateral area to achieve periodontal defects for a longer time, but is more surgically aggressive.

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AUTHOR CONTRIBUTIONS
IM: contributed to creating the concept and structure of the study, in establishing the experimental conditions for the intraoral protocol, and performed the experimental surgery on laboratory animals. HM: coordinated the experimental surgeries, interpretation of the data, formulated the research conclusions and supervised the drafting of the article. AS: participated in the drafting of the extra-oral protocol and performed the surgery on laboratory animals with the extra-oral approach. IN: participated in the writing and translation of the paper, contributed to structuring the bibliographical references, and took the photos during the surgeries. AJ: participated in researching the bibliographical references, contributed to the introductory part and in the drafting of the abstract. AD: participated in the surgical experiments, writing, editing and translation of the paper. All authors read and approved the final manuscript.

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CV

Dr. Mitruț Ioana has been a PhD student at the Department of Prosthesis Technology and Dental Materials of the University of Medicine and Pharmacy of Craiova since 2018. She is also a Prosthodontics resident at the same university. Her PhD thesis is entitled “Possibilities of using calcium fructoborate preparations in dentistry”. Her research interest are testing dental materials and other biomaterials on biological tissues, the applications of boron based compounds in oral health. She has a lot of experience in performing in vivo tests on laboratory animals.

Questions

1. The general goals of periodontal therapy are?
   a. Regenerative therapies;
   b. Multiple teeth extraction;
   c. Prosthetic therapies;
   d. Aesthetic therapies.

2. Laboratory rats can be used in periodontology research because:
   a. We can use as many animals as possible for tests;
   b. They have similar anatomy of the periodontal tissues with those of humans;
   c. They cannot copy the cellular complexities that occur in humans;
   d. Even if they are efficient they are less accurate than in vitro tests.

3. The maintenance of the animals consist of:
   a. Housing them in cages with continuous darkness;
   b. The surgery facility to be in another building to not disturb the animals in the cages;
   c. The cages should have an alternation of 12 hours of light / dark;
   d. The animals should be fed only once a day.

4. The possibilities for creating periodontal defects are?
   a. Injections of antibiotics;
   b. Placement of a retentive silk or ligature in the gingival sulcus;
   c. Extraction of healthy teeth;
   d. Food deprivation.
CONE BEAM TOMOGRAPHY AND PANORAMIC RADIOGRAPHY IN LOCALIZATION OF IMPACTED MAXILLARY CANINE AND DETECTION OF ROOT RESORPTION

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ABSTRACT

Introduction The aim of this study was to evaluate cases of impacted maxillary canines (IMC) using cone beam tomography (CBCT) and panoramic images in an attempt to assess if panoramic radiographs can provide information compatible with CBCT results regarding canine position and root resorption.

Methodology Fifty-six impacted maxillary canines from 48 patients were radiographically evaluated. The positions of the canine teeth were classified by Sector localization on panoramic radiographs and the same teeth were also analyzed by KPG on CBCT. Root resorptions in maxillary lateral incisors were also evaluated on CBCT. The relationships between panoramic and CBCT findings were compared by Chi-square test and Fischer's exact test.

Results Statistically significant correlations were found between panoramic Sectors and KPG indexes (p<0.001). KPG index values of 1, 3 and 4 corresponded to the panoramic Sectors 1, 4 and 5, respectively; but KPG index 2 matched the panoramic Sectors 3 and more often 2. Mid-alveolar impaction generally coincided with score 1 for both KPG index and panoramic Sector. In palatally IMC, this score value was generally 2 or 3 for the KPG index and 4 for the panoramic Sector (p≤0.001). Root resorptions in maxillary lateral incisors showed significant differences according to Sector localization and KPG index (p<0.05), namely they coincided with 2 and 3 in Sector evaluation and 2, 3 and 4 in KPG index.

Conclusions Sector location on OPG is found to be related to KPG index on CBCT, and it can help evaluate mainly certain positions of impacted canines; thus, unnecessary CBCT scans are not requested.

KEYWORDS

Impacted Canine; KPG Index; Radiography Dental; Digital Radiography Panoramic; Sector Classification.

1. INTRODUCTION

Maxillary canines play important roles in facial esthetics, dental arch development, and oral cavity functions. Non-erupted maxillary canines are relatively common because these teeth develop deep within the maxilla and follow a longer path to erupt into the oral cavity when compared to other teeth [1]. An impacted tooth can be defined as the tooth that has failed to erupt into the proper position in the dental arch within the normal period of growth, and maxillary canines are the most common teeth suffering from impaction except third molars. The prevalence of their impaction ranges from 1% to 3% in the general population [2-4].

The determination of impacted canine positions is critical for the planning of orthodontic-surgical treatment. The panoramic radiographic evaluation is the most common clinical approach used by orthodontists for this procedure. It should be known, however, that panoramic radiographs have some limitations in evaluating the labiopalatal positions of impacted canines [5]. In addition, it is difficult to localize and determine the root resorptions of adjacent teeth with this radiographic method because of the superimposition of the related structures, leading to a difficulty in distinguishing many significant details [6].

Many studies have been carried out to overcome these shortcomings regarding panoramic radiographic
evaluations [7-11]. One of them belonged to Ericson and Kurol [8] who proposed some measurements on panoramic radiographs to predict the possible impaction of maxillary canines in relation to the adjacent lateral incisors. Their sector classification was then modified by Leonardi et al [12] and Bacetti et al [13] and gained popularity among the orthodontists and dental radiologists [14,15].

Cone-beam computed tomography (CBCT) used for three-dimensional visualization has gained more popularity in dental clinics during the last 3 decades [16] and at present, it has been accepted as the most accurate method in impacted tooth localization [17] although CBCT gives more radiation to the patients than conventional radiographs. In order to develop evidence-based guidelines on the use of CBCT in dental and maxillofacial imaging, a project named SEDENTEXCT was accomplished between 2008-2011 in Europe [17]. According to this project, CBCT records may be indicated only in cases where inadequate information is obtained from conventional radiographs. In order to develop evidence-based guidelines on the use of CBCT in dental and maxillofacial imaging, a project named SEDENTEXCT was accomplished between 2008-2011 in Europe [17]. According to this project, CBCT records may be indicated only in cases where inadequate information is obtained from conventional radiographs about impacted canines and their localizations.

CBCT presents a reliable guidance of the used mechanics, force, and treatment style to move the impacted canines efficiently with lower complications. To standardize the classification of impacted maxillary canines and to predict treatment difficulty, KPG index was introduced by Kau et al [18] in 2009.

The aims of the present study were to investigate if the panoramic radiographs can provide information related with CBCT results regarding canine position and root resorption.

2. SUBJECTS AND METHODS

This retrospective radiographic study, being approved by the institutional ethical board (108400987-97-86), was carried out on the diagnostic records of 48 patients applied at the Orthodontic Department of the Dental School at Istanbul Medipol University; the patients complained of maxillary canine impaction. The age of the subjects ranged between 12-34 and the mean age was 18.31±4.99 years. The patients having any syndrome, tooth aplasia, or undeveloped canine root were excluded. Bilateral canine impaction was seen in 8 patients, while 40 of them had unilateral impaction. After a routine panoramic radiographic evaluation, CBCT scans were needed in order to obtain more detailed information on the impacted canines for button operation. Panoramic records (OPG) were obtained by Carestream (Kodak) OPG Dental Machine (Carestream, Canada). CBCT scans were taken by I-CAT Next Generation & i-Cat VisionQ machine, (Imaging Sciences International, LLC, Hatfield, PA) at a setting of 120 kVp and 3.7 m.

Both the OPG records and CBCT images of the 56 impacted canines were analyzed. The mesiodistal positions of the canine crowns were determined on panoramic radiographs and classified by the Sector classification method, which was modified by Leonardi et al [12] and Bacetti et al [13] (Fig. 1). The KPG index, a novel index based on 3D CBCT images, was calculated by summing the scores (0 to 5 scores) of the canine cusp tip and root tip on x, y and z planes (Fig. 2). The total KPG scores between 0 and 9 were classified as follows: 10 as easy, 14 as moderate, 15 and 19 as difficult and 20 and above as extremely difficult. These categories were named as 1, 2, 3, and 4 beginning from the easy group in order to make the comparison with the Sector groups easy. The root resorptions of adjacent maxillary lateral incisors and labiopalatal positions of the impacted canines were also evaluated on CBCT. The labiopalatal positions of the impacted canines were classified as labial, mid-alveolar, and palatal. Root resorptions were settled as yes or no. The labiopalatal positions of the impacted canines and resorptions at lateral incisors were correlated with the KPG indexes and Sector classifications. Panoramic and CBCT images were scored twice by one author (S.A.) at a two-week interval. Intraobserver reliability was assessed by Kappa coefficient.

The relationships between panoramic and CBCT findings were investigated by Chi-square and Fisher’s exact tests. The data analysis was performed using SPSS 16.0 software package (SPSS Inc., Chicago, IL, USA). P values lower than 0.05 were accepted as statistically significant.
CBCT and panoramic radiography in impacted canines

3. RESULTS

Kappa coefficients showing intraobserver reliability were high for both panoramic and CBCT images: 0.748 for lateral incisor root resorption and 0.858 for labiopalatal position of the impacted canine. Table I shows a statistically significant association between Sector classification and KPG index (p<0.001). KPG indexes 1, 3, and 4 corresponded to panoramic Sectors 1, 4, and 5, respectively, while KPG index 2 related to panoramic Sectors 2 and 3. The results regarding the labiopalatal positions of the impacted canines and resorptions at the lateral incisors are shown in Table II. As can be seen from these tables, mid-alveolar impaction generally coincided with score 1 in both KPG and Sector evaluations. The indicative scores were 2 or 3 in the KPG index and; 2, 3 and 4 in panoramic Sectors for palatally impacted canines (p≤0.001). In labially impacted canines, the indicative score was 3 for both KPG index and the panoramic sector. The root resorption of maxillary lateral incisors was found more in score 2 of the KPG index (p=0.004) and in score 3 of the Sector classification (p=0.011). The indicative scores were 2 or 3 in KPG index and; 2, 3 and 4 in panoramic Sectors for palatally impacted canines (p≤0.001).

4. DISCUSSION

The determination of impacted maxillary canine positions is very important to prevent root resorptions in adjacent teeth, to schedule ortho-surgical procedures, and to give an opinion about orthodontic treatment time. It has been stated that one of the major reasons for treatment failure of impacted canines is mistaken location and direction of traction (40.5%) [19]. The main objectives of the present study were to assess the relation between 2D and 3D visualization of impacted maxillary canines, to estimate the labiopalatal positions of impacted canines from panoramic radiographs, which were routinely used in orthodontic clinics, and to evaluate root resorptions in lateral incisors by CBCT. CBCT is the best contemporary method to diagnose and localize the impacted canines and their possible complications [6,20,21]. In the present study, KPG index values obtained according to CBCT were gathered in more localized categories than Sector classification made according to Panoramic radiograph. For example, while lateral tooth contact and root resorption appear only at 2 and 3 in the KPG index, they are evaluated in almost all classes in the Sector classification. This result may suggest once again that the diagnostic capability of the CBCT may be clearer.
According to the radiation dose which is the main disadvantage of the CBCT, although the CBCT exposure dose is relatively low compared with that of conventional CT, it is up to 10 times higher than that of intraoral and extraoral radiography used in dentistry [22,23]. To give a more practical example, it has been revealed that the average effective radiation dose of panoramic radiography is relatively lower, ranging from 4.1 to 36 μSv (2-3 days of natural background radiation level), whereas that of CBCT ranges from 19 to 368 μSv (11 days of natural background radiation level) [24, 25]. Thus, a reason for an examination and optimization of this radiographic technique are strongly needed [26]. It is accepted that CBCT scans should only be requested when there is a potential for CBCT images to provide new information not provided by conventional radiograph [17]. The cases in which diagnosis of impacted teeth is made in initial conventional orthodontic records, CBCT might be requested as a compliment [17]. Should that be the case, CBCT scan protocols should include a partial field of view comprising the maxilla or the mandible, only. In the light of this information, the present study attends to define a correlation between 2D and 3D qualitative analyses, at least when unnecessary CBCT scans are not requested.

