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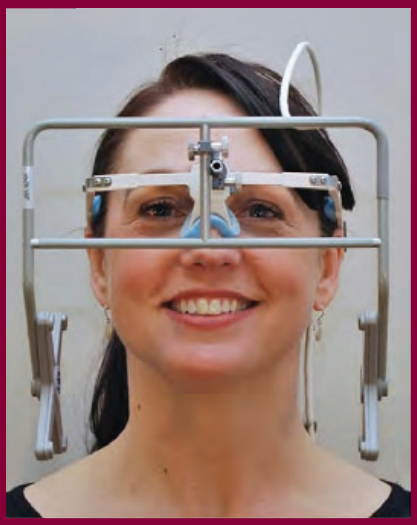

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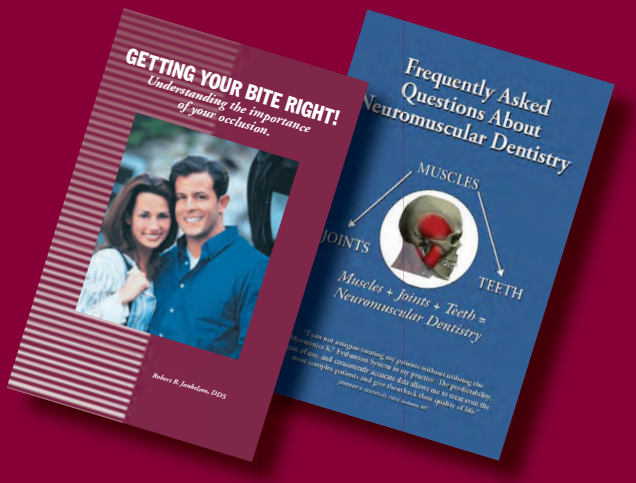

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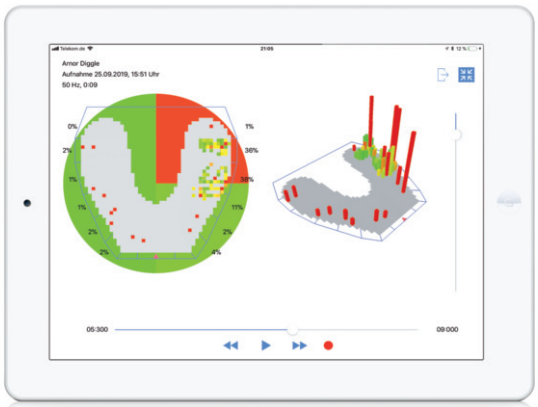

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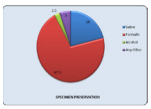

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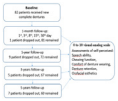

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Oral Health Systems in Europe - an overview

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Editor-in-Chief Section

Guest Editorial

Oral diseases are important components of noncommunicable diseases (NCDs). Notably, oral diseases afflict people of all ages. They often involve pain and discomfort, loss of oral functioning, impair quality of life, and they may lead to loss of work or school hours [1]. The predominant diseases and conditions of the mouth are dental caries, periodontal disease, loss of natural teeth, and oral cancer.

Oral diseases are often associated with the major chronic diseases because of common risk factors, primarily an unhealthy diet rich in sugars, use of tobacco, and excessive consumption of alcohol [2,3]. In addition, social determinants in oral health and health care are strong [1].

Oral diseases are a major public health problem to all countries in Europe. However, as for other NCDs, oral diseases vary extensively across countries and within countries. Social inequities in oral health status and use of oral health services are universal. Substantial variations in oral health care by education, family income and geographical areas are established among children, adolescents, adults, and older people throughout the European Region. Availability and access to oral health systems are important factors in people's oral health status. The purpose of the present article is to outline the diversity of oral health systems in Europe; particularly, the variety of public and private involvement in health care is described. Additionally, the report provides important international statements on challenges to oral health systems development. The work is built on a regional survey carried out by the author among all European Chief Dental Officers 2018-2019. This survey was based on a World Health Organization structured questionnaire prepared for self-administration. Experts in oral health services research reviewed the final summary of answers.

Oral health systems in Europe

Traditionally, delivery models for oral health care have been organized separately from general health care. Oral healthcare differs from medical care in that most care is provided within the primary health care sector while hospital based oral health care is limited. Across the Region, delivery models are different as financing systems for oral health care range from public to private schemes, and provision of clinical care, disease prevention and health promotion depends on the structure of services and number and type of personnel available [4,5].

In the Nordic countries (Denmark, Iceland, Finland, Norway, and Sweden), the state has an authoritative role in providing oral health care. The public sector is largely school-based and serves pre-school children, school-aged children and adolescents who are all eligible to comprehensive oral health care free-of-charge. Salaried personnel are financed through national or local taxation. In the Nordic countries, private dental practitioners offer oral health care to adults delivered on a fee-per-item basis subsidized partly by a national health insurance. Meanwhile, Iceland has no public sector for oral health. Preventive programmes offered by the public and the private sectors are advanced. Special public health programmes exist for care of vulnerable groups and older people. Community involvement, family engagement, mass communication, various media, and public health events are vital in population directed health education for the development of healthy lifestyles.

In the United Kingdom, the National Health Service (NHS) is responsible for general oral health care to the population. Oral health care is offered free-of-charge to children, pregnant women and nursing mothers, and subsidized care exists for adults. The NHS is financed through general taxation and mainly general dental practitioners deliver oral healthcare. In addition, oral healthcare is delivered to special target groups, such as vulnerable or disabled people. The service is complemented by a community service for children conveyed by salaried dentists. Dentists under private contracts deliver now a growing part of oral healthcare outside the NHS. Preventive programmes and health promotion in relation to schoolchildren, adolescents, and adults are organized.

In Ireland, a new National Oral Health policy outlines a reoriented HSE Public Health Service, where general practitioners or local dentists provide most primary healthcare, including prevention, routine primary care and complex care for all ages. Advanced oral healthcare will take place in dental or general hospitals or other approved centers. Vulnerable children and adults, including people with disabilities and the very old elderly, will receive additional support from community health services. Reimbursement of payments in practice will also transform from a predominantly fee-per-item system to a mixed general dental practitioner payment scheme covering prevention and clinical care. Both public and private insurance systems are in place.

Countries like Germany, France, the Netherlands, Belgium, Luxembourg, Austria and Switzerland provide oral healthcare from the long-established statutory sickness insurance systems offering reimbursement of patient costs. Employers and employees contribute financially to healthcare and the sickness funds negotiated about the level of fees with the dental associations. Services rely upon private dental practitioners, as a public sector with salaried dentists is negligible.

In Southern Europe, private dental practitioners provide oral healthcare on demand for children, adolescents and adults. The involvement of governmental resources or third party payment systems are only limited; insurance schemes exist though for distinct population groups. Public services may offer some treatment for children, primarily dental emergency care. Oral health services are predominantly treatment oriented and public health initiatives are limited.

The oral health systems of Eastern Europe and Central Asia have gone through a major transition from a state delivery service towards systems based on a mixture of state and private provision [5]. Public service for oral health provided by salaried dentists/ stomatologists is particularly available for child populations. Private services based on demand for care with private and/or public insurance are increasingly introduced for adult people. Throughout the years, the restorative care approach has been dominant among dental professionals of these countries though the philosophy of disease prevention and health promotion is now being adapted slowly. A number of Eastern European countries being new member states of the European Union are in process of establishing clinical preventive care, whereas the importance of population-based prevention and health promotion is less recognized, especially in the Commonwealth of Independent States (CIS).

Workforce for oral health

Dentists provide clinical care in terms of dental health examinations, early detection of disease, prevention and restorative dental care, periodontal care, complex dental treatment involving fixed crowns, bridgework, dental implants, treatment with removable dentures, and minor oral surgery. In general, advanced oral surgery and orthodontic care are specialties. Throughout Europe, chairside assistants or dental nurses assist dentists in their clinical work while oral hygienists – when available – are involved with preventive care.

Delivery of care depends on availability and type of oral health personnel. The density of practicing dentists in countries varies from 65.5 dentists per 100 000 population in the European Union to 34.8 dentists in the Commonwealth of Independent States, and to 21.1 dentists in the Central Asian Republics [6]. In the EU/EEA countries, the ratio of population to oral hygienist is low on average approximately 13,500:1; figures are not available from CIS and Central Asia.

Population coverage

Unequal distribution of oral health professionals implies that access to primary oral health services is low in certain areas of Europe. Dental coverage to primary oral health care facilities varies by country from 18% to 99% in schoolchildren, 35% to 75% among adults, and from 20% to 90% in older people [7]. In parallel, significant differences within countries are reported for the proportion of people attending for immediate healthcare in case of problems with teeth or mouth, from 55.4% to 96.1%. The attendance rate for oral healthcare is high in many Western countries where a substantial number of people generally attain preventive and curative care [4]. The population coverage for preventive services is particularly high in the Nordic countries [8]. In contrast, substantial amounts of people remain uncovered by care in countries in Eastern Europe and Central Asia [5,7], primarily due to shortage of oral health personnel or important cost factors.

The economic burden

Oral healthcare is costly as treatment in European countries overall involves out-of-pocket payments. The proportion of oral health expenditures ranges from 22% in the Netherlands to 98% in Spain [9]. Spending on oral health care may be catastrophic to households and is heavily concentrated among poor and disadvantaged population groups, including older people and those suffering from chronic disease. The experience of a heavy financial burden of oral healthcare often leads to a high level of unmet need for treatment [10].

Patient safety and quality of care

Treatment is complex in patients with severe disease manifestations and management is becoming more challenging with the greater use of advanced technologies for dental care. The financial load to patients depends on the complexity of the treatment. Major harm to oral health is often due to the outcome from inappropriate diagnostic procedures, low quality of record keepings, and poor patient communication. Quality in dentistry is measured by considering consequences of clinical care and satisfaction by people with

care received. The European Regional Organization of the World Dental Federation (ERO-FDI) has prepared a self-assessment tool for improvement of quality in dental practice and work for optimal outcome of the health care delivery system [11].

New technologies and the Minamata Treaty

Across the world, dentists have used dental amalgam as a key restorative material to treat dental caries. Though effective for dental care, the work with dental amalgam may potentially release mercury into the external environment. Recently, the United Nations Environment Programme jointly with WHO [12] strengthened the efforts for protecting the environment from hazards. The so-called *Minamata Convention* emphasizes the need for phasing-down the use of dental amalgam through substitution of restorative materials with new or use of other dental supplies whenever possible. Across all countries, *Best Management Practices* of dentistry are crucial to manage potential hazards from clinical care and the use of dental amalgam. However, it is worth emphasizing that dental caries prevention is the best way to avoid the use of dental amalgam, and WHO has underlined clinical and public health strategies for such preventive work [1].

Public health action against risk factors

Oral health should be an integral part of the national health systems within which oral health professionals may contribute to intervention against the risk factors of chronic diseases, particularly consumption of sugars, use of tobacco, and alcohol prevention.

An unhealthy diet and poor nutrition affect oral health during development and later during the life-course. The WHO Guideline on Sugars Intake for Adults and Children [13] includes a strong recommendation that the intake of free sugars be reduced in both children and adults. It is a strong recommendation that the intake of free sugars shall not exceed 10% of the total energy intake. To protect oral health throughout the life course, WHO also suggests a further reduction to below 5% of the total energy intake. WHO further suggests how oral health professionals jointly with national health authorities may contribute to reducing sugar consumption [14]. Tobacco is a major cause of periodontal disease, premature tooth loss, ulceration, and oral cancer. Oral health professionals play a special role in tobacco prevention [15]. Advantages of involving dentists in tobacco prevention are:

- they are knowledgeable about tobacco cessation;
- they may encourage patients to stop using tobacco;
- they play a professional role in early detection of tobacco-induced oral conditions;
- they can inform patients about the benefits of tobacco cessation, and
- they form an integral part of a national cancer prevention programmes.