The KPG index, introduced in 2009, presents an opportunity to localize the impacted canines using CBCT. Kau et al [27] carried out a study in 2013 to determine the level of agreement of orthodontists in the management of impacted maxillary canines, and found that the KPG index showed a good level of agreement with the clinician’s perception of difficulty. Dalessandrini et al [28] investigated the agreement between OPG based 2D measurements and the KPG index on 105 impacted maxillary canines. These authors stated that KPG index had higher intra- and interrater agreement than those of the 2D index, and that the KPG index allows clinicians to exactly evaluate the position of impacted canines [28]. As for panoramic radiograph, OPG has been accepted as a standard record in orthodontics. In addition to the clinical examination of the palatal lump, radiographic evaluation is generally needed to identify the positions of impacted canines. With a low radiation dose, OPG provides an overview of all dentoskeletal structures, but several factors, such as superimposition of the structures and inadequate visualization of anterior maxilla in horizontal and vertical planes, affect the image quality of the panoramic radiograph. Sector classification, carried out on OPG, is a very important diagnostic tool used in the evaluation of impacted canines [10,13,29]. Jung et al [15] showed that labially impacted canines were frequently in Panoramic Sectors 1, 2, and 3, mid-alveolus impacted canines in Sector 4, and palatally impacted canines in Sector 5. According to these authors, the labiopalatal positions of impacted canines can be predicted by Sector location on OPG. Olive [29] stated that there was a significant relationship between the mesiodistal position of impacted canines and the treatment time. Canines impacted in Sector 4 emerged after 21 months of treatment and canines in Sectors 2 and 3 emerged after 8 months of treatment.

In literature, there are studies [21,28,30-34] comparing the localization of impacted canines by means of 2D and 3D indexes. Sosars et al [30] evaluated 106 palatally displaced maxillary canines and they concluded that panoramic measurements were not reliable predictors of resorptions, except for severe resorptions, of the neighbor teeth. Khan Mohammed et al [31] stated that CBCT showed an increased accuracy of 31% compared to Panoramic radiography in localizing impacted maxillary canines. Haney et al [32] compared the differences between 2 imaging modalities regarding diagnosis and treatment planning of impacted maxillary canines. Two and three dimensional images of 25 impacted canines were evaluated by 7 of their faculty members, and significant disagreement was observed among the evaluators. As a result, they concluded that three-dimensional volumetric imaging might provide more accurate information for diagnosis and treatment plans. In a similar study carried out by Alqueran et al [21], OPG and CBCT images were obtained from 60 consecutive patients who had impacted or ectopically erupting maxillary canines, and these images were analyzed by 11 examiners. The results of that study showed that CBCT was more sensitive than conventional radiography for both canine localization and identification of root resorption of adjacent teeth. Although recent studies have shown that CBCT is the most sensitive and reliable technique in the evaluation of craniofacial structures, as stated previously, it gives higher radiation doses to the patients than the conventional radiographs, thus it has not come into use routinely in orthodontic clinics [33]. For this reason, it was necessary to detect possible relationships between Sector classification on OPG and 3D KPG index. If a strong relationship is detected between them, OPG can be used safely in impacted canine cases. The results of the present study showed that KPG indexes 1, 3, and 4 mostly matched panoramic Sectors 1, 4, and 5, respectively, and that KPG index 2 matched Sector 2 and 3. According to these results, it could be said that the Sector analysis is largely compatible with the KPG index. The accurate diagnosis of exact canine position, potential contacts, and root resorptions of the adjacent teeth may reduce complications during treatment. Jung et al [15] found root resorption in the adjacent teeth only in Sectors 3, 4, and 5. Ericson and Kurol [8] stated that canines in the Sectors 3, 4, and 5 comprised 65% of the related root resorptions.
In the present study, all of the root resorptions were in Sectors 2, 3, and 4 and in KPG index 2 and 3. There was no resorption case in Sector 5. As can be seen from Table 1, only 3 teeth of 56 impacted canine teeth were in sector 5, and 2 of them matched KPG index 4. This means that the canines in Sector 5 have a deep localization. But it should not be passed on without being told; these are a rather small numbers for drawing reliable conclusions about these scores. This fact may explain the difference between the results of the present study and those of Jung et al [15] and Ericson and Kurol [8]. These results showed that the Sector classification of the impacted canines may help to detect root resorptions at the adjacent teeth. If Sector evaluation on OPG is 2 or above, root resorption may have been at the adjacent lateral incisors, and thus CBCT evaluation should be recommended for detailed examination. The determination of the labiopalatal positions of the canine cusps tips was an important issue in the diagnosis and treatment planning of impacted canine cases. This evaluation can be made by Sector classification on OPG or KPG index on CBCT [10,15]. Jung et al [15] evaluated 73 impacted maxillary canines of 63 patients by OPG and CBCT, and classified them by sector location. According to their results, 26 out of the 30 labially impacted canines were located in Sectors 1, 2, and 3, while 15 out of the 23 mid-alveolus impacted canines and 17 out of the 20 palatally impacted canines were in Sectors 4 and 5. In the present study, roughly half of the labially impacted canines had 3 KPG and Sector scores. All mid-alveolus impacted canines had scores 1 and 2 in both KPG index and Sector classification. Of the 33 palatally impacted canines, 29 teeth were in the KPG index 2 and 3 and in Sectors 2, 3, and 4. These results suggest that sector location on OPG could help to predict the labiopalatal positions of the impacted canines as it is done by KPG index on CBCT.

5. CONCLUSIONS
The results of the present study can be summarized as follows:

- KPG indexes 1, 3, and 4 corresponded to panoramic Sectors 1, 4, and 5, respectively, while KPG index 2 is related to panoramic Sectors 2 and 3.
- Lateral incisor root resorption was seen predominantly in KPG index 2 and 3, and in Sectors 2, 3, and 4.
- Score 1 and 2 for both KPG index and Sector classification showed mid-alveolar impaction; score 3 showed labial impaction for both evaluation groups; and score 2 and 3 in KPG index 2, 3, and 4 in Sector classification were related to palatally impacted canines.
- OPG could help the evaluation of impactedmaxillary canine cases by providing information related to CBCT results.

CONFLICT OF INTEREST
The authors declare no conflict of interest.

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COMPETING INTERESTS
The authors declare that they have no competing interests and revised the article critically. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE
Written informed consent containing all the information about records and usage for study was obtained from all patients. All procedures in this study were approved by the Ethical Board of the Istanbul Medipol University (108400987-97-86) and complied with the Code of Ethics of the World Medical Association (Declaration of Helsinki).

AUTHOR CONTRIBUTIONS
SA: contributed to the concept and design of the study, to the acquisition, analysis and interpretation of the data and drafting the article. HO: participated by critically revising the article. All authors read and approved the final manuscript.

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Questions

1. Which is the most common clinical approach used by orthodontists to determine the impacted canine position?
   - a. Panoramic radiography;
   - b. CBCT;
   - c. Periapical radiography;
   - d. Bite wing radiography.

2. According to the SEDENTEXT Project, in which cases it is indicated to have a CBCT records?
   - a. In every impacted canine patient;
   - b. In case inadequate information is obtained from conventional radiographs about impacted canines;
   - c. Only adult patients with impacted canine;
   - d. Answers a-d are correct.

3. The aim of the present study to evaluate?
   - a. The efficiency of the CBCT to determine the impacted canine position;
   - b. The efficiency of the Panoramic radiographs to determine the impacted canine position;
   - c. The capacity of the impacted canine to resorb the root of the lateral tooth;
   - d. The correlation between effectiveness of KPG index and sector classification.

4. According to the present study results, in which common regions was the lateral tooth root resorption found in the KPG and Sector analysis?
   - a. 1;
   - b. 2 and 3;
   - c. 4;
   - d. 1 and 2.
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OSTEOSYNTHESIS MATERIALS IN MAXILLOFACIAL SURGERY: REJECTION, REMOVAL, CORROSION AND PARTICLE DETECTION RATES

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ABSTRACT

Background Titanium is traditionally the material of choice for osteosynthesis in maxillofacial surgery and has a wide array of application in this field. Conversely, a growing interest for alternative fixation methods has emerged in the literature. Promising results have been reported for 3D-designed and manufactured (CAD/CAM) titanium materials, whereas the use of biodegradable materials seems to be a more controversial topic.

Objective To conduct a narrative review on the complications related to osteosynthesis materials in maxillofacial surgery in terms of rejection-, removal-, corrosion- and particle detection rates.

Data Sources A literature search was performed in April 2020 using the electronic database PubMed (National Library of Medicine, NCBI). The search included studies published between 1999 and March 2019.

Study Selection Articles were eligible for inclusion when data for the outcomes of interest were available.

Data Extraction Complication rates including rejection-, removal-, corrosion- and particle detection rates were extracted.

Data Synthesis The data were synthesized and analyzed according to the different types of osteosynthesis materials and fixation methods. Finally, the results were summarized and recommendations were listed for different types of surgical indications.

KEYWORDS

Mandibular Reconstruction; Bone Plates; Postoperative Complications; Surgical Wound Dehiscence; Corrosion.

1. INTRODUCTION

The use of plates and screws for osteosynthesis is the golden standard in maxillofacial surgery. In the literature, a wide range of different types of materials are used for different purposes, and each type of material has its own properties. Stainless steel was the first type of material to dominate the market, but it has been left behind due to its toxic and corrosive properties [1]. Stainless steel was replaced by titanium as the golden standard for osteosynthesis, which was found to be much more efficient, because of its non-toxicity and corrosion-resistance [1]. Since the introduction of titanium, an important evolution has been witnessed from standard titanium plates and screws to 3D -designed and -manufactured (CAD/CAM) titanium plates and screws [2,3]. Other contenders in this field are the bioresorbable materials, which in theory are interesting because of their bioresorbable aspects and the possibility to avoid a second surgery to remove the osteosynthesis material [4,5]. Several studies have analyzed these different types of materials in detail, proving each material has its own advantages and disadvantages. However, an overview comparing the complication rates of the different material types is lacking. The aim of this narrative review was to compare the complication rates related to osteosynthesis materials and reconstruction plates in terms of rejection, removal, corrosion and particle detection in soft tissues.

2. MATERIALS AND METHODS

PubMed was searched for articles that compared the different outcomes of interest from human results concerning osteosynthesis material and reconstruction plates. A lot of different outcomes are described in the literature, and not all authors use the same terminology. The term ‘rejection’ could not be found as such in the database, therefore it was redefined as a collective term for different more
commonly used outcomes in the literature such as ‘infection,’ ‘wound dehiscence,’ ‘plate exposure,’ or ‘screw loosening.’ The search was split into 2 parts: the outcomes of ‘rejection’ and ‘removal’ were searched simultaneously (search A), as well as the outcomes of ‘corrosion’ and ‘particle detection’ (search B). The main keywords used to build the search strategy were: “rejection,” “equipment failure,” “infection,” “screw loosening,” “plate extrusion,” “plate exposure,” “wound dehiscence,” “device removal,” “plate removal” and “hardware removal” for search A; “corrosion,” “biocompatible materials/chemistry,” “titanium/chemistry,” “particle detection,” and “pigment deposition” for search B (see Appendix I for full search strategy). An initial review was done based on title and abstract with a restriction in time of 10 years for search A and no restriction in time for search B. Potential articles were then examined in full text. A total of 15 studies were included in search A, and three studies in search B (Fig. 1). Articles were eligible for inclusion when data for the outcomes of interest were available. Further restrictions for the articles are listed in the exclusion criteria.

### 2.1. Selection Criteria

#### 2.1.1. Inclusion Criteria

- **Search A:**
  - Population: N > 100
  - Intervention: the use of osteosynthesis material/reconstruction plates for any type of maxillofacial procedure
  - Outcome: infection, screw loosening, wound dehiscence, removal of osteosynthesis material/reconstruction plates
  - 10-year time restriction (2010-2020)
  - Study type: systematic reviews (and meta-analysis), RCT, experimental controlled studies, observational studies.

- **Search B:**
  - Intervention: the use of osteosynthesis material/reconstruction plates for any type of maxillofacial procedure
  - Outcome: corrosion, particle detection in lymph nodes/soft tissues
  - Study type: systematic reviews (and meta-analysis), RCT, experimental controlled studies, observational studies.

#### 2.1.2. Exclusion Criteria

- **Search A:**
  - Population: N < 100
  - Publication dates older than the past 10 years
  - Study type: case reports, expert opinions, animal studies, ex vivo experiments

- **Search B:**
  - Study type: case reports, expert opinions, animal studies, ex vivo experiments

### 3. RESULTS

#### 3.1. Rejection- and Removal Rates

##### 3.1.1. Titanium Materials

**3.1.1.1. Miniplates vs Reconstruction Plates**

2 studies were found that compared these fixation systems. One systematic review included 5 studies with 511 cases who underwent vascularized osteocutaneous flap reconstruction of the mandible [6]. Patients with miniplates had a slightly higher rate of complications than did cases using reconstruction plates (RR = 1.1), but no significant difference in complication rates was found between the groups. The second retrospective study included 682 patients with fractures of the mandibular symphysis/body [7]. Both plating techniques used in this study (1 large plate vs 2 miniplates) show very good outcomes, but the application of a second bone plate increased the incidence of wound dehiscence, plate exposure, and need for plate removal significantly. Overall, a higher rate of complications was found in the miniplate groups. Therefore, one large reconstruction plate is recommended above titanium miniplates as a treatment for vascularized osteocutaneous flap reconstruction of the mandible and for fractures of the mandibular symphysis/body.

**3.1.1.2. Single Miniplate vs Double Miniplate**

2 studies compared the use of a single- vs a double miniplate system in the treatment of a mandibular angle fracture. Both studies concluded that a single miniplate fixation system resulted in good stability and fewer postoperative complications, including wound problems/dehiscence, infection, screw loosening, plate fracture and hardware removal [8,9].

**3.1.1.3. 2.0 mm Locking Reconstruction Plates**

2 studies were included that used 2.0 mm locking reconstruction plates for mandibular reconstruction. The first study included 307 patients who had undergone osteocutaneous free flap reconstruction with 2.0 mm locking plate fixation following mandibular resection for benign or malignant neoplasia or osteoradionecrosis [10]. Plate removal was necessary in 27%, most likely due to surgical site infection or fistula formation. The second study included 162 patients with segmental resections of the mandible reconstructed with angular stable plates [11]. They compared 2.0 mm with 2.5 mm locking reconstruction plates. No significant difference in complication rates was reported between the two types of plates. Plate removal was necessary in 28%, which is similar as the findings reported in the first mentioned study. A total complication rate of 28% was reported, including loose screws (4.3%), oral- (7.4%) and extraoral dehiscences with fistula formation (11.7%).
Dehiscences were seen significantly more often in larger defects and with longer plates. Moreover, the rate of dehiscences was significantly higher in the midline. In conclusion, plate removal of 2.0 mm locking reconstruction plates is reported to be around 28%, and the probability of a complication seems to increase with the size of the defect. Therefore, when assessing complication rates, it is important not only to take the type of osteosynthesis material into account, but also anatomic factors such as defect size or anatomic location of the fracture, which seem to have a significantly more important impact on the success rate of the osteosynthesis than the osteosynthesis material itself.

3.1.1.4. Locking vs Non-Locking Plates/Screws

2 systematic reviews with meta-analysis compared a 2.0 mm locking plate system vs a non-locking system. The double-threaded screws of locking 2.0 mm miniplates locking to the bone and the plate create a mini–internal fixator, which results in a more rigid construction with less distortion of the fracture or osteotomy, less screw loosening, and less interference with bone circulation due to the slight pressing of plates against the bone. In short, theoretical advantages of the locking miniplate system mainly include less precision required in plate adaptation because of the internal/external fixator, less alteration in osseous or occlusal relationship on screw tightening, greater stability across the fracture sites and less screw loosening [12]. One study found a cumulative RR of 0.79, meaning the use of the locking plate in the fixation of mandibular fractures decreased the risk of the event (postoperative complication) by 21% [13]. However, despite the theoretical advantages of locking systems, neither of these systematic reviews found a significant difference in postoperative complication rates with the use of locking screw/plate systems when compared to the use of non-locking systems in the management of mandibular fractures.

3.1.1.5. Bicortical Screws

One study investigated the use of bicortical lag screws in 259 patients who had been treated by either BSSO or bimaxillary-osteotomy, with a total of 502 sagittal split osteotomies performed [14]. Removal of the osteosynthesis material was necessary in 5.6% of the cases. Bicortical screws had to be removed at 2.9% of the sites, and 2.3% of the removals were related to infection, including 1.2% of intra-oral fistula formation. In conclusion, the authors found that rigid fixation with 3 bicortical screws after BSSO is reliable with a low rate of postoperative removal of the osteosynthesis material. Other reported incidences indicate a lower rate of removal of bicortical screws than of miniplates [14]. Bicortical lag screw fixation was found to be at least as safe as miniplate fixation. Moreover, because of better fragment compression, bicortical lag screw fixation offers faster bone healing.

3.1.2. 3D (CAD/CAM) Materials

2 studies that compared 3D (CAD/CAM) plates and screws with standard titanium plates and screws were included. One retrospective study included 142 subjects who underwent microvascular mandibular reconstruction [3]. Perioperative complication rates were 35.9% in the titanium control Group vs 20.7% in the CAD/CAM custom plates Group. Hardware removal was necessary in 20.2% of the titanium plates vs 5.6% of the CAD/CAM custom plates. CAD/CAM custom plates utilized for rigid fixation during microvascular mandibular reconstruction demonstrated fewer complications and statistically lower reoperation rates when compared with prebent/preformed titanium plates. The other study included was a systematic review and meta-analysis including a total of 661 patients in 17 studies that compared 3D miniplates with the standard two-miniplate technique in mandibular fractures [2]. Mandibular fracture fixation with 3D miniplates was found to decrease the risk of postoperative complications by 52% compared with standard miniplates (OR 0.48). Infection and wound dehiscence were less common in the 3D miniplate Group (OR 0.58; OR 0.36, respectively), but these findings were not significant. The cumulative analysis showed a statistically significant difference in the outcome of hardware failure, favoring 3D miniplates (OR 0.14, p = 0.004). The results of this meta-analysis showed that the use of 3D miniplate fixation had lower complication rates when compared with the use of standard miniplate fixation in the management of mandibular fractures. This result was statistically significant. Another interesting outcome measured in this systematic review was the operative time: 3D plate technique showed a significant time benefit (p<0.00001). The authors concluded that the major advantage of the 3D miniplate technique is the simultaneous stabilization of the tension and compression zones, making the 3D plates a time-saving alternative to conventional miniplates.

3.1.3. Biodegradable Materials

The use of biodegradable materials for osteosynthesis has been an interesting evolution on the market. The theoretical advantage of their resorbable properties sounds promising, as it could resolve the problem of the need for a second surgery for removal of other non-resorbable materials. However, this feature does not tell much about the clinical usefulness of such materials, as it does not exclude other complications such as non-union, infection, hardware failure or removal. One systematic review and three RCT’s were included in this report. The removal rates varied between 1.5%-16.4% in the titanium control Group and 3.6-26.4% in the biodegradable test Group [5,15]. The risk of necessity for biodegradable plate and screws removal was two times higher compared to titanium plates and screws after long-term follow-up >5y (HR 2.0, p = 0.036) [5]. Abscess formation was the main reason for plate/screw removal in both groups [4,5]. Regarding plate/screws removal after >2 and >5 years follow-up, the performance of the Inion CPS biodegradable system was inferior compared to the KLS Martin titanium system following the fixation of mandibular, Le Fort-I, and zygomatic fractures, and bilateral sagittal split osteotomies (BSSO) and/or Le Fort-I osteotomies [4,5]. Given the higher rates of plate removal, there seems to be no place for the clinical usage of Inion CPS in treatment of these fractures.
clinical usage of Inion CPS in treatment of these surgical indications. Another RCT included 200 Japanese adults with jaw deformities diagnosed as mandibular prognathism who underwent BSSO surgery [16]. The authors found complication rates of 8.2% in the biodegradable Group and 3.3% in the titanium Group, including similar infection rates of 3.6% and 3.3%, respectively. However, although a greater frequency of material-related complication was observed in the biodegradable fixation plate Group, no statistically significant differences were found in the incidence of material-related complications between the biodegradable and titanium groups. The authors suggest that the use of biodegradable plates should be recommended only for minimally loaded situations.

3.2. Corrosion- and Particle Detection Rates
In this second search, the focus was mainly set on the rates of corrosion and particle detection in soft tissues. An extended search was performed for both outcomes. Data were found reporting titanium particles detected in animal lymph nodes after osteosynthesis before [17,18], and several articles mentioned the detection of titanium particles in locoregional lymph nodes, which are thought to be due to the corrosion of the titanium [15]. However, reports of titanium and titanium dioxide in tissues adjacent to hardware and in regional lymph nodes have shown that only clinically insignificant amounts of these materials accumulate [1]. The data analysis in this report focusses on the incidence of corrosion and pigmentation deposits from titanium fixation systems.

Three studies that examined the outcomes of interest were included. Acrero et al. carried out a prospective histological study on 37 commercially pure titanium miniplates, removed from 23 patients who had undergone surgery for maxillofacial traumatic injuries or deformities [18]. Hole-like images were found in 35.1% of the plates studied. The authors suggest that such anomalies may be corrosion effects in a biomaterial, with titanium-particles released to the surrounding tissues. Dark pigmented deposits were found in 80% of the specimens of soft tissue surrounding the analyzed plates. Defects on the surface of the biomaterial and pigmented deposits in soft tissues surrounding the plates suggest a higher development of corrosion in titanium than previously reported. In a more recent study, 60 pure titanium plates retrieved from 44 patients and 60 soft tissue specimens taken from adjacent locations were examined [19]. Pigmented deposits were detected in 68% of the soft tissue specimens. These pigmented deposits were initially also attributed to the presence of titanium particles, as in most similar studies. However, elemental analysis of pigmented deposits did not confirm this assumption. The authors concluded that the incidence of ‘titanium deposits’ might have been overestimated in the past. Moreover, this study did not report any signs of corrosion of the metal plates. These findings correspond to the results of the third study included, where no evidence of macroscopic or microscopic titanium corrosion or deterioration in the tissues was found [20]. There was no evidence to support the view that titanium miniplates should be removed routinely due to corrosion up to a period of 13 years. Overall, these findings suggest that corrosion and particle deposition in surrounding soft tissues are clinically irrelevant and should not be considered as a reason for the removal of titanium osteosynthesis material on the long-term.