Effective use of fluoride in Europe

Dental caries is preventable through limiting the intake of sugars and effective use of fluoride. According to WHO, water, salt, milk, and toothpaste are important vehicles for the administration of fluoride [16]. The evidence on the use of fluoride for the prevention of dental caries is strong; importantly, the effective use of fluoride for prevention reduces inequities in dental caries. In Europe, the preventive effect of fluoridated water is shown in Ireland; the beneficial effect of fluoridated salt is confirmed in Switzerland, while the positive outcome of milk fluoridation is demonstrated in Bulgaria [16].

Continuous development of oral health systems

Effective oral health systems shall match the population needs and ensure that all people requiring care are covered by essential and financially fair oral health care. Moreover, the number and work experiences of oral health personnel in countries should be adequate and enable establishing outreach care, oral disease prevention and health promotion. Southern Europe and countries in Eastern Europe and Central Asia should strengthen population reach and preventive dentistry; the introduction of oral hygienists may facilitate such progress. Moreover, community directed activities should be recognized, as they are successful in raising the awareness of oral health among people and the significance of personal care for avoiding diseases of the mouth and promoting healthy lifestyles.

Important target groups

Oral health professionals give care to patients of all ages. Across Europe, children and adolescents, pregnant women, older people and vulnerable individuals are key target groups for oral health. In certain Western countries, community or school services offers dental care to children and adolescents. The Nordic countries have implemented advanced programmes encompassing systematic dental treatment, preventive dental care and promotion of healthy lifestyles in line with the WHO concept of Health Promoting Schools [17]. Thus, the national programmes are financed from public health resources and cover all children and adolescents. In countries in Southern Europe, school oral health programmes are rare and private dental practitioners then serve children and young people. Systematic schemes for oral health should be developed. In Eastern Europe, school dental services existed over decades but such programmes have closed down in some countries over

the past years. Hence, school oral healthcare should be revitalised or renovated for provision of systematic dental care and disease prevention of these target groups [17].
Evidence is readably available from European countries about the extraordinary high needs for oral health care of older people. Consequently, public health intervention for oral health of older or defenseless people should be established by building age-friendly and financially fair primary oral healthcare [18].

Surveillance

Just a few European countries have introduced oral health surveillance systems for the assessment of the population oral health, evaluation and the appropriate adjustment of the national oral health systems. In particular, surveillance systems are required in Southern Europe and countries of Eastern Europe and Central Asia. Countries should build integrated oral health surveillance systems to examine at what level national and regional oral health targets are achieved. The case of Ireland illustrates recently the significance of surveillance data for reforming oral health systems. Comprehensive national and regional oral health data were used for a complete reformulation of health policies and revitalization of the national oral health system according to the primary health care model. WHO policies were instrumental in reorienting the system towards disease prevention and health promotion of all target groups. Importantly, WHO has designed assessment tools for the surveillance of key population groups [19].

International response for public health

Recently, WHO as well as the United Nations have called upon national health authorities to improve their oral health systems. In 2021, the WHO World Health Assembly confirmed a Resolution (A74.5), which calls upon Member States to integrate oral health systems with general health systems and to deliver preventive services and health promotion. The WHO Regional Office for Europe has strengthened its work for prevention and control of noncommunicable diseases (NCDs) in Europe; the principles are described in the 2016 *"Action plan for the prevention and control of noncommunicable diseases in the WHO European Region"* [20]. The NCD action plan provides strategies for the incorporation of oral disease prevention and health promotion in national health programmes, which may guide countries in their work for better health [2,3]. Moreover, the strategic plan incorporates the concern for chronic disease risk factors and for breaking the inequalities in oral health across and within countries [10]. The 2019 United Nations policy statement (A74/L4) on Universal Health Coverage (UHC) emphasizes that countries improve the availability, access, affordability, quality and efficiency of health services. The political declaration on achieving UHC was confirmed by all Member States and the declaration applies to oral health systems.

Conclusions

In conclusion, the prevalence of oral diseases continues to be high in Europe and they afflict people of all ages. The burden of disease is extraordinary among the underprivileged population groups and those who are uncovered by oral health care. Across Europe, it is vital to reduce the continuing financial burden of dental services. Oral diseases are avoidable. In Western European countries, the concept of prevention has gained firm attention and the load of disease is reduced markedly among children and adolescents over the past 20 years. In Central and Eastern Europe, restorative care or disease treatment remains the governing philosophy in oral health care and for these countries, further efforts should be made to introduce population-directed disease prevention. In all European countries, it is essential that national health authorities jointly with dental professionals would strengthen intervention against the risk factors such as consumption of sugars, tobacco, and harmful alcohol. The establishment of national surveillance schemes of the key WHO population groups is useful for measuring population progress in disease intervention and the accomplishment of targets for oral health.

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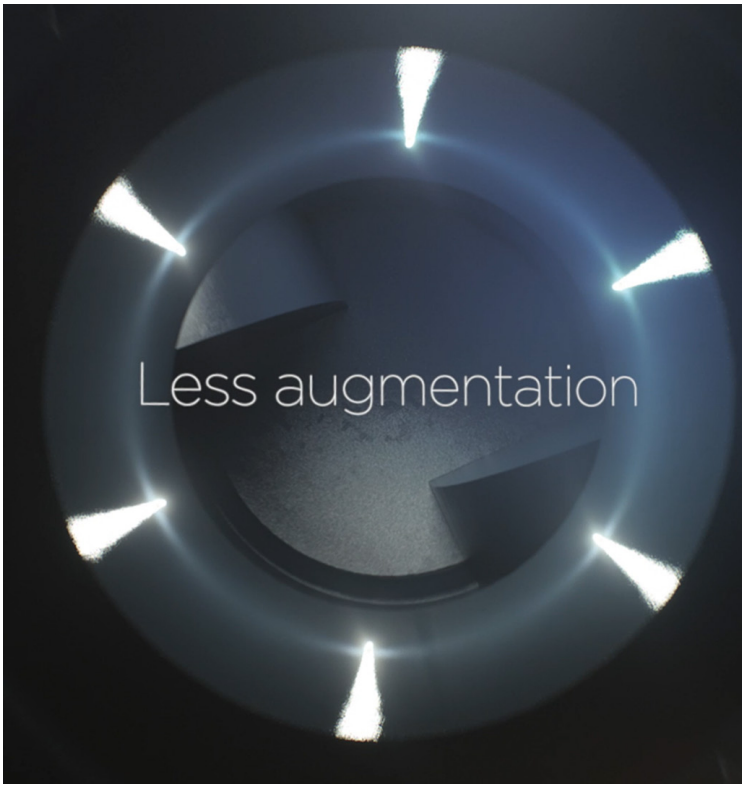

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Letter

Rudolf Slavicek's Scientific Contributions

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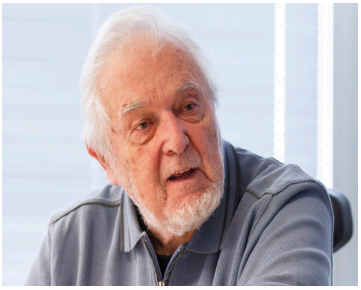

Rudolf SLAVICEK died in Vienna (Austria) on the first of January this year at the age of 93. He was serene, with a sense of accomplishment. He was an inspiring, tireless, strong-willed man, inventor and philanthropist. He devoted his life to the mastery of integrated occlusion in oral functions, acquiring a world reputation. His many scientific contributions will not only not fade away, but will grow: so, he will not disappear.

HIS HISTORY

Through his medical training (doctor of medicine in 1954, with incipient knowledge of cardiology), his training in dentistry (certified in 1957), his specialised training in restorative and prosthetic dentistry (1958), in orthodontics (1958-60), but also through his passion for anthropology and anatomy, Rudolf Slavicek gained an extremely broad cultural base, while in Vienna, Austria, between 1946, the year of his baccalaureate, and 1960. It is on this very solid base that he will build a professional career rich in innovations. Between 1960 and 1975 he initiated his quest for knowledge by reading and meeting the great international authors in the field of oral functions and dysfunctions. He worked, for example, with Lauritzen, Lundeen, Wirth, Gibbs and Ramfjord. Parallel to his private practice in Vienna, he developed a teaching career at a late stage, in which he demonstrated that the combination of broad culture, intelligence and a willingness to share can generate creative results that had a considerable influence on the field of occlusion, which concerned all aspects of dentistry.

He himself said "I took my time joining an academic career". At the age of 50 (1978), he became an Associate Professor, defended his PhD in 1982, became a full-time University Professor in 1984, and was Dean of the Faculty of Dentistry in Vienna from 1992 to 1997.

He retired from the university in 1998, inviting all his close colleagues to a memorable farewell seminar in Vienna. This was not the end, but in fact a new start to a new teaching career at the private Danube University in Krems, where he offered master courses in oral function-dysfunction. He then founded VieSID (Vienna School of Interdisciplinary dentistry), which is managed by his son Christian Slavicek.

The training programmes provided by VieSID are attended by a large number of colleagues from many countries around the world.

There are now several VieSID branches in different countries. At the same time, in 2006, he created the "Summerschool" with the support of Sadao Sato and Jean-Daniel Orthlieb. Thus, first in Krems, then in Vienna, in collaboration with the dental faculty, every year for five days in July, many colleagues meet around his former students.

The event started with about 20 participants and now it has about 300 participants from 4 continents. (Fig. 1a,1b) The "summerschool" has become a cult event of an impressive scientific level in the warm atmosphere of a real family.

The topics are multidisciplinary, focusing on oral functions around orthodontics and prosthetics. Rudolf Slavicek had a nice formula to define orthodontics: "an orthodontic treatment is a great occlusal reconstruction with natural teeth".

Figure 1a. Second Summerschool in 2007.

Figure 1b. Summerschool in 2019.

Letter

HIS WORK

Without being exhaustive, five major themes can be highlighted.

- Anterior guide or mandibular steering

In 1982, Rudolf Slavicek published an extensive research work combining morphological, cephalometric and axiographic analyses to better understand mandibular functions. He obtained his PhD and published his work in a first book "Die funktionellen determinanten des kauorgans - The functional determinants of the masticatory organ" [1]. He studied, among other things, the lingual morphology of the anterior teeth, the inclinations of the guiding slopes of the maxillary teeth (Fig. 2a, 2b); he developed the principle of absolute slopes (in relation to the reference plane (Fig. 3), the Axio-Orbital plane) and relative slopes (in relation to the occlusal plane) [2,3].

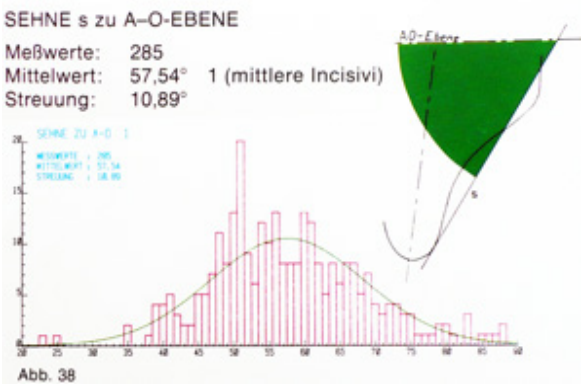

Figure 2a. Measurement of incisal slope from silicone impression cup N = 285, m = 57.54°, Et = 10.89°.

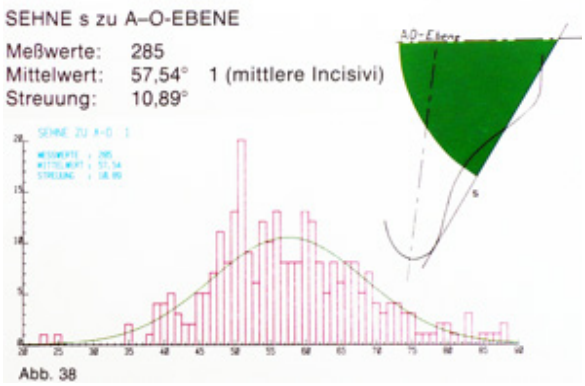

Figure 2b. Measurement of canine slope from silicone impression section N = 277, m = 48.73°, Et = 9.88°.

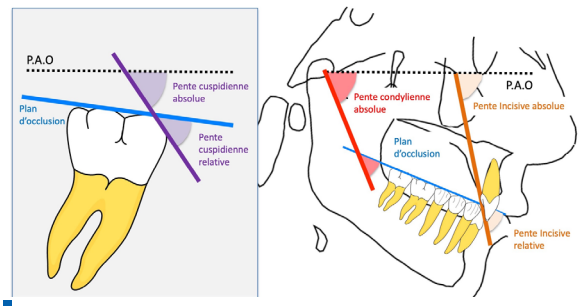

Figure 3. The determinants of guidance: absolute (/ Axio-Orbital Plan) and relative (/ Occlusion Plan) slopes.

Starting with this work, he would fundamentally optimize the concept of canine function by inventing the sequential guidance [4], the functional angle of freedom (Fig. 4), the retrusive control [5,6]. These are concepts to guide prosthetic or orthodontic reconstruction (Fig. 5), not rules to be found in all natural occlusions. He later proposed to replace the term guidance by the term control to emphasize the importance of proprioception of the anterior teeth.

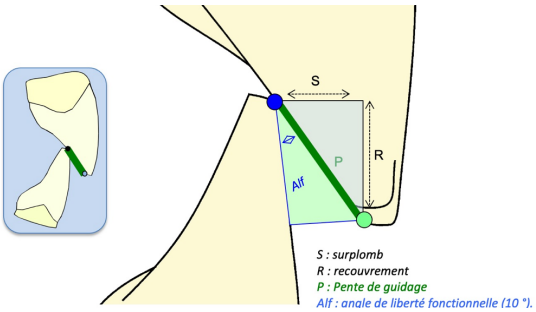

Figure 4. The functional angle of freedom: about 10° (allowing forward movements) it is to be found whatever the inclination of the anterior teeth, possibly compensating for skeletal shifts.

Figure 5. The Anti-Retroposition Guide (ARG): ideally located on the mesial side of the lingual cusp of the maxillary first premolar, it optimizes the occlusal guidance between OIM and ORC (less loaded, more discriminating area).

- SAM Articulator

Already before the 1980s, Rudolf Slavicek collaborated with a new company in Munich, the SAM company, to develop an articulator that was between the semi-adaptable and the fully adaptable articulator, but was still simple and precise to use. The SAM articulator will incorporate condylar housings and curvilinear Bennett inserts and will be an outstanding success; thanks to its precision, robustness and simplicity, it will be an exceptional success, which is still relevant today (Fig. 6a, 6b).

Figure 6a. SAM Articulator: (a) SAM I.

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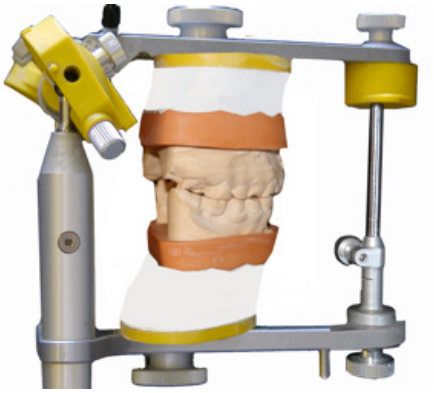

Figure 6b. SAM Articulator: (b) SAM II.

- Axiography

At the end of the 1970s, the development of axiography saw Rudolf Slavicek as a guest on various international podiums [7,8]. Derived from Campion (1902), Gysi, Lee, Lundeen, the axiograph proposed by SAM structures (Fig. 7a), with relatively simple means, the registration of condylar translations by eliminating condylar rotations [9]. In addition to measurements for the individual programming of condylar boxes, Rudolf Slavicek was able to develop a method for the diagnostic analysis of intracapsular TMJ disorders [10]. In the 1990s, mechanical axiography evolved with the development of electronic condylography CADIAX (Fig. 7b, 7c) by the Gamma company headed by Christian Slavicek [11].

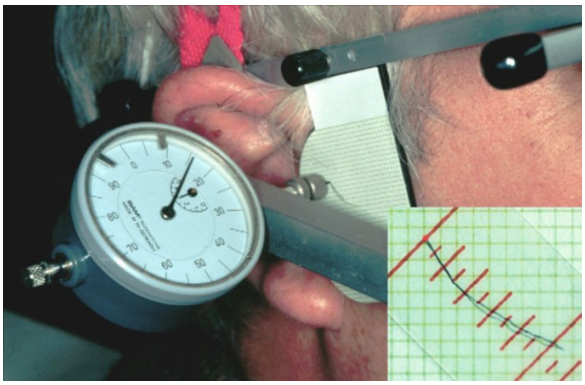

Figure 7a. From axiography to condylography: 1980, SAM mechanical axiograph.

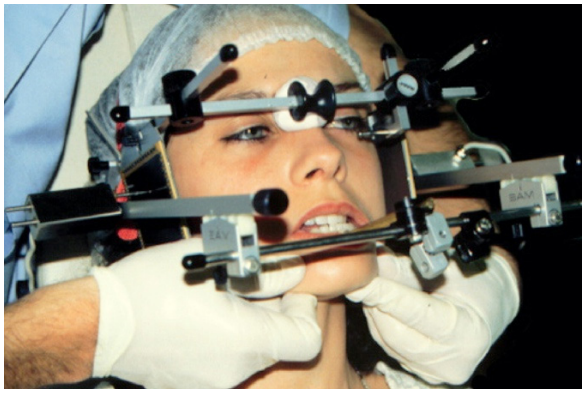

Figure 7b. From axiography to condylography: 1990, SAM electronic axiography.

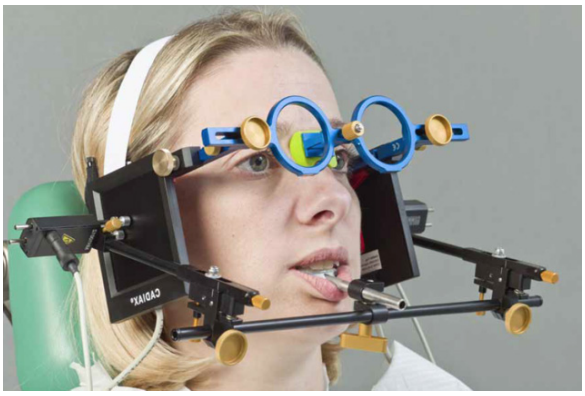

Figure 7c. From axiography to condylography: 2015, Cadiax - Gamma electronic condylography.

- Cephalometry

Also, at the end of the 1970s, Rudolf Slavicek developed a concept of global analysis that superimposes cephalometric, axiographic and occlusal (from the articulator mounting) data on the same axio-orbital reference plane [3]. These superimpositions allow the combination of condylar slope (axiography) and occlusal plane inclination (cephalometry) data to calculate the reconstruction of cuspidial slopes and guide slopes (articulator). Computerised cephalometry developed in the 1980s has evolved with the development of CADIAS software providing numerous possibilities for therapeutic simulation VOT (Fig. 8).

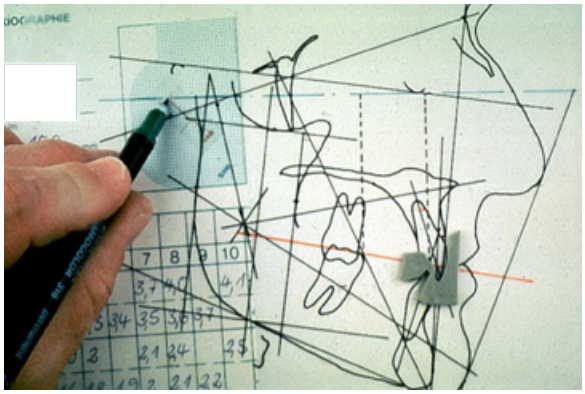

Figure 8. Superposition of computerised cephalometric tracings and mechanical axiographic tracing: CADIAX analyses in 2022.

- Bruxism

In 1984, Rudolf Slavicek supervised a university thesis defended by Karin Kail in Vienna. This visionary work introduces the manducatory apparatus as an organ for the discharge of emotional tensions, i.e. bruxism appears as a stress-relieving valve [12]. This concept was subsequently validated by numerous research studies published by Sadao Sato's team at the Kanagawa Dental University in Japan. This team work led to the development of the "Bruxckecker" (Fig. 9), a simple means of evaluating grinding bruxism [13].

Letter

Figure 9. Bruxchecker: thermoformed splint, 0.1 mm thick, coloured red, worn overnight, showing the reality of occlusal confrontations by the traces of friction having erased the red dye. A simple, relevant, curiously unknown tool.

- Cybernetics

As Rudolf Slavicek matured and dominated the mechanical aspects of mandibular function, he was able to take a step back and integrate his occlusal-functional concept into the broader framework of the patient's whole organism [14]. This is embodied in the cybernetic concept of the "masticatory organ" (Fig. 10) published in his book "Das Kauorgan" in 2002 [15]. In 2008, supported by Spinger, he decided to publish a new peer-reviewed journal, International Journal of Stomatology & Occlusion Medicine (IJSOM). This European, multidisciplinary, "medical occlusion" oriented journal was intended to motivate and encourage his colleagues to publish their work in this forum of communication and discussion. Recently, Professor Slavicek published a new three-part book, "Concepts in Oral Medicine" (2016), which presents numerous illustrations of the holistic therapeutic approach according to the principles of the Vienna School.

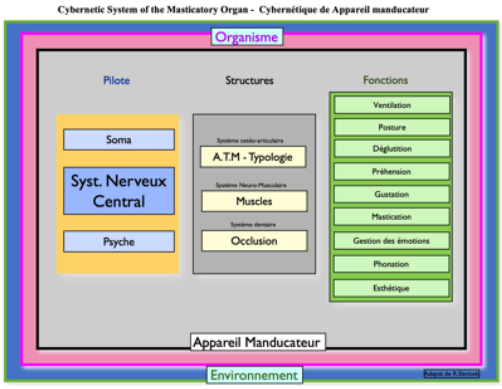

Figure 10. The cybernetic system of the multi-structural, multi-functional "masticatory organ" makes binary views obsolete.

CONCLUSION

Intelligence, broad scientific culture, simplicity, empathy, absence of sectarianism, clinical involvement and great strictness in implementation, characterize his brand and his "School" of thought. We can all see and more clearly when we stand on the broad shoulders of this giant.