4. CONCLUSION
This review provides an overview of the complication rates related to different types of osteosynthesis materials and systems used in maxillofacial surgery, including rejection-, removal-, corrosion- and particle detection rates in surrounding tissues.

Reported incidences of removal of titanium fixation systems in maxillofacial surgery ranged from 5.6% to 28%, depending on the type of titanium fixation system and the surgical indication. When comparing titanium- to 3D (CAD/CAM) materials, reported hardware removal rates are up to four times lower for 3D manufactured materials. Moreover, the use of the 3D miniplate fixation has significantly lower complication rates in the management of mandibular fractures. Therefore, CAD/CAM fixation systems are recommended in the management of mandibular fractures. Biodegradable materials, however, are not recommended for clinical usage in the treatment of traumatic fractures or osteotomies in the maxillofacial area, given the higher rates of plate removal after >5y follow-up.

Finally, corrosion and particle deposition in the surrounding soft tissues seem to be clinically irrelevant and should not be considered as a reason for removal of the titanium osteosynthesis material on the long-term.

CONFLICT OF INTEREST
The authors declare no conflict of interest.

ACKNOWLEDGMENTS
None.

AUTHOR CONTRIBUTIONS
SEB: data acquisition, analysis and interpretation of the results, author of the article. CP: substantial contribution to the conception and design of the study, revision of the manuscript.
Appendix I: Pubmed search strategy

Search A:

Search B:

REFERENCES

1. What fixation system has the lowest complication rates and is therefore recommended in the management of mandibular fractures?
   - q. Double titanium miniplate system;
   - q. Biodegradable materials;
   - q. 3D (CAD/CAM) fixation systems;
   - q. Locking plates/screws.

2. The risk of postoperative complications is:
   - q. Decreased by approximately 50% with 3D miniplates compared to titanium plates in the management of mandibular fractures;
   - q. Three times higher in terms of hardware removal with biodegradable materials compared to titanium plates;
   - q. Significantly lower for double miniplates compared to single miniplates;
   - q. Not significantly different for double titanium miniplates compared to a large reconstruction plate in the management of mandibular fractures.

3. Regarding plate/screws removal after >5 years follow-up following fixation of traumatic fractures and osteotomies in the maxillofacial area, the performance of the biodegradable system was assessed as:
   - q. Superior compared to the titanium system, therefore the clinical usage of a biodegradable fixation system in the treatment of these surgical indications is strongly recommended;
   - q. Superior compared to the titanium system, therefore the use of biodegradable plates should be recommended for maximally loaded situations;
   - q. Equal compared to the titanium system, therefore the use of biodegradable plates could be a clinically useful alternative in the treatment of these surgical indications;
   - q. Inferior compared to the titanium system, therefore there seems to be no place for the clinical usage of biodegradable systems in the treatment of these surgical indications.

4. Which of the following statements is true regarding corrosion and/or particle deposition in surrounding soft tissues?
   - q. Corrosion rates of titanium miniplates are clinically relevant and should be considered as a reason for the removal of titanium osteosynthesis material on the long-term;
   - q. Corrosion rates of titanium miniplates are clinically irrelevant and should not be considered as a reason for the removal of titanium osteosynthesis material on the long-term;
   - q. Pigment deposition rates in surrounding soft tissues of titanium plates of up to 90% have been reported and should therefore be considered as a reason for the removal of titanium osteosynthesis material on the long-term;
   - q. Reports of titanium deposits show no evidence of particle accumulation in tissues adjacent to titanium hardware nor in regional lymph nodes.

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Questions

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FEATURES OF HIGHLY VIEWED YOUTUBE VIDEOS ON ALL-ON-4 AND SKY FAST & FIXED

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ABSTRACT

Introduction The study aimed to assess features of highly viewed YouTube videos on an alternative of implant-supported fixed prosthesis, namely All-on-4 and SKY fast & fixed, compared to those with a considerably lower number of views.

Methodology Eighty YouTube videos were analyzed, 40 that registered the highest numbers of views, and as control 40 with a considerably lower numbers of views. The search was conducted in February 2020. Data were collected on bibliometric indices, general video features and medical information presented.

Results Highly viewed videos had variable features, tended to date at least 4 years back, with a 5-minute duration, in English, either in spoken or written form, with multiple forms of media content, information presented by the dentist, mainly on implant placement and definitive fixed prosthesis, clearly indicating identification data on the dentist’s and the dental clinic name. When compared to videos with a considerably lower number of views, the latter are often longer, in other languages than English, have images as multimedia content, the information presented frequently includes theoretical medical aspects, fragments from clinical interventions, information on definitive fixed prosthesis, and frequently mention identification data on the dentist’s name and the dental materials used.

Conclusions Highly viewed videos on dental theme as All-on-4 and SKY fast & fixed have features that differentiate them from those with a considerably lower number of views. Knowing this information helps making videos that meet the users’ needs and are more likely to reach their purpose, namely the general population education.

KEYWORDS

Patient Education; Dental Implant; Prosthodontic; Media.

1. INTRODUCTION

Nowadays patient-information sources on medical issues are numerous and diverse. In fact, online resources are an important category, they are used considerably more frequently, with an impact that still needs to be better known considering their various content and sometimes doubtful credibility [1,2]. Among the online resources, videos are a particular category that registers an increased use, being a good tool for medical information for both the public and medical professionals [3]. They can be accessed on different platforms, among which YouTube is one of most popular. Previous research that assessed the information quality of medical aspects presented by online videos suggested that YouTube is not currently an appropriate source of information, considering sometimes it spreads misinformation [4,5]. Analyzing such documents, it can be easily noticed that they are different in many respects. Considering their increased use, it is important to know the features of highly viewed online videos, which allows medical professionals to make not only videos that transmit the correct information, but also ones that are likely to be accessed by many persons, and therefore reach their purpose to educate. The aim of this study is to assess features of highly viewed YouTube videos on an
alternative of implant-supported fixed prosthesis, namely All-on-4 and SKY fast & fixed, compared to those with a considerable lower number of views. Comparisons were made regarding the videos general characteristics such as age, length, language used, multimedia content, as well as some aspects related to their medical theme, namely the presenter’s training, type of medical information presented, reference to treatment steps, identification data.

2. METHODOLOGY

For this study a search on YouTube in February 2020 was conducted. The search terms used were “All-on-4” and “Fast and fixed”. There were 40 videos analyzed that registered the highest numbers of views, and as control 40 videos with a considerable lower numbers of views. Data were collected on the following aspects:

- bibliometric indices i.e., number of views, likes, dislikes, and comments;
- general features of the video: the date the video was posted; length of the video (registered in seconds); the language used in the video (registered as English, other language, or without spoken or written communication); multimedia content (if they comprised text, images, audio, videos, animation, and also registering the number of modalities used);
- medical aspects: presenter (dentist, dental nurse, dental technician, patient, unclear, no one); type of medical information presented (theoretical aspects, dentist interviews, fragments from clinical interventions, imaging data, other); medical information presented in regard to treatment steps (data collected during patient evaluation, during surgical intervention for implant placement; of interim prosthesis, of the definitive fixed prosthesis, during follow-up); identification data on the dentist, dental clinic, dental implant manufacturer, and dental materials used.

A statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS Statistics) Considering the data distribution, nonparametric tests were used. For the group comparison the Mann Whitney test and chi-square test were used, according to variable type. The p-values < 0.05 were considered to be statistically significant.

3. RESULTS

Eighty videos were analyzed, 40 videos with the highest number of views (between 71332 and 1232391 views), and 40 with a considerably lower number of views (between 964 and 1562 views). Highly viewed videos dated back a median of nearly 4 years, ranging widely, from 4 months to almost 11 years. The median of their duration was nearly 5 minutes, almost double compared to the one observed in the group with lower number of views, the longest video being almost 50 minutes.

The majority of the videos were in English, but while videos without spoken or written language communication registered lower number of views (e.g., a median of 92974 views in the group of high viewed videos), those in English and in other languages registered higher and similar number of views (median of 192542 views for the videos in English, and 192703 views for the videos in other languages). In highly viewed videos various multimedia content was used, as text, audio, video and images in the majority of them. More frequently the dentist presented or explained the information in highly viewed videos, while patients more frequently presented this information in the videos with a considerable lower number of views, but the difference was not statistically significant. In none of the videos the dental assistant or the dental technician presented the information. In most highly viewed videos fragments were included from the clinical interventions, along with presentation of theoretical aspects, with a statistically significant higher frequency than in the videos with a lower number of views. With a low frequency, aspects as treatment cost and insurance coverage, treatment alternatives, maintenance procedures, dentist-patient relationship, types of materials used, history of dental implants were mentioned. In most highly viewed videos information was included on implant placement and definitive fixed prosthesis, while in most of those with a considerable lower number of views aspects were discussed related to follow-up, patient evaluation and implant placement. Identification data were more frequently encountered in highly viewed videos, most frequently being mentioned the dentist name (Table 1).

4. DISCUSSION

Highly viewed videos on dental theme as All-on-4 and SKY fast & fixed have different features, tend to date at least 4 years back, with a duration of about 5 minutes, mainly in English, either in spoken or written form, with multiple forms of media content (text, audio, video, images), with information presented by the dentist, mainly on implant placement and definitive fixed prosthesis, clearly indicating identification data on the dentist’s name and the dental clinic name. When compared to videos with a considerable lower number of views, the latter have a greater number of likes, dislikes and comments, have a longer duration, have spoken or written language communication in other languages than English, have more frequently images as multimedia content, the information presented includes more frequently theoretical medical aspects and fragments from clinical interventions, as well as information on the treatment steps more frequently on definitive fixed prosthesis and less frequently on follow-up, mention more frequently identification data regarding the dentist’s name and the dental materials used, and less frequently data on the dental clinic.
The age of the videos may be a factor that has an impact on the document’s visibility, but this research similar to others found that most highly viewed videos on a specific medical theme have very different range in this regard, the trend being of about 4 to 5 years [6,7].

The specific particularities of the video most probably have an impact on its viewing. They should not be too long or too short. This study suggests that the duration should be of about 5 minutes. Other studies found that the duration of highly viewed videos on other medical themes is longer, of about 10 minutes [7], or of about 8 minutes [8], or less, of about 3 minutes [9]. Probably the complexity of the medical topic has an impact on the video length. Chen et al. [8] study results found that useful videos are of a larger duration compared to misleading videos.

These studies show that videos in English were most used. Even so, there were videos in other languages with a very high number of views. An explanation may be that individuals frequently search information in their native languages, due to the fact that they probably understand it more easily. Explanations relatively often include medical terms, which are sometimes difficult to understand in the native language, sometimes even more difficult to understand in other languages, these being among the barriers and difficulties in understanding medical information [10]. Other researchers found similar results, as the one of Dutta et al. [11], that found that videos in Hindi on COVID-19 pandemic had a higher number of views than those in English.