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Min Zhu, Mario Medina, Romesh Nalliah, Viyan Kadhium, Eric Bell, Taehoon Han, André Boehman, Jesse Capecelatro, Margaret Wooldridge

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ATTITUDE TOWARDS ORAL BIOPSY AMONG GENERAL DENTAL PRACTITIONERS OF VADODARA, A CITY IN THE WESTERN STATE OF INDIA

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ABSTRACT

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Introduction In practice, the diagnosis of certain oral lesions must be made by biopsy. A biopsy constitutes an essential diagnostic tool in application to patients with oral pathology. However oral biopsy is not routinely performed in general dental practice. The present study aimed to explore the attitudes of General Dental Practitioners (GDPs) towards oral biopsy for diagnosis of oral lesions in Vadodara city, Gujarat, India.
Methodology A questionnaire was distributed to 200 general dental practitioners, consisting of several items addressing the socio-demographic and professional aspects and their attitudes towards oral biopsy procedures.
Results Our study showed that 73% of the GDPs do not perform a biopsy on their own. Out of which 32% of GDPs gave the reason of lack of skills and knowledge while 7% of GDPs lacked confidence in performing a biopsy on their own. 28% of the GDPs were not aware of the medium of specimen preservation.
Conclusion There is a need for better education and training of GDPs to perform oral biopsy procedures on their own and create awareness among them about the proper referral of the specimen to oral histopathological centers which will aid in accurate diagnosis of the lesions.

KEYWORDS

Oral Diagnosis; Attitudes; Biopsy; General Dental Practitioners; Oral Lesions.

1. INTRODUCTION

Biopsy is often an indispensable procedure in the diagnosis of myriad of benign and malignant oral conditions. The term "Biopsy" was introduced into medical terminology in 1879 by Ernest Besnier [1]. Biopsy is a procedure consisting of procurement of tissue from a living organism with the purpose of examining it under the microscope in order to establish a diagnosis [2]. The word biopsy originates from the Greek terms "bios" (life) and "opsis" (vision): vision of life [1,3].
Biopsy has been one of the oldest methods developed by the Arab physician Abulcasim (1103-1107AD), used for the accurate diagnosis of any abnormality in the oral environment as it is an accurate and pronominal aid used for establishing the histological characteristics of lesions which appear suspicious and so, it helps in their differentiation [4,5]. Biopsy of all kinds should be used frequently, not only for establishing initial/early diagnosis but also for providing more accurate clinical surveillance of the disease process.
General dental practitioners (GDPs) often being the primary oral health care providers are required to have a basic understanding of the biopsy procedure which should be emphasized during undergraduate training and they should be able perform them as and when required [4]. In general, the GDP is required to detect and recognize oral lesions and inform the patient accordingly – providing a diagnosis and adequate treatment indications. Therefore, GDPs must know not only where, when and how to perform a biopsy but also how to manage the information derived from the procedure [6]. Early detection of an oral lesion and prompt biopsy in general dental practice not only reinforces patients' confidence but would also reduce the number of successful lawsuits brought for delay or failure to diagnose [4]. Biopsy is advised for all oral lesion in question, if persisting

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for more than 2 weeks even after the removal of the irritating factor, if any. Clinicians have to decide the type of biopsy required based on the site, clinical nature of the lesion, and proximity to vital structures [7].

Many factors may make a biopsy problematic and be reason for not undertaking it in general practice. These include: fear of medico-legal implications, unfamiliarity with the biopsy technique, a lack of faith in personal diagnostic skills and the contention that biopsy is a specialist procedure. There is also concern that if the lesion proves to be malignant, the GDP is not equipped to inform the patient that they have cancer [8]. It is found that many GDPs do not perform the biopsy procedure on their own in their routine clinical practice.

Hence the present study aimed to explore the knowledge and attitudes of general dental practitioners towards the oral biopsy procedure in and around the Vadodara city region.

2. METHODOLOGY

A descriptive, cross-sectional study was conducted using a questionnaire of 15 questions comprising 2 open-ended and 13 close-ended questions. The questionnaire was designed to collect information about demographics of GDPs, clinical experience of GDPs, attitudes of GDPs towards oral biopsy, methods used for obtaining biopsy, material used for specimen preservation, referral to specialized centers (oral or general pathology laboratories).

The questionnaire was previously evaluated by means of a cognitive pre-test procedure to ensure that the questions were appropriate, understandable among the dental practitioners. The pilot survey was targeted to five dental professionals selected due to their accessibility and proximity to the investigational team. Changes in the questionnaire were then made accordingly and the pilot study samples were deleted from the final study sample. Following which, the purpose of the study was explained to the GDPs, so consent was obtained and the questionnaire was given.

A total of 200 GDPs in and around Vadodara city who consented to participate were included in the study while all professionals exclusively dedicated to some dental specialties were excluded. The questionnaire was distributed and retrieved personally to/from all the dental surgeons who participated in the study and anonymity in completing the questionnaire was sought in all cases.

The data collected were tabulated and statistically analyzed using of descriptive statistics.

3. RESULTS

All of the 200 GDPs who owned their clinics were approached with the questionnaire, they answered all the questions considering that their demographic details would be kept confidential. The response rate was 100% as the dentists were approached personally.

Among them, 63% (126) of the dentists had been running their clinics for 1 to 5 years while 18 % (36) of them had their clinic running for more than 5 years. Furthermore, 19% (38) of the dentists had been running the clinic for more than 10 years. 175 (87.5%) GDPs had worked at other dental clinics before opening their own practice. Additionally, 73.5% (147) dentists had consultants of speciality in oral surgery visiting their clinic (Fig. 1).

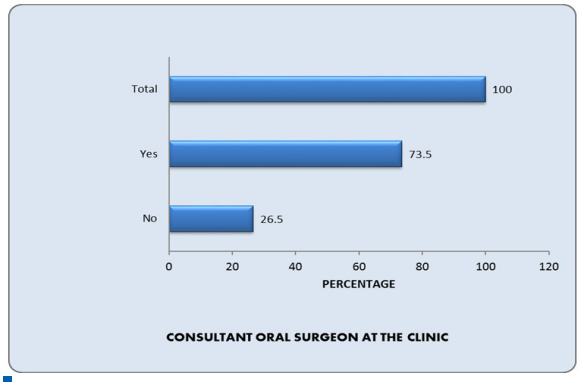

Figure 1. Consultant Oral Surgeon at the clinic.

All the GDPs answered that it was indeed very important to perform a biopsy. However, only 26.5% (53) of the GDPs performed a biopsy on their own while 73.5% (147) of them referred the patient to a specialist (Fig. 2).

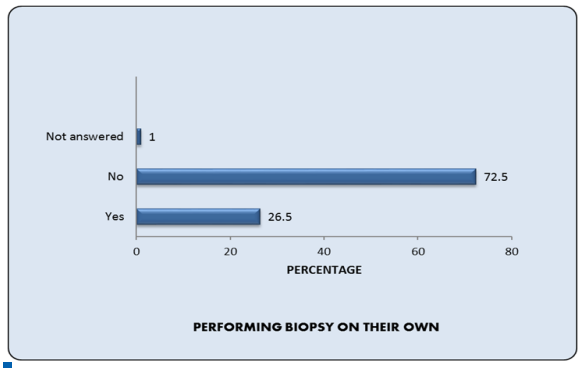

Figure 2. Performing biopsy on their own.

On answering which type of lesions they encountered during their practice which requires a biopsy, they stated that according to their knowledge, cysts and premalignant lesions were encountered most commonly (36% each) while 34% encountered benign and 32% malignant lesions (Fig. 3).

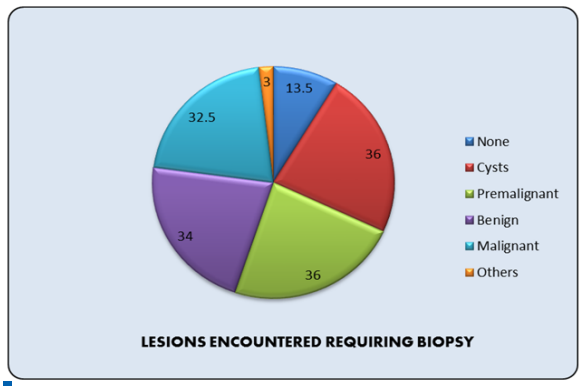

Figure 3. Lesions encountered requiring biopsy.

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The questionnaire sought to evaluate the knowledge of the GDPs regarding the medium of specimen preservation after removal. 67.5% practitioners used formalin as the medium of specimen preservation, while 20% believed that it can be preserved in saline. Furthermore, 2.5% answered that specimens can be preserved in alcohol; while 5% were not aware of the medium of preservation of the specimen (Fig. 4).

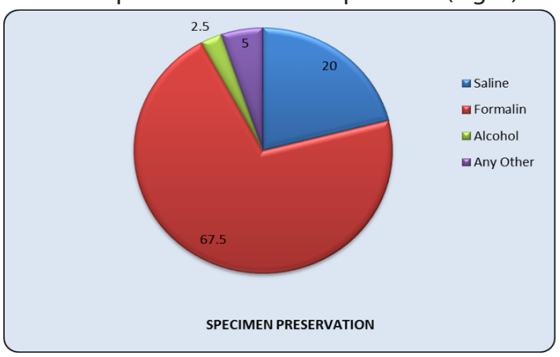

Figure 4. Specimen preservation.

Upon asking what type of biopsy they would perform 53% of GDPs answered incisional biopsy (Fig. 5).

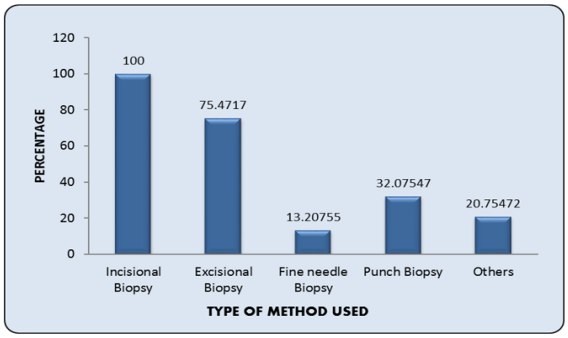

Figure 5. Type of method used.

31.4% of the GDPs lacked the experience and skills to perform a biopsy. 25.52% of GPDs reasoned that they did not perform a biopsy as they lacked the materials required for biopsy, while 6.9% opted for lack of confidence as an answer (Fig. 6).

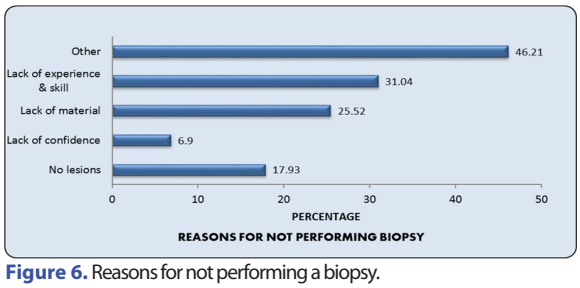

Figure 6. Reasons for not performing a biopsy.

58.5% (117) of the GDPs sent the biopsy to an oral pathologist for analysis, while 38.5% (77) of them sent it to a general pathologist (Fig. 7).

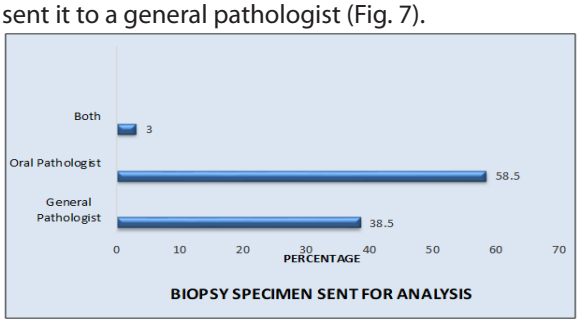

Figure 7. Biopsy specimen sent for analysis.

81% (162) of the GDPs sent the biopsy specimen to a private laboratory that they are in contract with, while only 16.5% (33) preferred to send it to institutions such as government hospitals and dental colleges where more than one pathologist is involved in the diagnosis (Fig. 8).

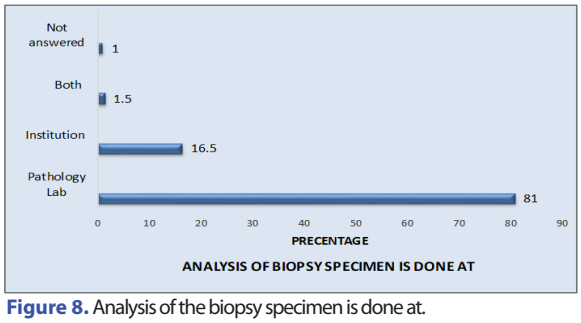

Figure 8. Analysis of the biopsy specimen is done at.

4. DISCUSSION

Biopsy, a Greek-derived word loosely translated as "view of the living," is defined as removal of tissue from the living organisms for the purpose of microscopic examination and diagnosis [9].

A biopsy is of paramount importance because it is strongly related to the early detection of oral cancer. Although most dentists prefer to refer biopsy cases to specialist or higher centre, most believe that routine biopsies are well within the scope of a GDP as this would provide direct access to prompt management. GDPs are often unfamiliar with the different clinical patterns of oral malignancy. In 1955 Boyle commented that an individual's qualifications have little to do with their ability to perform a biopsy. His words appear valid today since the issue of who should biopsy remains controversial [9,10].

A wide array of procedures and techniques is available to assist in the diagnosis of oral disease. Every patient should receive a thorough head and neck examination and appropriate dental radiographs. The clinical and radiographic examinations may provide sufficient information for the diagnosis of certain entities. However, many diseases of the mucosa, other soft tissue and bone require additional information to make a precise diagnosis. This information in many instances may be provided by biopsy and submission of tissue for histopathologic examination [11].

This study was undertaken to evaluate the knowledge and attitudes of GDPs regarding the biopsy procedures, medium of specimen preservation, referral to specialist when in doubt and the choice of referral to a general pathologist or an oral pathologist, as all these factors do have an impact on a patient's diagnosis and treatment plan.

In general dental practice the detection of oral cancer in an early stage might come across as a difficult task and to convince patients in order to prevent is also a continuous challenge in dental field. Therefore, a dentist must be aware of the factors which play a very important role in causing cancer, its clinical signs and symptoms.

Apart from oral potentially malignant disorders and malignant lesions, there are an array of lesions

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like reactive pathologies (epulis, fibroma), benign epithelial tumors etc. which can be excised in toto when detected in a routine dental checkup. Although the patient may not be aware of the presence of such lesions, patients can be educated about the same and GDPs would be the first to detect and diagnose the lesions at an early-stage, building patient compliance towards the GDP.

The questionnaire included whether the GDPs perform the biopsy on their own and they have a consulting oral surgeon coming to their clinic. 73.5% of GDPs had an oral surgeon coming to the clinic as a consultant while 26.5% of the GDPs perform biopsy on their own. This was in accordance with Warnakulasuriya and Johnson who found that 21% of dentists in United Kingdom [12] and Seoane et al. reported 24.5 % GDP's perform biopsies in Northwest Spain [13].

Regarding the reasons for not performing a biopsy, 31.4 % gave the lack of experience and skills as a reason, 25.52% went with lack of material, whereas 6.9% went with lack of confidence.

Given the results we can evaluate that in general practice, GDPs encounter a wide variety of benign, malignant, premalignant, cysts, etc. This allows us to emphasize the accessibility of GDP to a patient and his important role in the diagnosis of oral lesions. It demonstrates how important it is for a GDP to have sufficient knowledge on oral pathology and their diagnosis, and also how significant the lack of knowledge is, as it could lead to misdiagnosis and how it can affect a patient's treatment.

In this study,13.5% of GDPs performed biopsy on their own which is in accordance with the studies done by Murgod V et al. [4], Cowan et al. [14] and Diamanti et al. [11] who reported that 14.93%, 12% and 15% respondents performed biopsies on their own respectively. Warnakulasuriya and Johnson found that 21% of dentists in the United Kingdom [11] and Seoane et al. reported 24.5 % GDP's perform biopsies in Northwest Spain [12]. In Norway, Berge found that 56% of dentists attempted biopsy [15].

Our study also clearly revealed that 26% of GDPs refer the patient to a specialist. According to the results of the study done by Murgod V et al. in Belgaum city, in the southern region of India, it was revealed that 64.67% of GDPs either call a specialist or refer the patient to a higher centre [4]. Reports by Wan and Savage in Brisbane, showed 76.2% of GDPs refer the biopsy cases to a specialist [1]. The reasons for not performing a biopsy on their own could be due to several factors like fear of unfamiliarity to biopsy technique, lack of faith in personal diagnostic skills, lack of materials, misconception that it is a specialist procedures or concern if the lesion is malignant.

In our study 31.4% of GDPs gave the lack of skills and knowledge as a reason and 6.9% of GDPs said they lack confidence, whereas 46% of them opted for not giving a specific answer. Wan and Savage stated that 58.1% of GDPs did not feel competent to undertake any biopsies mainly due to lack of experience, confidence and practical skills [1]. Diamanti et al. reported 25% of GDP's surveyed did not feel competent to perform biopsies while Greenwood et al. found that only 21% of GDPs were prepared to carry out biopsies [9,16]. The lack of experience in performing a biopsy by a GDP is a result of the lack of importance attached to the practical teaching of biopsy techniques during their training.

Although the current curriculum of the Dental Council of India (DCI) for the Bachelor of Dental Surgery (BDS) degree includes various biopsy techniques in didactic lectures, the clinical quota requirement of dental surgery mainly stresses tooth extractions and it does not have any specific mention for biopsy procedure [17]. In addition, the DCI curriculum for the internship of dental students for the undergraduate course emphasizes mainly extractions and disimpactions. The requirement for the undergraduate course completion is only one biopsy for an oral cancer case which is not sufficient as biopsies are to be performed for other lesions as well. Furthermore, training them at an early stage is important as the GDPs are the primary or the first line of dental care giver. Furthermore, in rural setups in countries like India, Oral Surgeons may not be always available.

On asking about the type of biopsy they perform, the majority knew only about incisional biopsy. This explains the need for the GDP to have a grasp on biopsy techniques, their indications and contraindications. This would assist them to decide on the type of biopsy required in individual cases.

Regarding the preservation of the specimen after removal and before sending it for analysis, 67.5% GDPs knew that it is supposed to be preserved in formalin and send to the Oral Pathologist, while 20% believed that saline could be used for this purpose Specimen preservation is a very important aspect in biopsy results. If the tissue is not preserved in the proper solution, a lot of artefacts can occur leading to difficulty in diagnosis. This will lead to repeating the biopsy, causing unnecessary trauma to the patient and a delay in diagnosis thereby, affecting the quality of the treatment given to the patient.

5. CONCLUSION

In time we have witnessed that the dental field is growing at huge speed and achieving new developments every day. However, when it comes to performing a biopsy which is indeed a gold standard for the diagnosis of oral cancer, we are inept. Many GDPs do not perform a biopsy on their own due to lack of confidence and skills. There is a need for further training in biopsy procedures to gain confidence to perform biopsy procedures on their own for GDPs in addition to creating awareness with accessible pathology support.

We have seen various organisations holding conferences related to many dental procedures but not many have been organized for basic procedures like biopsy. Even during the COVID era, dental education has continued unhindered in the form of online webinars, yet only few sessions were seen to focus on the biopsy procedures and their

technical aspects. Oral cancer is definitely difficult to deal with, however as the saying goes that 'Timing is everything', early and timely diagnosis will definitely help improve the longevity and quality of patients' lives. Biopsy should be mandatory in all the suspicious lesions and so should be training for performing biopsy procedures for GDPs. This study was an attempt to urge the concerned organizations to revisit the curriculum of the undergraduate dental course and incorporate the basic biopsy procedure as part of the training.

CONFLICT OF INTEREST

I (we) certify that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

RP and **MT**: concept, protocol, data gathering or analysis and their interpretation. **RP**, **DV** and **PA**: critically revised the manuscript.

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Questions

1. The term Biopsy was coined by:

❑a. Erasmus Wilson;
❑b. Ernest Besnier;
❑c. Thomas E Bond;
❑d. Robert Gorlin.

2. The most common solution for specimen preservation is:

❑a. Saline;
❑b. Alcohol;
❑c. Formalin;
❑d. Distilled water.

3. What is the indication for performing a biopsy?

❑a. A non-healing long standing lesion;
❑b. To arrive at a final diagnosis;
❑c. Lesions hampering normal physiological function;
❑d. All of the above.

4. Incisional biopsy is

❑a. Removal of a small portion of tissue from a larger lesion;
❑b Removal of a smaller lesion in toto;
❑c. Removal of scrapings from the lesion;
❑d. All of the above.

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Original Articles

EX VIVO DIGITAL COMPARISON OF FOUR IMPRESSION TECHNIQUES USING AN INDUSTRIAL LASER SCANNER

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ABSTRACT

Introduction The aim of the study was to compare different impression techniques used for fixed prosthodontics.

Methodology A master cast with prepared abutments was created from polymethyl-methacrylate (PMMA). A high-resolution industrial scanner was used to create a virtual reference model. Four different impressions were made, three with polyvinyl-siloxane (PVS) (n = 10 for each): one-step putty-wash (1SPW), two-step putty-wash prepared with an escape channel (2SPW-Ch), two-step putty-wash with a polyethylene spacer foil (2SPW-Fo), and one with polyether monophasic technique (MP) from the PMMA model and digitized with an industrial scanner. The stereolithographic (STL) files of the impressions (n = 40) were exported. Each file was compared to the reference using the Geomagic Verify software. Six points were assigned to enable virtual calliper measurement of tooth diameters and distances of varying sizes within the arch.

Results In the case of die diameters, the deviation from the mould ranged from 31.84 to 180.64 µm. At the stump diameter level, the MP and 1SPW techniques showed significantly more minor differences than the 2SPW-Ch, and the MP was significantly more accurate than the 2SPW-Fo. At medium distance, the deviation ranged from 42.74 to 136.47 µm. Therefore, MP was found to be significantly more accurate than 2SPW-Ch. When examining the long distance, the difference was between 162.62 and 348.85 µm. The MP and 1SPW impression techniques proved significantly more accurate than the 2SPW-Ch technique for long distances.

Conclusions With both simultaneous techniques, significantly more true results were achieved than with the two-step techniques.

KEYWORDS

Dental Impression Technique; Scanning of the Impression; Monophase; One-Step Putty-Wash; Two-Step Putty-Wash.

1. INTRODUCTION

One of the most critical steps in our dental processes is to make impressions with reasonable accuracy. The impression allows the dental technician to have the same condition on the model as in the patient's mouth. When examining impressions, trueness and precision can be examined, and these two together constitute accuracy. ISO 5725 uses two terms, trueness and precision, to describe the accuracy of a measurement method. Trueness refers to the closeness of agreement between the arithmetic mean of a large number of test results and the true or accepted reference value. Meanwhile, precision refers to the closeness of agreement between test results [1]. In this study, only the trueness of the impressions was examined. A review article published in 2016 defined the still tolerable inaccuracy in the crown's fit between 50 and 200 µm after the turn of the millennium [2]. The article by McLean and von Fraunhofer from 1972, which is still frequently cited, gives the 120-micron deviation as an inaccuracy threshold, so this level of accuracy must be aimed at for impressions [3-5].