Similar to other research on other medical topics, patients’ testimonials and dentist interviews are frequently used to present information [12,13]. This study shows that videos in which the speakers are dentists are more likely to register a higher number of views compared to videos in which the speakers are the patients. This may be explainable considering the information may be considered more valid when is presented by a specialist in the field.

It is important to adequately include medical information that is pertinent to the subject discussed in the video, but also aspects that are important from the patient’s perspective [14].

### Table 1. Features of videos analyzed.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Highly viewed videos</th>
<th>Low viewed videos</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likes (median)</td>
<td>332.5</td>
<td>4</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Dislikes (median)</td>
<td>39.5</td>
<td>0</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Comments (median)</td>
<td>25.5</td>
<td>0</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Date (median)</td>
<td>April 3rd 2016</td>
<td>September 16th 2016</td>
<td>0.126</td>
</tr>
<tr>
<td>Duration (median)</td>
<td>289 seconds</td>
<td>145 seconds</td>
<td>0.006*</td>
</tr>
<tr>
<td>Language: English:other: none (no.)</td>
<td>28:8:4</td>
<td>35:0:5</td>
<td>0.007*</td>
</tr>
<tr>
<td>Multimedia content</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- text (no.)</td>
<td>34</td>
<td>32</td>
<td>0.246</td>
</tr>
<tr>
<td>- images (no.)</td>
<td>25</td>
<td>15</td>
<td>0.012*</td>
</tr>
<tr>
<td>- audio (no.)</td>
<td>34</td>
<td>35</td>
<td>0.785</td>
</tr>
<tr>
<td>- video (no.)</td>
<td>31</td>
<td>34</td>
<td>0.685</td>
</tr>
<tr>
<td>- animation (no.)</td>
<td>15</td>
<td>15</td>
<td>0.858</td>
</tr>
<tr>
<td>- media forms (median)</td>
<td>4</td>
<td>3,5</td>
<td>0.142</td>
</tr>
<tr>
<td>Speakers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- dentist (no.)</td>
<td>19</td>
<td>11</td>
<td>0.065</td>
</tr>
<tr>
<td>- patient (no.)</td>
<td>13</td>
<td>20</td>
<td>0.012</td>
</tr>
<tr>
<td>- unclear (no.)</td>
<td>5</td>
<td>5</td>
<td>&gt;0.999</td>
</tr>
<tr>
<td>- nobody (no.)</td>
<td>10</td>
<td>10</td>
<td>&gt;0.999</td>
</tr>
<tr>
<td>Type of medical information presented</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- theoretical aspects (no.)</td>
<td>18</td>
<td>5</td>
<td>0.001*</td>
</tr>
<tr>
<td>- dentist interviews (no.)</td>
<td>16</td>
<td>9</td>
<td>0.064</td>
</tr>
<tr>
<td>- fragments from clinical interventions (no.)</td>
<td>23</td>
<td>14</td>
<td>0.024*</td>
</tr>
<tr>
<td>- imaging data (no.)</td>
<td>14</td>
<td>9</td>
<td>0.165</td>
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<tr>
<td>Refer to treatment steps</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>- patient evaluation (no.)</td>
<td>19</td>
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<td>- interim prosthesis (no.)</td>
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<tr>
<td>- definitive fixed prosthesis (no.)</td>
<td>24</td>
<td>14</td>
<td>0.013*</td>
</tr>
<tr>
<td>- follow-up (no.)</td>
<td>11</td>
<td>24</td>
<td>0.006*</td>
</tr>
<tr>
<td>Identification data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- dentist name (no.)</td>
<td>29</td>
<td>18</td>
<td>0.005*</td>
</tr>
<tr>
<td>- dental clinic name (no.)</td>
<td>21</td>
<td>31</td>
<td>0.037*</td>
</tr>
<tr>
<td>- dental implant manufacturer (no.)</td>
<td>14</td>
<td>7</td>
<td>0.054</td>
</tr>
<tr>
<td>- dental materials (no.)</td>
<td>9</td>
<td>2</td>
<td>0.018*</td>
</tr>
</tbody>
</table>
The results of this research indicate that highly viewed videos presented more frequently on the definitive fixed restoration. Considering the treatment alternatives analyzed, All-on-4 and SKY fast & fixed are indicated for completely edentulous patients, most frequently treated by removable complete denture, definitive fixed restoration is an important factor for decision making from the patient’s perspective, thus, most probably the presentation of this information increased the number of views of those videos. Other research on YouTube videos on medical topics, such as Tang et al. [13], suggest that medical content influences the number of views, given the viewer’s interest.

The method used for this research is similar to other studies in the scientific literature [6,9]. View count of YouTube videos was the indicator used to rank documents according to their being accessed. This index was presumed to help identify and differentiate videos with a greater or lower impact on forming the consumer’s opinion. As others (e.g., likes), it has flaws related to several factors, as it does not indicate that the video was viewed entirely, is influenced by the video age, it is suspected not to be very accurate, as there is usually a small number of videos with a considerable higher number of views. Even so, considering the increasing use of Internet sources of information, bibliometric indicators have to be defined, and many of them for Internet videos are based on view count, as an indication of the video success. Bibliometric indicators for Internet media is an area that needs to be better known. We must clearly state that view count is not an indicator of content quality, which was also not aimed to be an objective of this research. This study was meant to try to identify some of the characteristics that facilitate creating a success video from the perspective of persons without medical training. This information could be useful for medical practitioners when creating a video for patients’ education and information.

4.1. Study limitations

The study limitations are the following: YouTube has 27 filters which determine which videos are shown first. A view is defined as a click on this movie, it does not mean that the whole movie has been viewed. The age of a movie must have an influence on its views. The older the movie, the higher the number of views, because the probability that an old movie is picked up is higher than the one for a brand-new movie been picked, unless a filter is set for most recent ones. The number of views is not a quality criterion but a result of filter choice, of aggressive marketing by the manufacturer and other non-disclosed parameters in YouTube. The number of likes is low with a frequency of 0.064% being insignificant. The method used did not allow to target the trueness of the information presented. Hence, it is impossible to deduct if the implant treatment is good, bad or problematic. Another study limitation is the fact that a comparison was made to a limited number of videos with a considerably lower number of views, the rest of them probably having various other characteristics. Also, considering the specific topic analyzed i.e., All-on-4 and SKY fast & fixed, most probably videos on other dental and medical topics may present different particularities. In this research users were considered to be private individuals.

5. CONCLUSION

Highly or less highly viewed videos on dental themes as All-on-4 and SKY fast & fixed are meant for the general population and bear no scientific or educational value. In the level of evidence these video’s score less than a case-report. The number of views depends on the parameter chosen and is not a measure of quality nor of trueness. Video-information as found on YouTube cannot replace well-executed formal studies published in peer-reviewed dental journals and should not be recommended to clinicians or to patients.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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All authors have an equal contribution to this manuscript as the first author.

AUTHOR CONTRIBUTIONS

CP: concept, data analysis, data interpretation, critical review.
RT: concept, data analysis, data interpretation.
LL: concept, data analysis, data interpretation.

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YouTube videos on All-on-4 and SKY fast & fixed

Full text links CrossRef PubMed Google Scholar

Full text links CrossRef PubMed Google Scholar WoS

Full text links CrossRef PubMed Google Scholar Scopus WoS

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Questions

1. Which of the following statements about patient-information sources on medical aspects is incorrect:
   - a. Are numerous and diverse;
   - b. Are sometimes of doubtful credibility;
   - c. Patients use only online resources for medical information;
   - d. Online videos are not good tools for medical information.

2. The correct statement regarding medical information videos:
   - a. Can be only accessed on YouTube;
   - b. Are used only for patients’ information;
   - c. Are used only for medical professional information;
   - d. Sometimes spread misinformation.

3. Which of the following statements about highly viewed YouTube videos on All-on-4 and SKY fast & fixed is correct:
   - a. Have an average duration of 5 seconds;
   - b. Are always in English;
   - c. The presenter is most commonly a patient;
   - d. Commonly include information on the definitive fixed prosthesis.

4. Highly viewed YouTube videos on All-on-4 and SKY fast & fixed, compared to videos with a considerable lower number of views:
   - a. Have on average a shorter duration;
   - b. Have on average the same duration;
   - c. Mention more frequently identification data on the dentist’s name;
   - d. Are always in English.
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INTRA-ORAL REPAIR OF CERAMIC CHIPPING USING RESIN COMPOSITE: DESCRIPTION OF A STEP-BY-STEP TECHNIQUE

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ABSTRACT

Aim This article aims to present and discuss an intra-oral repair technique for repairable ceramic fractures in tooth- or implant-supported fixed dental prostheses.

Summary In the intra-oral repair technique, after insulation with rubber-dam and proper cleaning, a bevel was prepared at the margins of the fractured area with a fine-grain diamond bur. Conditioning with 9.6% hydrofluoric acid was carried out for 120 s in the bevel and in the fractured area. On the clean and dry surface, the silane coupling agent was applied and allowed to react for one minute. Afterwards, the resin adhesive was rubbed on the surface, allowing the restoration of the area to repair with small increments of resin composite. The intra-oral repair was finished and polished with discs and rubber tips, and the occlusion was adjusted.

Key learning points 1. To execute a minimally invasive approach. 2. To repair the damaged ceramic area of a prosthesis restored in a single session. 3. To learn the meticulous order of surface conditioning, finishing and polishing protocols.

KEYWORDS Adhesion; Ceramics; Chipping; Intra-Oral Repair; Resin Composite.

1. INTRODUCTION

Despite advances in digital laboratory strategies to manufacture tooth- and implant-supported fixed dental prostheses (FDP), obtaining personalized esthetic results, especially in anterior areas, still depends on traditional ceramic stratification techniques. In these techniques, feldspar porcelain is applied on the framework, layer by layer, using powders with different colors and opacities [1]. An excellent esthetic result is obtained in multi-layered prostheses; however, an interface is generated between the framework and the veneering ceramic, representing the most fragile link of this type of restorations [2]. Thus, chipping and fractures of the veneering ceramic are frequently observed in such FDPs [3]. This is due to the lower strength of porcelain compared to the material used in the framework (metal or zirconia); the presence of residual stress resulting from the incompatibility of the thermal expansion coefficients (CET) between the materials, and the tension resulting from the cooling that occurs after ceramic sintering [4].

Associated with this, laboratory factors, such as the irregular thickness of the veneering ceramic, inadequate infrastructure design, and the presence of defects and micro-porosities incorporated after stratification, further increase the risk of failure. Insufficient dental preparation, inadequate occlusal adjustment, lack of ceramic polishing after occlusal adjustment, stresses during chewing, trauma, or the presence of parafunctions also contribute to the formation of cracks and their propagation until fracture [5,6].

Clinical follow-up studies report that fractures of the veneering ceramic and the presence of dental caries are the most frequent failures in metal-ceramic FDPs [7]. The fracture of the veneering ceramic is also observed in prostheses with zirconia frameworks, with failure rates ranging between 6 to 15%, after 3 years [8]. These prostheses have a higher percentage of failures than traditional metal-ceramic FDPs, which present chipping or fracture rate of about 4% over a 10-year period of clinical follow-up [9].
Regarding failures, different behaviors are also observed in implant-supported FDPs. In these prostheses, the masticatory load is about 8 to 10 times greater than in the teeth, due to the lack of proprioceptive receptors in the periodontal ligament [10]. The implant/prosthetic component has an elasticity module much higher than the natural tooth [11], which results in a higher concentration of stresses and an increase in failures. Fractures and chipping of the veneering ceramic were observed in about 12.4% of implant-supported FDPs, after 5.7 years [12].