According to the ISO standard, which currently regulates the properties of elastic impression materials, the kneadable material with the lowest reproducibility must have a resolution of at least

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75 µm, so there is no material scientific obstacle to achieving this trueness and accuracy [6]. Therefore, in addition to the spread of digital dentistry, information on the trueness of traditional impression techniques remains of paramount importance. The reason for this is twofold. On the one hand, the digitization of conventional impressions or models is one of the possible routes to CAD / CAM techniques; on the other hand, the vast majority of dental offices still use traditional impressions [7,8]. In addition, numerous studies and factory data are available on the impression materials themselves and their accuracy [9]. However, the trueness and accuracy of the various impression techniques are still not widely researched. Most in vitro examinations of impressions use simplified bodies, such as cones instead of teeth or tooth models [10,11]. In many studies, only two or three techniques are compared in an analogous way or by the evaluation of trained clinicians, but not in a qualitative way [12-14]. In the present in vitro study using a PMMA master cast with prepared stumps, the four most commonly used precision impression techniques are compared to explore whether there was a difference in the sampling trueness of these techniques. The hypothesis is that one-step impression techniques are truer than two-step techniques.

2. METHODOLOGY

The following four impression techniques are examined in the present study:
- the one-step putty-wash technique (1SPW),
- the monophase technique (MP),
- the two-step putty-wash technique prepared with escape channels (2SPW-Ch), and
- the two-step putty-wash technique prepared with a polyethylene spacer foil (2SPW-Fo).

Ten impressions were taken from a PMMA master model using each technique, i.e., altogether 40 impressions were created [15,16]. On the upper jaw master model, supragingival, chamfer shoulder preparation of the right first premolar (14), left first incisor (21), first premolar (24), and second molar (27) were prepared. In all cases, the impressions were made considering the manufacturer's instructions, the literature recommendations, and consensus [11,17,18]. Impression materials with the recommended consistency for the impression technique were applied in all cases, as stated in the factory recommendation [18]. For the 1SPW technique, a metal stock impression tray was used, with ISO-1 (Express XT Penta H; 3M ESPE), and ISO-3 consistency (Express XT Light Body; 3M ESPE) polyvinylsiloxane (PVS) impression material. The tray was filled with heavy-bodied material, its entire surface was covered with the wash material, and on all of the prepared teeth, an impression syringe was used to inject the wash material [15]. For the MP technique, a custom-made tray prepared by the dental technician from Lightplast Baseplate (Dreve-Dentamid, Unna, Germany) and ISO-2 consistency polyether impression material (Impregum Penta Soft; 3M ESPE) were used [19]. For the proper adhesion of the impression material to the tray, the Polyether Adhesive (3M ESPE) was applied as required by the manufacturer. The mixed impression material was filled into the tray, and all the prepared stumps were injected with an impression syringe.

A metal stock tray and ISO-0 putty consistency PVS impression material (Express XT Penta Putty; 3M ESPE) were used for the two-time impressions, followed by ISO-3 consistency PVS wash material (Express XT Light Body; 3M ESPE). Two different techniques were applied to ensure decompression. In the first case, escape channels were cut in the impression on both mesial and distal sides of each prepared tooth while alternating on the oral and buccal sides of the non-prepared teeth (2SPW-Ch) [16]. In the second case, the surface of the putty material was covered with a polyethylene spacer foil (Impression Separation Wafer GC Europe) to provide the proper gap for the wash material (2SPW-Fo) [20]. In all cases, the impression materials were mixed with the impression mixing machine as recommended by the manufacturer (Pentamix; 3M ESPE) or with a factory impression gun (Garant; 3M ESPE) following the manufacturer's instructions [21].

A PMMA master model was applied in the study because its material did not affect the setting of the materials used in any way. As the model is durable, many impressions could be taken without distortion or change. To the best of our knowledge, the model itself did not affect the results of this study in any way [7,22]. The impression-taking procedure was standardized using a Kaán impression tool [23]. Each tray was filled with impression material to the edge of the impression tray. The same 3 kg weights were used at all impressions. At the Kaán tool, you can position the cast only in one way accordingly. The directions and extent of the force were the same at all impressions, thus standardizing the impression conditions (Fig. 1). The impressions were taken by one calibrated person.

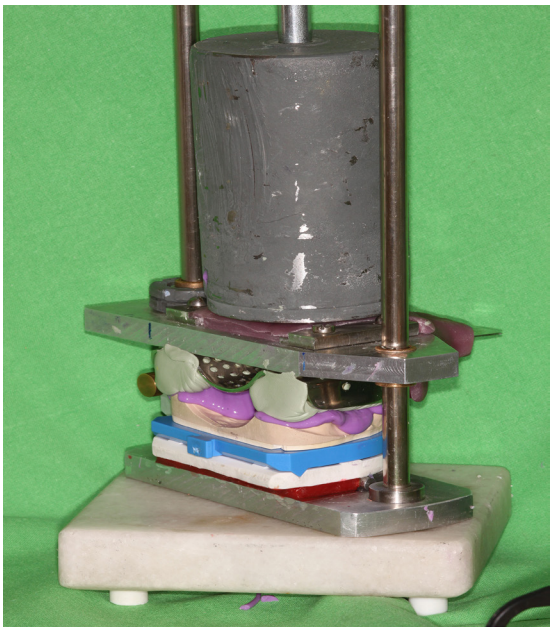

Figure 1. The Kaán impression tool.

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In the first step, the master model was scanned by an industrial dot laser scanner (Two Scan; Varinex Informatikai Zrt., Budapest, Hungary), and then the forty prints were scanned as well [24]. As previously recommended, a minimum of 1, a maximum of 24 hours elapsed between the impressions being completed and the scan [25]. After scanning the impressions, the resulting .stl files had to be compiled to allow comparison of the data set with the data set obtained during the master model scan [26].

During the measurement, an incision plane was determined in the virtual space manually, which intersected all the prepared teeth examined. The reference points were determined automatically. The program selected points that could be used as reference points. Both the plane and the reference points were determined only once and were transferred between each measurement. The distances between measurement points were selected on the master model scan to establish the baseline data. Then the corresponding distances on each impression scan were measured and compared to the baseline (Software: Geomagic Verify, Geomagic Inc., Morrisville, NC, USA).

The mesiodistal (MD) and bucco-palatal (BP) diameters of the prepared teeth 14, 21, 24, 27 were measured in the incision plane. Furthermore, distances between 24 distal (24D) and 27 mesial (27M) measuring points (20 mm small distance), between the 24 mesial (24M) and 27 distal (27D) measurement points (32 mm medium distance), and 52 mm large distance between 21 mesial (21M) and 27D were measured [13,27]. GraphPad Prism 5 Software (GraphPad Software Inc., San Diego, CA, USA) was used for statistical analysis. The Kruskal–Wallis Test and Dunn's multiple comparison post-hoc test were applied to examine the correlation between groups, with a significance threshold of $p < 0.05$.

3. RESULTS

Thus, six stump diameters (14BP, 21MD, 24BP, 24MD, 27BP, 27MD) and two distances (medium distance between 24M–27D and large distance between 21M–27D) were analyzed further (Fig. 2). Since the diameters of the stumps fell in the same size range, a common average of the six stump diameters was calculated for better statistical processability. Furthermore, only six instead of the originally planned eight diameters and two instead of three distances were examined. The problem arose when selecting the incision plane: some of the measuring points were in an area with undercuts during the scan. This is a problem, because in the invisible regions, the computer-calculated data were displayed partially, which significantly distorted the measurement results [28]. Therefore, the study did not consider the apparently false results between the 14 MD diameter and the 21 BP diameter and 24D–27M (short distance) [29].

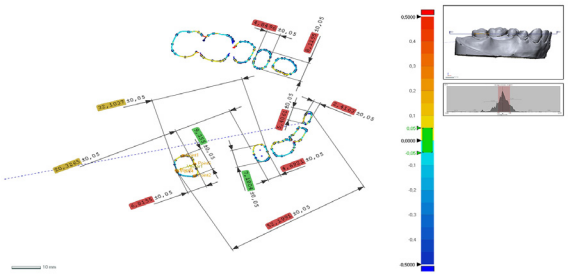

Figure 2. Measurement report. The selected distances and the intersection plane on the master model are shown in the top right corner.

The mean deviation for the six stump diameters was 31.84 µm for the MP impression technique (SD: 28.29), 56.48 µm for the 1SPW (SD 89.07), 74.04 µm for the 2SPW-Fo (SD 157.51), and in the case of 2SPW-Ch, it was 180.64 µm (SD 338.17). Examining the trueness of the stump sampling, we can observe the following trend: the truest was the MP technique followed by 1SPW, 2SPW-Fo, and finally the 2SPW-Ch. In terms of die diameters, MP was significantly truer than 2SPW-Fo and 2SPW-Ch, while 1SPW was significantly truer than 2SPW-Ch. The other differences were statistically not significant (Fig. 3).

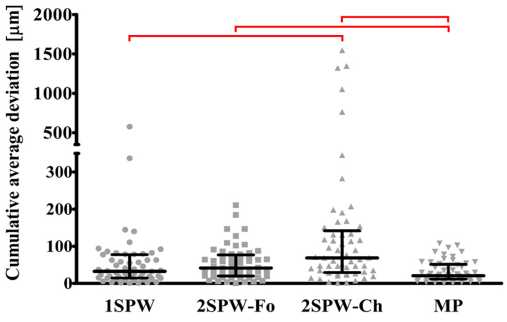

Figure 3. The cumulative average deviation for the six stumps. The red clasp indicates a significant difference ($p < 0.05$).

For the medium distance between 24M and 27D, the trend was the same as found at the level of the stumps. The MP technique proved to be the truest; the deviation from the sample was 42.74 µm (SD: 31.22), followed by 1SPW 71.37 µm (SD: 53.67), 2SPW-Fo 83.46 µm (SD: 57.25), and then 2SPW-Ch 136.47 µm (SD: 61.57). A significant difference was found only between MP and 2SPW-Ch. The other differences were not significant statistically (Fig. 4).

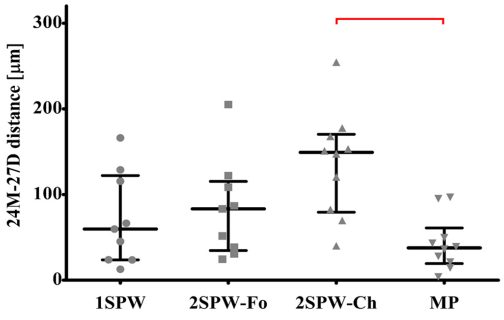

Figure 4. The average deviation for the medium distance. The red clasp indicates a significant difference ($p < 0.05$).

For the large distance between 21M and 27D, the trueness was as follows: the slightest deviation, 162.62 µm (SD: 68.24), was found for 1SPW. This

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was followed by MP 188.32 µm (SD: 48.48), 2SPW-Fo 286.14 µm (SD: 174.18), and finally 2SPW-Ch 348.85 µm (SD: 122.68). For the 2SPW-Ch technique, both 1SPW and MP proved significantly truer (Fig. 5).

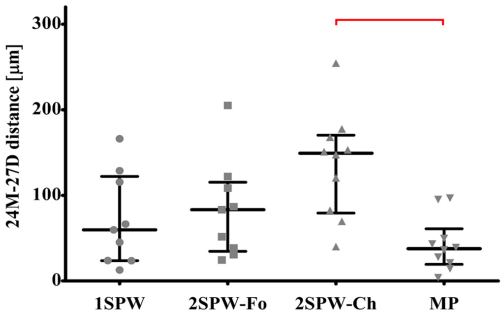

Figure 5. The average deviation for the long distance. The red clasp indicates a significant difference ($p < 0.05$).

4. DISCUSSION

Regarding the sampling trueness of the impressions, the strict deviation of 50 µm only fits the diameters of the stumps, and the medium distance measured between 24M and 27D with the MP impression technique [2]. The trueness of 1SPW with 2SPW-Fo techniques fell outside this range but is well within the most generally accepted trueness of 120 µm for both distances mentioned above [3]. The sampling trueness of the 2SPW-Ch technique shows a difference of more than 120 µm, even in the case of the stump diameter. The distance measured between the stumps increases even more with the increase of the examined length. Concerning long distance, the degree of deviation from the initial sample remained below 200 µm in the case of the 1SPW and the MP techniques, while for the 2SPW-Fo technique, it almost reached 300 µm. However, it does not make sense to use the 120 µm deviation for medium and long distances, since the distances examined are larger by orders of magnitude than for stump diameters. In this case, it is better to express the extent of the deviation in proportion to the distance examined (Table 1).

Table 1. The average deviation for the medium and long distances in percentage.

	1SPW	2SPW-Fo	2SPW-Ch	MP
medium distance	0.222%	0.259%	0.425%	0.133%
long distance	0.311%	0.548%	0.668%	0.360%

Thus, for all the examined distances, except for the largest studied length, the MP technique showed the slightest difference, followed by the 1SPW and the 2SPW-Fo methods, and in all cases, the 2SPW-Ch technique performed the worst. The first and second places were reversed for the largest distance examined.

Pastoret et al. found that the 1SPW technique performed best for short distances, while the MP technique performed best the long distances, but in both cases, the 2SPW-Fo technique remained below them [17]. Rudolph et al. and Luthardt et al. established the order 1SPW, MP, 2SPW with a spacer cap, while Dugal et al. found the 1SPW technique to be more accurate than the 2SPW with spacer cap [13,18,30]. According to Mann et al., the 2SPW-Fo impression technique is more accurate than the 2SPW-Ch technique [16]. These findings are all in accordance with the results published here.

Contrarily, Caputi et al. found a unique 3-phase impression technique to be the most accurate, followed by the 1SPW, and finally, the MP techniques [31]. The discrepancy may be that the MP technique was used with PVS and a stock tray instead of polyether and a custom tray. Nissan et al. found the latter to be the most accurate in both studies when comparing techniques using 1SPW, 2SPW-Fo, and 2SPW with a spacer cap [11,20]. The third technique, which was not examined in the present study, proved to be the most accurate. However, Nissan et al. did not succeed in detecting a significant difference between the 1SPW and the 2SPW-Fo techniques they examined, which coincides with the results presented here. In his study, Nissan used the same ISO 0, putty consistency impression material for all three techniques, which is not ideal for the 1SPW technique. This may be partially responsible for the different results. Jamshidi et al. found the 2SPW-Ch technique significantly more accurate than the 1SPW technique. However, in the one-step technique, the wash material was injected only on the stumps, they did not cover the kneadable base, and both techniques had the same ISO 0 consistency [12].

In the most relevant literature, the simultaneous techniques proved to be more accurate, i.e., less difference can be expected when using them than in the case of separate time impression techniques, except for some less commonly used, individually modified two-step techniques [17,30]. In almost all studies examining two-step techniques, using the 2SPW-Fo technique or 2SPW with spacer cap gave better results than the 2SPW-Ch method [11,16]. All this is in line with the results presented here.

However, there is no consensus on which simultaneous technique provides greater trueness: MP or 1SPW? One important reason for the discrepancy may be that the combinations of impression material and impression tray recommended primarily for the 1SPW and MP techniques were not appropriately used in all studies [11,12,31]. As is well known, the 1SPW impression technique is primarily based on ISO 1 consistency (and not ISO 0, as in several of the studies cited), and a stock tray is recommended. In contrast, for the MP technique, the use of ISO 2 medium consistency material and a custom tray gives the best result [18]. In the latter case, polyether impression material has an advantage over PVS due to its thixotropic effect.

According to our study results, it can be said that the one-step impression techniques performed better. This may be due to the deformation during the replacement of the impression for the second time.

Additionally, the hydraulic distortion, and finally the imperfect connection between the two different consistencies at the two-step impression techniques may account for the better performance of one-step techniques.

Within the limitations of this study, it can be concluded that better clinical results can be achieved using one-step impression techniques, either MP or 1SPW, while preparing fixed prostheses. In the case of using the two-step putty-wash technique, the decompression with only escape channels might be insufficient, leading to hydraulic distortion and inaccurately sitting fixed prosthesis in the end. However, it is essential to note that besides the MP and the 1SPW impression techniques, even the 2SPW-Fo method provides adequate results at the stump level, only 2SPW-Ch proved to be insufficient this level.

5. CONCLUSION

Within the limitations of this study, the hypothesis was confirmed: it was proved that the MP and the 1SPW, i.e., the simultaneous techniques, showed significantly better trueness among the examined precision impression techniques. In contrast, the 2SPW-Ch technique proved to be the most inaccurate at all diameters and distances.

CONFLICT OF INTEREST

The authors have no financial interest in any of the companies whose products are used in this study.

AUTHOR CONTRIBUTIONS

BJ, **SZK**, **MJ** and **JB**: concept. **SZK**, **BV**, **GJK**: protocol. **BJ**, **SZK**, **MJ**, **BV**, **GJK**: data gathered and analyzed. **PH**, **JB**: interpretated and critically revised the manuscript. All authors read and approved the final manuscript.

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CV

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Questions

1. Monophase impression are correctly made with impression material of the following consistency:

❑a. ISO-0;
❑b. ISO-1;
❑c. ISO-2;
❑d. ISO-3.

2. PMMA is ideal for master cast material because:

❑a. It does not affect the setting of impression materials;
❑b. It has a nice color;
❑c. It is sufficiently flexible;
❑d. It hardens heat.

3. In our study, the distances between the following teeth were evaluated:

❑a. "Small distance": between 24 distal and 27 mesial points;
❑b. "Extra long distance": between 14 mesial and 27 distal points;
❑c. "Medium distance": between 24 mesial and 27 distal points;
❑d. "Horizontal distance": between 14 mesial and 24 mesial points.

4. On the large distance the most true impression technique in our study is:

❑a. One-step putty-wash technique;
❑b. Monophasic technique;
❑c. Two-step putty-wash technique with spacer foil;
❑d. Two-step putty-wash technique with escape chanel.

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Original Articles

COMPARATIVE EVALUATION OF THE RELATIONSHIP OF TEETH COLOR AND SOFT TISSUE COLOR OF THE FACE IN INDIVIDUALS WITH NATURAL DENTITION

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ABSTRACT

Introduction The aim of this study is to make it easier for dentists to choose artificial tooth color in fully and partially edentulous patients by evaluating the relationship between the color of the soft tissues of the face and the color of the teeth.

Methodology The CIEL*a*b* color values of the maxillary central teeth of the volunteers participating in the study were measured by spectrophotometer, and skin, lip and eye color were measured from facial images containing ceramic blocks to standardize the light and color values using Adobe Photoshop software. The Kolmogorov-Smirnow test and Spearman Rank Correlation test were used to evaluate the data.

Results It was observed that there was a higher correlation between the L* values of the teeth and the L* and b* values of the skin.When the analysis between the color measurements taken from the lip photographs and the teeth was examined, it was seen that there was a statistically significant positive correlation between the L* values of the upper central teeth and the a* values of the lip.

Conclusion The results showed that the CIEL*a*b* parameters of skin color and lip color can be used in the selection of tooth color in case of loss of natural teeth or discoloration of existing teeth.

KEYWORDS

Color Measurement; Digital Camera; Spectrophotometer; Skin Color; Tooth Color.

1. INTRODUCTION

There is abundant and strong scientific evidence that the appearance of a person's face and teeth has a profound effect on perception and questioning by others [1–3]. It is also thought that the appearance of the face and teeth have a great impact on the development of the personality of the individual, getting a job, performing, believing in himself and being a victor. The social status of a personality and the attractiveness of a smile are related to each other [4].

While in the past, functional demands were taken into account in oral treatments, today the focus has shifted to aesthetic dentistry with the decrease in caries prevalence [5,6]. Establishing an appropriate balance between illusion and reality is the basis of aesthetic dentistry [7]. The ultimate purpose of aesthetic dentistry is to create beautiful smiles that are compatible with the teeth, gums, lips and face of the patient that complement each other in natural proportions [8]. One of the most important issues in aesthetic dentistry is color selection. Therefore, every dentist should know the color matching procedures for aesthetics [9].

For nearly a century, dentists have used tooth color shade guides for accurate color matching. This traditional way of picking colors is oversimplified and too subjective to constitute a standart [10]. While visual color selection with tooth color shade guides is the most common color matching system, it is considered inconsistent and subjective as it is affected by lighting, age, gender, eye fatigue [11]. In addition to the subject of color selection, which is a very challenging process in dentistry, dentists and technicians need to communicate about tooth colors during prosthesis production procedure. However, verbal communication of color differences is limited. A good color match is directly related to the quality of the prosthesis. The more precisely the tooth colors can be defined, the more accurate porcelain colors can be obtained [12–15].

To obtain the natural and harmonic restoration color, it is necessary to have an objective, precise and systematic method, from the color matching procedure in dentistry to its reproduction in the laboratory [16].

Color measuring instruments and systems such as spectrophotometers, colorimeters, spectroradiome-

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ters and digital image analysis techniques have become increasingly popular, especially in dental research. Spectrophotometers are considered among the most accurate, useful and flexible tools for color matching in dentistry [11,17]. It was found to offer a 33% increase and a more objective match in 93.3% of the cases [18].

Recent advances in photography and technology have been updated with the widespread use of the digital camera for color imaging. Digital cameras have the ability to record numerical data in an object, which data can then be used to produce an image when viewed on a computer and transmitted over the internet. Images produced by a digital camera can be analyzed using suitable imaging software that allows color values to be collected from all or part of such images. This is a much cheaper process than using traditional color measuring instruments such as spectrophotometers or colorimeters [19–21]. Digital imaging systems, on the other hand, are comparable to spectrophotometers, as they provide additional information for color measurements and can measure appearance properties beyond true color when applied correctly [22–24].

Tooth color selection can become more difficult for clinicians when there is no tooth to be used as a reference. In these cases, the choice of tooth color may be more subjective [6,25,26]. Patients not only have a healthy mouth, but they also demand a beautiful smile that is one with the shape of the face, eyes, hair and teeth. It is accepted that the harmony between tooth color and soft tissues, as well as the shape and arrangement of the teeth, significantly affects the aesthetics of the smile [27,28].

There is not enough scientific data support about the relationship between tooth color and soft tissue color of the face. The existence of a possible relationship between the soft tissue color of the face and the tooth color will facilitate the dentist's selection of artificial tooth color in fully and partially edentulous individuals. Since skin color and tooth color measurements are made with traditional and visual methods, more subjective data have been obtained in the previous studies. For this reason, in our study, tooth color was measured with a spectrophotometer and the soft tissue color of the face was measured with the help of a camera by creating a standard environment. The aim of our study is to question the existence of a possible correlation between tooth color and soft tissue color of the face in order to eliminate lack of scientific data support in the literature. The hypothesis of this study is the presence of a correlation between tooth color and the soft tissue color of the face.