Regardless of the prosthesis present in the oral cavity, fractures and chipping result in great discomfort for the patient, who seeks care to solve this problem and esthetic compromise, especially when the fracture occurs in the anterior area. The replacement of these restorations must be carefully evaluated by the clinician, since it involves additional costs, as well as increase in working time [5]. If the prosthesis has good marginal adaptation and adequate esthetic quality, the fractured area can be repaired without the need of removal, as long as the failure has not compromised the structural, functional and esthetic integrity of the prosthesis [13].

2. INTRA-ORAL REPAIR USING RESIN COMPOSITE

The technique of resin composite intra-oral repair is a minimally invasive approach that aims to restore the damaged area of a prosthesis, avoiding its removal and subsequent replacement [6]. If the clinician chooses to replace the prosthesis, she/he must consider that removing the prosthesis with burs can lead to greater wear of the dental tissue, in addition to being a more expensive and complex procedure. On the other hand, intra-oral repair is a quick and economical procedure, which can be done in a single clinical session, without the need for additional clinical steps or laboratory costs [14].

In this technique, the fractured area is restored with resin composite materials. For the intra-oral repair to be successful, it is essential to confirm the clinical and radiographic quality of the prosthesis before the intervention along with assessing the type and size of the failure. A direct repair with resin composite can only be made if the prosthesis has good marginal adaptation and adequate esthetics [14]. The patient must be informed about the advantages and disadvantages of the intra-oral repair technique before the procedure.

The fracture that occurs in the veneering ceramic may or may not expose the framework. Thus, different materials may be present after the fracture, guiding the adhesive protocol that should be used during the repair technique (Table 1). Regarding the size, the failures can be small, moderate or large [15]. Minor failures, such as discreet chipping of the veneering ceramic, can be solved by finishing with discs and polishing with rubber tips. Intra-oral repairs made with resin composite resin can solve small and medium failures that present esthetic and functional implications. On the other hand, major failures, which involve areas of proximal and occlusal contacts, are usually resolved with indirect repairs made in the laboratory or by replacing the prosthesis [15].

The durability of intra-oral repairs made with resin composite depends of the factors such as the location of the failure, adhesive potential of the substrate, previous treatment of the surface to be repaired, quality of the adhesive protocol, and direction and magnitude of the forces applied in the resin composite repair [6]. In order to improve the adhesive potential of different ceramic substrates, surface treatments such as conditioning with hydrofluoric acid (HF), air-abrasion with aluminum oxide particles or tribo-chemical treatment followed by the application of a silane coupling agent can be used [16,17].

<table>
<thead>
<tr>
<th>Table 1. Surface conditioning protocols for different substrates present in intra-oral fractured areas.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Substrate present after fracture</strong></td>
</tr>
<tr>
<td>Tooth (enamel or dentin)</td>
</tr>
<tr>
<td>Metal</td>
</tr>
<tr>
<td>Feldspathic porcelain and glass-ceramics (leucite and lithium disilicate)</td>
</tr>
<tr>
<td>Oxide ceramics (zirconia)</td>
</tr>
</tbody>
</table>
3. DESCRIPTION OF THE TECHNIQUE

The intra-oral repair technique is indicated for dental- and implant-supported fixed prostheses that have small to moderate failures. In addition, these prostheses should have good clinical and radiographic adaptation, in addition to an acceptable esthetic appearance [12,14]. The steps to make an intra-oral repair in resin composite are described below:

1. After identifying the need to make an intra-oral repair (Fig. 1), match the color of the resin composite that will be used during the clinical protocol (Fig. 2). A shade guide or a small increment of photopolymerized resin composite over the area can be used for shade selection.

2. Insulation of the working site with rubber-dam to protect the soft tissue and adjacent teeth from the damaging effects of hydrofluoric acid (HF), and to keep the area dry during adhesive procedures, avoiding contamination with saliva.

3. Make a prophylaxis of the area to be repaired with brushes and prophylactic paste without fluoride to remove the contaminants present on the ceramic surface (Fig. 3).

4. Prepare a bevel in the remaining ceramic with a fine-grain diamond bur (Fig. 4). Use abundant irrigation to avoid heating of the ceramic, preventing the propagation of cracks. The bevel will allow a smoother transition between the ceramic and the resin composite, in addition to increasing the area available for adhesion of the material (Fig. 5).

5. The remaining ceramic surface that will not be repaired, must be protected by glycerine gel or a polyfluoroethylene tape. Air-abrasion of the area can also be made before acid conditioning, for 10 seconds, in order to obtain a more effective cleaning (Fig. 6). If adhesion is made on feldspathic porcelain, 9.6% hydrofluoric acid should be applied to the bevel and fractured area for two minutes (Fig. 7). If the metal or ceramic infrastructure is exposed, it must be properly treated before conditioning the porcelain. In exposed metal frameworks, air-abrasion the surface with alumina particles coated with silica or silica only (particle size range: 30 to 50 microns, blasting pressure: 2.5 bar), for approximately five seconds in a circling motion, and rotating the nozzle at a distance of approximately 10 mm. In zirconia infrastructures, air-abrasion or tribo-chemical treatment with silica deposition must also be made before the application of the silane coupling agent. The lithium disilicate infrastructures respond well to conditioning with hydrofluoric acid for 20 seconds, allowing the action of the silane agent and bonding with the adhesive resin.

6. After conditioning, wash the area with abundant water for three minutes. Neutralizing agents can be applied on the area for one minute to neutralize the action of the acid. The area is washed and dried again.

7. Apply silane coupling agent on the dried area with a clean disposable brush (Fig. 8). The silane is maintained for one minute and the solvent is removed with oil-free air.

8. Rub the adhesive resin over the area with a clean disposable brush for 20 seconds (Fig. 9). The adhesive resin excess is removed by aspiration and photo-polymerized for 20 s.

9. Afterwards, the intra-oral repair is performed with the resin composite previously selected, through small increments. Place each increment in the area with a spatula, placing them in position (Fig. 10). Each increment is photo-polymerized for 20 seconds (Fig. 11).

10. The repair is finished with discs and polished with rubber tips and polishing paste (Figs. 12 and 13). Afterwards, check the patient’s occlusion so that the repaired area is not overloaded during the function (Fig. 14).
Figure 3. Rubber-dam and cleaning of the area with prophylaxis paste.

Figure 4. Preparation of the bevel with a fine-grain diamond bur (KG Sorensen, FF Series, Brazil).

Figure 5. Completed bevel.

Figure 6. Air-abrasion with aluminum oxide particles for effective cleaning of the area. Before air-abrasion, the remaining ceramic was protected with glycerin gel and the adjacent teeth with protective tape.

Figure 7. Conditioning the fractured area and bevel with 9.6% hydrofluoric acid gel (Pulpdent, USA) for two minutes.

Figure 8. Application of the silane coupling agent (RelyX, 3M ESPE, USA) over the conditioned area with a clean disposable brush.

Figure 9. The adhesive resin bonding (Adper Scotchbond Multi-Purpose, 3M ESPE, USA) is rubbed on the area with a clean disposable brush, and the excess adhesive is removed with disposable suction.

Figure 10. A small increment of resin composite (Filtek Z-350 XT, 3M ESPE, USA) is placed in the area.

Figure 11. Each increment is photo-polymerized for 20 seconds.

Figure 12. The intra-oral repair is finished with discs.
Intra-oral repair of ceramic chipping

4. DISCUSSION

If intra-oral repair on a prosthesis is indicated upon fracture or chipping, the esthetic and functional problems caused by these failures can be more quickly resolved, without the need for removal and subsequent replacement of the prosthesis [12,14,15]. This procedure reduces the cost and time of treatment, and also provides immediate comfort to the patient, who has his problem solved in a single clinical session [14]. However, the success and longevity of resin composite intra-oral repair depends on compliance with the adhesive protocol, which will be defined according to the type of ceramic exposed after the failure [13,17,18]. In this technique, adhesion is essential to maintain the resin composite repair strongly attached to the damaged surface, without the need to create additional mechanical retentions on the ceramic surface, which would certainly result in increased failure and possible crack propagation.

The surfaces of ceramic materials currently available on the market exhibit different adhesive behavior based on their composition and crystalline structure [16-18]. Feldspathic porcelains and vitreous ceramics such as leucite and lithium disilicate are acid-sensitive ceramics, responding well to classic adhesive techniques that employ hydrofluoric acid and the application of the silane coupling agent. The more glass phase is present in the microstructure of these ceramics, the greater the surface roughness produced by acid conditioning, improving the bond to the resin adhesive [16]. The use of silane coupling agent allows the union of silicon dioxide (SiO₂) present in the ceramic surface with the resin adhesive [13]. These agents are inorganic-organic hybrid bifunctional molecules, capable of creating a siloxane network with the hydroxyl (OH) of the silica present on the ceramic surface, and copolymerizing with the adhesive agent, which will bond with the restorative material. However, the use of hydrofluoric acid must be performed carefully, as it can result in damage to soft tissues, like burns, due to their corrosive potential [14,15]. The severity of the burn is dependent upon the concentration of the acid and the duration of the exposure [19]. In this way, proper control of conditioning time, adequate absolute isolation, as well as a good suction system, should be used when employing the intra-oral repair technique.

In contrast, zirconia is an acid-resistant ceramic, which does not respond well to acid conditioning as it does not have silica in its microstructure. Additionally, zirconia is an inert substrate with low surface energy and wettability [17]. To obtain a strong and reliable adhesion to zirconia surfaces, it is essential to employ methods based on the use of air-borne particle abrasion with alumina particles or physicochemical methods use silica-coated alumina particles (tribochemical silica coating) followed by silanization. After the application of silane, the zirconia surface can be chemically activated by using functional-monomer containing adhesive promoters (such as 10-methacyrloyloxydeceyldihydrogenphosphate - MDP) [17,18].

Other precautions that must be taken during the intra-oral repair technique refer to the execution of a bevel on the margins of the fractured area; a refined finishing and polishing, and a careful occlusal adjustment [14]. A larger area of ceramic is exposed after making the bevel, with more silica particles, increasing the surface available for adhesion. In addition, especially in failures that occur in esthetic areas, a smoother transition between the two different materials (resin composite and ceramic) can be achieved. The finishing and polishing of the repair guarantees greater patient comfort, as well as reducing the possibility of future pigmentation, which would imply its replacement [14,15]. The occlusal adjustment after the intra-oral repair is decisive for its success, since often premature contacts and occlusal interference are responsible for the failure and, if they are not solved, the intra-oral repair will certainly fail.

5. CONCLUSIONS

- The intra-oral repair is a minimally invasive technique that increases the survival of prostheses that have suffered chipping of the veneering porcelain.
- Resin composite is the material of choice for this technique as it can be used for direct failure repair.
- The damaged ceramic area of a prosthesis can be restored in a single session, with an adequate aesthetic and functional solution.
- The prosthesis can be kept functional in the mouth, without the need for replacement and costly replacements.
- The meticulous execution of an adequate adhesive protocol will guarantee the success and longevity of the repair made.

CONFLICT OF INTEREST
The authors declare no conflict of interest.

REFERENCES
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16. Özcan M, et al. - The meticulous execution of an adequate adhesive protocol will guarantee the success and longevity of the repair made.

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None

AUTHOR’S CONTRIBUTION
MO: concept, design of the study and critical revision, revising the article critically for important intellectual content, final approval of the version to be submitted.
LG: acquisition of data, drafting the article. CV: acquisition of data, drafting the article, final approval of the version to be submitted.
Intra-oral repair of ceramic chipping

Questions

1. Intra-oral repairs with resin composite are indicated for:
   - a. Small to moderate failures in the veneering ceramic of bilayer prostheses;
   - b. Large failures in occlusal areas;
   - c. Large failures in proximal areas;
   - d. Failures that compromised the integrity of bilayer prostheses.

2. For the success of the intra-oral repair technique, it is important to consider:
   - a. The prosthesis must be removed to facilitate the adhesive protocol;
   - b. A chamfer should be performed on the margins of the fractured area;
   - c. The ceramic around the fractured area must be removed until the infrastructure is completely exposed;
   - d. A bevel should be made on the margins of the fractured area.

3. To make the intra-oral repair technique, it is important to use:
   - a. Relative insulation made with cotton rolls;
   - b. Clean and disposable brushes for applying silane agent silane and resin adhesive;
   - c. Coarse grain bur to prepare the fractured area;
   - d. Retraction cords for isolation.

4. The most suitable treatments for the exposed surface after the ceramic fracture are:
   - a. Conditioning with 9.6% hydrofluoric acid for metal surfaces;
   - b. Conditioning with 9.6% hydrofluoric acid for zirconia surfaces;
   - c. Conditioning with 9.6% hydrofluoric acid for feldspathic porcelain surfaces;
   - d. Tribo-chemical treatment for feldspathic porcelain surfaces.
TECHNICAL COMPLICATIONS OF IMPLANT RESTORATIONS: COMPONENT DEFORMATION, FRACTURE, SEPARATION

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1Department of General Dentistry, School of Dentistry, Virginia Commonwealth University, Richmond, VA 23298-0566 USA

Aim
To review mechanical irreversible implant restoration complications, and discuss prevention and troubleshooting.

Summary
A variety of complications, involving different components are discussed, with clinical presentation, possible causes, prevalence data and accompanying circumstances. Recovery procedures and troubleshooting protocols are also presented.

Key learning points
a. irreversible complications of implant restorations are less frequent as compared to screw loosening, but more expensive to deal with; b. as in the case of screw loosening, most irreversible complications may be related to the relative overload of the implant-restoration assembly; c. load control, by careful implant placement, restoration design and execution, as well as patient commitment in wearing an occlusal guard are paramount in preventing both reversible and irreversible mechanical implant complications.

ABSTRACT

Technical Complication; Implant; Fracture; Prosthodontics; Deformation.

KEYWORDS

Technical Complication; Implant; Fracture; Prosthodontics; Deformation.

1. INTRODUCTION

With the global market for implants expected to double in the next decade [1], more general practitioners are placing, restoring, and maintaining dental implants [2]. However, follow-up care and maintenance amounts to almost a third of the total treatment costs [3], which makes servicing implant restorations and understanding failures paramount. Screw loosening, the primary complication of screw-retained implant restorations, is considered a reversible complication as long as there is no significant deformation to the implant or superstructure connection. Other complications related to component wear, deformation fracture, or separation of different materials in a heterogenous system are irreversible and may or may not be related to screw loosening. This article aims to review these other less common complications and why they might occur.

2. COMPONENT WEAR AND DEFORMATION

Once the intimate fit of the abutment and implant is loosened, unintended movement occurs in the assemblage, with resulting wear of the implant platform and corresponding abutment surface. A loose joint favors non-uniform loads on the components with the likelihood of accelerated wear, deformation, and even fracture. Driving around with a loose ball joint in one’s suspension is just looking forward for the vehicle to lose control when the joint fails. On the same reasoning, we reiterate that a loose implant screw is an emergency.

For single unit restorations, the most common type of wear appears as rounding of the angles of the hexagon of the abutment, a result of screw loosening and discrete rotation of the abutment. The concurrent deformation at the receiving end of the implant can also occur. Such changes become more evident with increased lapse of time from screw loosening to retightening.

Screw deformation can occur by bending on the long axis, thread alteration, and head damage. Bending is almost exclusively associated with off-axial overload, before or after screw loosening. Sometimes, a bent screw can become lodged in the implant and simply break at repeated attempts to unscrew, further complicating the retrieval procedure. Thread alteration can be caused by significant over-torqueing, cross-threading, or presence of debris at the time of insertion. When engaging the threads of the implant, the advancing screw should rotate with ease.
Resistance should only be met when the entire length of the screw has beenthreaded. Resistance to rotation felt from the beginning indicates unmatched screw, cross-threading, or the presence of debris at the site of insertion. Head damage can be caused by over-torquing, incorrect access of the driver bit, or using an unmatched driver bit. Sometimes the screw access orifice is not reasonably aligned with the implant/screw axis, and upon torquing, the shank of the driver binds on the lateral walls of the channel. Such a circumstance not only creates the risk of chipping off restorative material around the orifice, but also may prevent full engagement of the driver in the screw head, risking stripping the screw. The screw head deformation is more frequently encountered for internal hexagon heads (for example Astra Tech / Dentsply Sirona, York, PA, USA; Biohorizons Dental Systems, Birmingham, AL, USA), and less likely for star pattern heads (for example Nobel Biocare USA, Yorba Linda, CA, USA; Straumann USA LLC, Andover, MA, USA).

3. COMPONENT FRACTURE

Component fracture is a more serious, but less frequent complication that may render recall and future appointments more time and expense intensive. Any component of the assembly can undergo fracture under uncontrolled load and/or as a consequence of poor planning/design. Implant fracture (Fig. 1) is rare - less than 1% at 5 year [4], however, it renders the fixture unusable. Abutment screw fracture (Figs. 2, 3, 4) is relatively rare, at 0.35% at 5 years [5,6], or 3.5% over 15 years [7].

Abutment fracture can occur as an isolated complication (Fig. 5), or associated with a screw fracture (Figs. 6, 7). Abutments with internal connections fail most frequently where the internal connection and the base of the abutment meet. The fractures compromise both the ability of the joint to keep the abutment properly seated on implant and the anti-rotational feature of the system. The fracture of monolithic structures can be catastrophic in full arch restorations and occurs most of the time through a distal screw access orifice (Fig. 8) if a long distal cantilever is designed, with a frequency of 1.4% [8].

Insufficient material thickness around screw access orifices can be a risk factor for future fracture (Fig. 9).

4. VENEERING FRACTURE AND SEPARATION OF COMPONENTS

Veneering porcelain fracture occurs in up to 10% of the implant supported restorations [9-12] as opposed to the tooth-supported restorations at 2% [13]. The risk increases if the opposing dentition is also an implant supported restoration and the patient is not wearing an occlusal guard [10]. The likelihood of veneering porcelain fracture appears to be associated with the restoration size [9,14], and where there is unsupported material (Fig. 10) at the screw access orifices [15,16]. Fracture/chipping of the veneering porcelain covering zirconia structures is much more frequent – 14.7% than monobloc fractures [8]. Localized chipping can be especially damaging when it involves the incisal margins, and may require full replacement, just as a catastrophic fracture.

In general, when using full contour all ceramic full arch restorations, the best results are to be expected for truly monolithic zirconia and partial cutback zirconia [17-25], as opposed to fully cutback designs that are more prone to porcelain chipping [18,22,25]. Another complication that can occur in extensive zirconia restorations is the separation of components, when titanium cylinders dis-cement from the monolith (Fig. 11). The fracture of acrylic veneering on extensive restorations is probably the most frequent complication of such structures [26], representing 17% of the mechanical complications [27]. The critical factor incriminated was poor framework design [27], which did not provide proper support for the veneering material.

As it is, implant supported restorations do require maintenance and eventual repairs/replacements. A knowledgeable practitioner and a compliant patient would work together for the best achievable prognosis of such prostheses. As techniques and materials evolve, upgrading existing restorations could produce even better results.

**Figure 1.** Implant fracture with platform wall separation: clinical (a) and radiographic (b) view.

**Figure 2.** Abutment screw fracture: a. radiographic view before complication; b. restoration separated from implant with fractured screw head; c. shank and threaded end of screw still inside the implant.

**Figure 3.** Double screw fracture in implant supported fixed partial denture.

**Figure 4.** Screw fracture at transition from shank to threaded end.
Screw loosening is the primary implant complication encountered of screw-retained restorations. However, this complication alone is often of very little financial and physical consequence. Component wear and deformation, component fracture, and veneering fracture and separation of materials are more detrimental in terms of repair and/or replacement financially and procedurally for the patient and the restorative dentist. The careful recognition of high-risk cases and diligent treatment planning, including design of the final restoration, is important to limit or avoid these complications completely.

DISCLOSURE
The authors reviewed and approved this manuscript, have no conflicts of interest nor off-label or investigational use in this manuscript. Furthermore, the authors have no financial, economic or professional interests that may have influenced the design, or presentation of the related information.

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None

AUTHOR'S CONTRIBUTION
SU, PW: agree to be accountable for the content of this work. SU: contributed to the content and data gathering. PW: contributed to the content and critically revised the manuscript.
REFERENCES


Dr. Sorin Uram-Tuculescu is a Professor at the Department of General Dentistry, School of Dentistry, Virginia Commonwealth University. He is involved in pre-clinical/clinical teaching, service, and research, while maintaining a part-time private practice. He authored/co-authored 7 textbooks, participated in the drafting of 50+ published papers and presentations, and lectures nationally and internationally.

Questions

1. Compared to screw loosening, component fracture is:
   - a. More frequent;
   - b. Less frequent;
   - c. About as frequent as screw loosening;
   - d. More frequent in monolithic restorations.

2. The fracture of full-arch monolithic implant restorations occurs most frequently:
   - a. At or near the midline;
   - b. Just behind canine areas;
   - c. Through a distal screw access orifice;
   - d. Where the meso-structure meets the superstructure.

3. Which of the following is not true regarding veneering porcelain fracture in implant restorations?
   - a. Is more frequent that in tooth-supported restorations;
   - b. Is more likely if the opposing arch is also an implant-supported restoration;
   - c. Can be associated with unsupported material;
   - d. Is less frequent than in tooth-supported restorations.

4. The fracture of acrylic veneering in full arch implant restorations is most likely related to:
   - a. Equilibration in group function;
   - b. A restoration in the mandible;
   - c. Poor metal framework design;
   - d. Class III jaw relationship.
THE BEST DEVICE FOR DOCTORS TO TREAT BRUXISM - GRINDRELIEF PRO

The incidence of stress-related bruxism (separate from TMJ pathology) is on the rise. Comparing prevalence studies in both sleep bruxism and awake bruxism, the three studies in Sweden, Denmark, and Israel identified a higher overall prevalence of awake bruxism compared to sleep bruxism. Patients with Obstructive Sleep Apnea (OSA) also suffer from sleep bruxism. According to the American Dental Association (ADA), 95% of people will experience bruxism at some time in their life.

Best practices recommend that the dentist and/or prophylactic nurse, in addition to prophylactic hygiene, look for the 10 most common clinical diagnostic indications:

1. Flattened canines
2. Abfraction
3. Popping, clicking pain in TMJ
4. Frequent headaches, migraines
5. Chipped, worn incisal edges
6. Worn cusp tips
7. Isolated bone loss
8. Cracked teeth
9. Broken restorations

If one or more of these clinical diagnostic indications are present or NOT, it is recommended that each patient be routinely asked if they have experienced “jaw pain” especially on waking or are aware of clenching / grinding.

The literature of the last decade shows a series of research works on the use of different oral devices (OAs) in the management of sleep bruxism (SB) in adults.

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Clinical technique
GrindRelief PRO can be fitted by a dentist, dental assistant or a hygienist in about 10 minutes. Because the GrindRelief PRO device can be softened and re-fitted whenever needed, it is also perfect for children, whose dentition will change or fit when subsequent restorations / dentures are provided. The lower cost, reduced installation time, recommends the GrindRelief PRO device as extremely effective for the treatment of sleep bruxism in both adults and children.

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

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**Advanced Laser Surgery in Dentistry**

Author: Georgios E. Romanos  
Publisher: John Wiley & Sons, Inc., USA  
Language: English  
ISBN: 978-1-119-58330-1  
Edition: 1/e  
Publish Year: 2021  
Pages: 238, illustrated  
Price: € 234,00

Professor Georgios E. Romanos, tenured Professor in the Department of Periodontology and Director for Laser Education at the School of Dental Medicine in Stony Brook, New York, USA and Professor in the Department of Oral Surgery and Implant Dentistry at Johann Wolfgang Goethe University, Frankfurt, Germany presents his experience as an academic and clinical expert in the field of laser in the book entitled "Advanced Laser Surgery in Dentistry".

The book has 8 chapters and two appendices which cover oral surgery, periodontology, and implant dentistry, based on the latest research, knowledge, and clinical practices. The book is a state-of-the-art reference for laser technology needed by dentists. To support the text, the book includes high quality color photographs, which cover wound healing, oral surgery, periodontology, implant dentistry and laser fundamentals and safety considerations.

"Advanced Laser Surgery in Dentistry" provides readers with a step-by-step guide to the use of lasers in the dental office and discusses likely new directions and possible future treatments in the rapid field of laser dentistry. Readers will also benefit from a wide variety of topics, including:

- a detailed introduction to the basics of lasers, including the beam, laser cavity, active mediums, lenses, resonators and delivery systems
- an exploration of lasers and wound healing, including healing of soft tissues and bones, as well as laser-assisted excisions and osteotomies
- an analysis of lasers in periodontics, including laser-assisted bacteria reduction in the periodontal tissues and the removal of subgingival dental calculus
- a discussion of lasers in implant dentistry and peri-implantitis treatment

"Advanced Laser Surgery in Dentistry" is a very useful guide for oral and maxillofacial surgeons, periodontists and implant dentists, as well as for general dentists, to be present in the libraries of dental students and residents who want to improve their understanding of oral procedures and dental-based laser technology.
Contemporary Oral Medicine
A comprehensive approach to clinical practice

Editors: Camile S. Farah, Ramesh Balasubramaniam, Michael J. McCullough
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Oral medicine is defined as the dental discipline dealing with the oral health care of medically complex patients – including the diagnosis and management of medical conditions that affect the oral and maxillofacial region. Oral medicine is primarily a non-surgical specialty, concerned with the diagnosis, prevention, and predominantly nonsurgical management of medically related disorders and conditions.

Camile S. Farah, Professor of Oral Oncology, Dean and Head of the UWA Dental School, and Director of the Oral Health Centre, University of Western Australia, Perth, Australia, Ramesh Balasubramaniam, BDSc graduate of the University of Western Australia, Perth, Australia, and Michael J. McCullough, Professor of Oral Medicine at the Melbourne Dental School, University of Melbourne, Melbourne, Australia, as editors provide the readers with an excellent book on Oral Medicine entitled “Contemporary Oral Medicine: A Comprehensive Approach to Clinical Practice”.

The book is the most comprehensive and up-to-date guide in oral medicine and includes 45 chapters divided in 3 volumes. Volume 1 has 12 chapters and covers normal variations in the anatomy of the maxillofacial region, clinical evaluation of oral diseases, diagnostic in head and neck pathology, pharmacotherapeutic approaches and cutaneous pathology and tumors of the head and neck.

Volume 2 contains 15 chapters which address odontogenic and non-odontogenic bacterial infections, viral and fungal oral and maxillofacial infections, gingival pathology, mucosal malignancies, salivary gland disorders, oral manifestation of systemic diseases and their treatments and pediatric oral medicine.

Volume 3 consists of 18 chapters covering topics such as neurophysiology, clinical evaluation and biopsychosocial aspects of orofacial pain, masticatory muscle pain, internal derangements and arthritic conditions of the temporomandibular joint, sleep medicine and therapy for sleep disordered breathing.

This book is a fresh holistic approach to clinical practice. It will serve as an outstanding textbook for undergraduate and postgraduate students. All chapters include a multitude of clinical cases and illustrations that enable the reader to appreciate the diversity and potential complexity of Oral Medicine.

Through the valuable information it contains on contemporary oral medicine, it successfully constitutes a comprehensive clinical practice guide that is welcome in every practitioner’s library.

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

*Advances in Periodontal Surgery* provides valuable information to the readers and is a useful support for practitioners of all levels of experience, as well as for students approaching the field of periodontics.

The Books Review is drafted in the reviewer's sole wording and illustrates his opinions.
**Infection Control in the Dental Office**

**A global perspective**

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The book entitled "**Infection Control in the Dental Office**" reviews the principles of infection control and standards of care in several countries, discussing them in the context of contemporary dental practice. Professor Louis G. DePaola and Dr. Leslie E. Grant, as editors, have divided the book into 15 chapters.

After a first introductory chapter on infection control, there follow three chapters on an overview of infectious diseases that concern dental practitioners, namely: blood-borne pathogens, other viral infections and bacterial infections.

The aim of the book is to enable dentists to ensure that appropriate measures are taken for each contact with a patient, thus reducing the risk of transmitting the infection - a goal that is becoming increasingly important in view of the threats posed by new infectious diseases or recurrent and drug-resistant infections. Readers will find information and guidance on all aspects of infection control in the dental office: hand and respiratory hygiene, use of personal protective equipment, safe handling of sharp objects and safe injection practices, management of occupational exposures, maintenance of water quality in the dental unit, surface disinfection and cleaning and sterilization of dental instruments.

Thus, "**Infection Control in the Dental Office**", which gathers the latest information is an invaluable guide for all dental practitioners, including dentists, dentists specialists, dental hygienists and dental assistants.

**The Books Review is drafted in the reviewer's sole wording and illustrates his opinions**
**Textbook of Oral Cancer**
Prevention, diagnosis and management

Editors: Saman Warnakulasuriya, John S. Greenspan
Publisher: Springer Nature, Switzerland
Language: English
ISBN: 978-3-030-32315-8
Edition: 1/e
Publish Year: 2020
Pages: 452, Illustrated
Price: € 128,39

Saman Warnakulasuriya, Professor Emeritus of Oral Medicine and Experimental Pathology at King’s College London, UK and John S. Greenspan, Professor Emeritus of Oral Pathology and Associate Dean Emeritus for Global Oral Health in the School of Dentistry at the University of California, San Francisco, USA as editors together with 49 prestigious contributors from 5 continents have drafted an important book entitled *Textbook of Oral Cancer - Prevention, Diagnosis and Management*. The editors want to present important achievements that have been made in these areas, to summarize current evidence, and to identify future perspectives.

The book is divided into 31 chapters and an index on supplementary information. The presentation of global epidemiological data of particular interest to public health specialists, precedes a review of the major risk factors for oral cancer, tobacco, alcohol and areca nut, and the role of human papillomavirus in the etiology of oropharyngeal cancers.

Chapters 5, 6 and 7 present the clinicopathological aspects of the disease. Proper tumor staging is important in treatment decisions, and follows the recently released 8th edition of the American Joint Committee on Cancer Staging Manual.

Chapters 8, 9, 10 and 11 summarize current knowledge on the investigations needed to detect oral and oropharyngeal cancer useful to clinicians and head and neck pathologists who manage diagnostic services in secondary care institutions.

Chapters 12 and 13 cover topics ranging from diagnosis to management of potentially malignant oral disorders, and then chapters 14 and 15 discuss new biomarkers that can help diagnose cancer and lead therapy and the importance of early detection of the disease.

Chapters 16, 17 and 18 deal with disease prevention and focus on controlling lifestyle risk factors and chemoprevention, including information on ongoing clinical trials and secondary prevention approaches.

Chapters 19, 20, 21, 22, 23, 24, and 25 describe various primary treatment modalities and principles underlying surgical and radio-chemotherapy treatment and factors affecting survival.

Chapter 26 deals with palliative care and support for patients with oral cancer, and chapters 27 and 28 focus on advances in molecular therapies and immunotherapy and their role in managing oral cancer through personalized medicine.

Chapters 29, 30 and 31 present cancer biology and carcinogenesis, a critique of cancer stem cells in oral carcinoma and controversial factors on causation of oral cancer.

All contributors to this textbook brought together their expertise to provide a comprehensive synthesis of the current state of knowledge about oral cancer.

The book is aimed at clinicians working in oral medicine, otolaryngology, oncology, head and neck cancer and maxillofacial pathology, especially helping students, residents and surgeons to manage oral cancer patients as comprehensively as possible in routine practice.

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*The Books Review is drafted in the reviewer’s sole wording and illustrates his opinions*
Obstructive sleep apnea is a potentially serious sleep disorder. It causes breathing to repeatedly stop and start during sleep. The book entitled "Management of Obstructive Sleep Apnea - An Evidence-Based, Multidisciplinary" Textbook provides up-to-date information on the diagnosis and surgical and nonsurgical management of obstructive sleep apnea.

Divided into five parts, it begins with principles and fundamentals of Obstructive Sleep Apnea (OSA). It explains the classifications, pathophysiology, health consequences, neurocognitive and neuropsychological effects and diagnostic considerations in metabolic diseases associated. The next part approaches Diagnostic Considerations for OSA. It shows how to clinically evaluate the patient, what diagnostic test to make, Cone-Beam CT use, craniofacial morphology related to OSA, the linking between orthodontics and OSA and mandibular condyle resorption. The subsequent part addresses the non-surgical management, namely oral appliance therapy, the use of positive airways pressure and emerging options for management. The surgical management of OSA covers an entire part and includes adenotonsillectomy, palatal surgery, hypopharyngeal surgery, miniscrew-assisted maxillary expansion techniques, orthognathic surgical considerations and conventional maxillomandibular advancement (MMA) versus modified MMA with segmental osteotomy. The last part tackles maxillomandibular advancement for OSA and presents the MRI evaluation, clinical, occlusal, and cephalometric analyses, maxillary and mandibular surgical procedures, counterclockwise rotation of the maxillomandibular complex for the correction of dentofacial deformities, virtual surgical planning and digital workflow for concomitant temporomandibular replacement and maxillomandibular advancement surgery, postoperative management, myofunctional therapy and physical therapy, virtual surgical planning and computational fluid dynamics and morphometric changes.

This textbook is designed to help sleep medicine specialists, surgeons and dentists who care for OSA patients by providing a comprehensive strategy for the evaluation and management of such patients approaching it from the perspective of multiple specialties, orthodontic, maxillofacial, ENT, neurology, sleep medicine and pulmonary physicians, and plastic surgery residents, advanced dental and medical students.
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The more you do.

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