2. METHODOLOGY

2.1. Sample Description

150 people aged 20-25, studying at Faculty of Dentistry, Ege University, Izmir participated in this study. Permission was requested from all individuals participating in the study to take photographs, the reason for the study and all necessary information were explained in detail, and an informed consent form was signed by all patients. Our study was approved by the Ege University Faculty of Medicine Research Ethics Committee No. 20-11T/51.

The exclusion criteria of the patients are listed in the following items:

1. If over 25 years old,
2. If the maxillary central incisors are not fully erupted,
3. If there is any developmental defect in the maxillary central incisors,
4. If there is caries in the maxillary central incisors,
5. If any restoration, root canal treatment or teeth whitening procedures have been applied to the maxillary central incisors,
6. If extrinsic coloration is high in maxillary central incisors,
7. If there is any post-surgical scarring or malformation on the face,
8. If there is any skin disease and the presence of intense tan,
9. If the orthodontic treatment of the individual is continuing, the individuals were not included in the study.

2.2. Measurement of Tooth Color with Spectrophotometer

Tooth color was measured from the middle third of the labial portion of both maxillary central teeth. Before the color selection, dental prophylaxis was applied to the target teeth with a mixture of pumice and water in order to keep the measurement surface clean and free from stains. Before the measurement procedure, a lip retractor was placed in the mouths of the individuals participating in the study.

The tooth shade selection was made using the Vita EasyShade Advance spectrophotometer (VITA Zahnfabrik GmbH, Bad Säckingen, Germany). All measurements were made under 112 cm wide Led Fluorescent lighting with a temperature of 6500°K and a color rendering index (CRI) of 95 (Philips & Co, Netherlands).

It is known that the spectrophotometer device has a fixed enhanced light source from fiber optic light at the measuring end, so the device can record tooth tones in any light beam. For this reason, the lighting conditions of the environment were ignored with the recommendation of the manufacturer.

The Vita EasyShade Advance spectrophotometer device, consisting of a base and a handpiece part, was calibrated using a ceramic calibration plate fixed to the device before data collection. The measuring handpiece part of the device was held on the ceramic plate prepared for the calibration of the device, and it was held until the sound indicating that the calibration was done was heard. Calibration was repeated before each tooth measurement.

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Before each measurement, an infection protection barrier (VITA Easyshade Infection Control Shield, Vita Zahnfabrik, Bad Säckingen, Germany) was attached to the tip of the spectrophotometer to prevent cross-infection. The "Single Tooth Option" was selected from the color selection menu. The measuring tip of the device was placed at a 90^0 angle to the middle third of the labial surface of the tooth. Measurements were made in accordance with the manufacturer's instructions and attention was paid to the correct positioning of the measuring tip.

All measurements were made by the same investigator to ensure standardization. The average of three consecutive measurements from the middle third of the labial surfaces of the targeted teeth was taken, and the CIE L* a* b* values and the values of the Vita 3D Master scale were recorded. All obtained values were recorded on previously prepared forms.

2.3. Standardization of the Area to Take Portrait, Eye and Lip Photographs and Camera Settings

In order to standardize the environment before the photo shoot, a room in the Ege University Faculty of Dentistry was designed to be used in this study as described below. All the windows of the room were closed with opaque thick black covers in order to prevent any light from leaking in and it was ensured that it was isolated from all light sources. All portrait, eye and lip photos were taken in this room.

A non-reflective black screen was used as the background for the portrait photos. A stool was placed 75 cm in front of the background so that the dark tones in the hair of the people to be photographed could not confused with the background. All shots were taken with the subject to be photographed sitting on a stool. Two speedlight overhead flashes (Godox TT685F, Fujifilm Compatible Top Flash, GODOX Photo Equipment Co., Ltd, Shenzhen, China) were used as light sources, angled 45 degrees in front of the person to be photographed. Two 10x10cm soft boxes were used to increase the light quality, to keep the light power standard and to provide a softer light spread. (Godox SB1010 10x10cm Flash Softbox, GODOX Photo Equipment Co., Ltd, Shenzhen, China) A randomly chosen ceramic block was fixed to a bracket on the end of a tripod to ensure its position remained the same across all photographs. A stationary system was designed by fixing the overhead flash on the other end of the bracket. The ceramic block was positioned to align the outer canthus of the subject's right eye for each portrait and eye photograph, and the right commisura labiorum for all lip photographs. External light sources and ambient conditions were kept constant for all individuals.

All photos were taken with NIKON D90 digital lens adjustable camera (Digital Single-Lens-Reflex, DSLR camera) and Nikon AF-S DX Micro NIKKOR 85mm f/3.5G ED VR lens. Before the photo shoot, ISO 200 (International Standards Organization), aperture f5/6, exposure time 1/125 sec. After the first photo was taken with a gray card, the white balance settings of the ceramic block in the photos were applied to the other photos. A tripod was used to ensure that images can be taken from the same distance for all portrait, eye and lip photos and to keep the camera stable during shooting.

2.4. Taking Portrait, Eye and Lip Photographs

After checking the standardization of the area to be photographed, the volunteers participating in the study were asked to gently wash their faces with warm water to remove dirt and cosmetics. The volunteers were kept at room temperature for 20 minutes after face washing. Volunteers sat on a stool 75 cm in front of a black background; The axis of the camera lens was kept at eye level of the patient. Prior to the photo shoot, the volunteers were asked to remove photographic distractors such as hats, jewelry, and glasses. During the photographing process, the Frankfort Horizontal plane of the individuals was positioned parallel to the ground, and the Midsagittal planes were positioned perpendicular to the ground.. Before taking the photo, the auto focus feature was turned off in the camera settings, and all the photos were taken from 1.5 meters where the desired data could fit into the frame in the clearest way. The first photograph was taken with the aid of a standard gray reference card (Original White Balance Reference; Michael Tapes Design) with known color values. The photograph was taken in high resolution, flash and raw data format (Fig. 1).

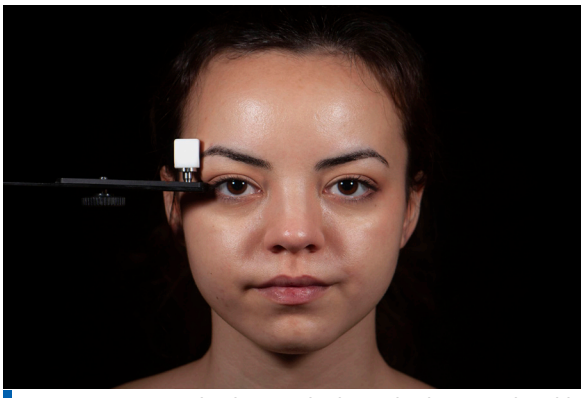

Figure 1. Portrait, eye, lip photograph taken with Nikon D90 adjustable camera with digital lens.

The camera stored the images in NEF format because the image data was not processed intact.

2.5. Color Analysis of Photographs

2.5.1. Skin Color Analysis from Portrait Photographs

After taking the portrait photographs of the volunteers participating in the study, all the images were transferred to the computer. In order to ensure standardization control for each portrait photograph taken, the CIEL*a*b* value of the intersection point of the lines drawn from the four outer corners of the ceramic block to the center of the rectangle in the first photograph taken with a gray card was measured with the Adobe Photoshop program (Fig. 2).

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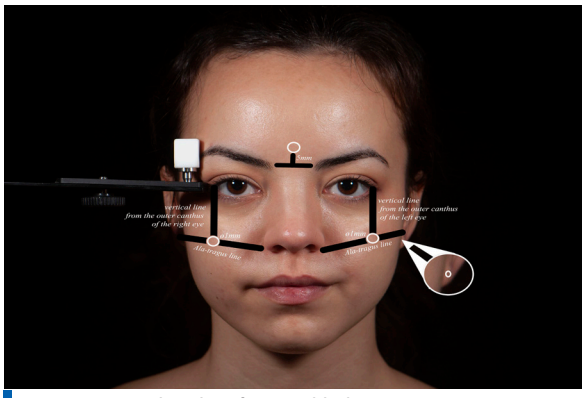

Figure 3. CIEL*a*b* value of ceramic block.

In order to ensure that the ceramic block, whose CIEL*a*b value was measured as 94.0.0 with the spectrophotometer, gives this value for each photograph, the measurement point was selected using the white balance tool in the Adobe Photoshop program. The white balance values in all the photos were adjusted according to this point located in the middle of the ceramic block.

In order to standardize the skin color analysis of each volunteer participating in the study, four reference regions were determined in the portrait photographs (Fig. 3).

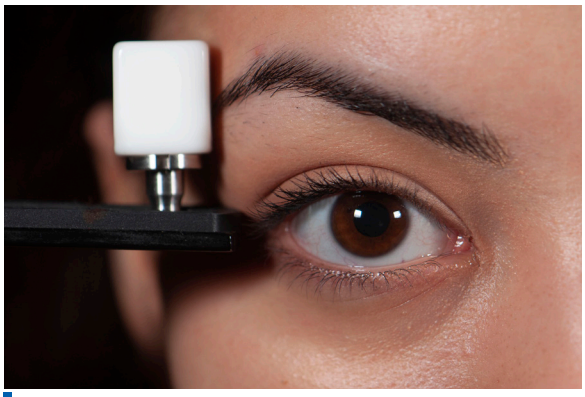

Figure 3. Reference regions for skin color measurement from portrait photographs.

For the first region, the circular region with a width and height of 1 mm, where the vertical descending line from the outer canthus of the right eye and the ala nasii-tragus line intersect on the right cheek was taken as reference. For the second region, the circular region with a width and height of 1 mm, where the vertical descending line from the outer canthus of the left eye and the ala-tragus line intersect on the left cheek, was taken as reference. For the third region, the circular region with a width of 5 mm above the nasal bridge and a height of 1 mm was taken as reference. For the fourth region, the circular region with a width and height of 1 mm at the midpoint of the left earlobe was taken as reference.

To determine skin color, the average CIEL*a*b* value of these four different regions in the portrait photograph of each volunteer was taken. The Adobe Photoshop (Adobe Inc., San Jose, CA, USA) program was used to determine the CIEL*a*b* value of four different regions of the face. The average of the CIEL*, a* and b* values of four different reference regions was automatically measured from a total of approximately 10,000 separate points in the selected regions. By using this method, it was aimed to prevent changes in the skin such as skin spots, mild skin inflammations and sunburn, which may cause deviations in the measurement results.

In all photographs, the absence of clipping was checked on the histogram showing the exposure levels. It was also checked with histogram whether the reference regions for the analysis of skin color remained in the overexposure or underexposure areas. After making sure that the four reference regions were in the areas where the exposure value of the light was normal, the measurements were carried out.

2.5.2. Eye Color Analysis from Eye Photographs

After taking the eye photographs of the volunteers participating in the study, all the images were transferred to the computer. In order to ensure that the light and color values of all photographs are the same, it was checked that the selected ceramic block gave the same CIEL*a*b* values for each eye photograph. In order to standardize the eye color analysis of each volunteer participating in the study, the reference region to be measured in the eye photographs was determined with the Adobe Photoshop program.

The eye was divided into two equal hemispheres with a horizontal axis passing through the center of the pupil. By removing the pupil in the lower hemisphere, the iris in this hemisphere was taken as a reference for eye color analysis. Thus, the shadow areas formed by the eyelash in the upper hemisphere and the light reflections created by the ceramic block used for standardization were eliminated (Fig. 4).

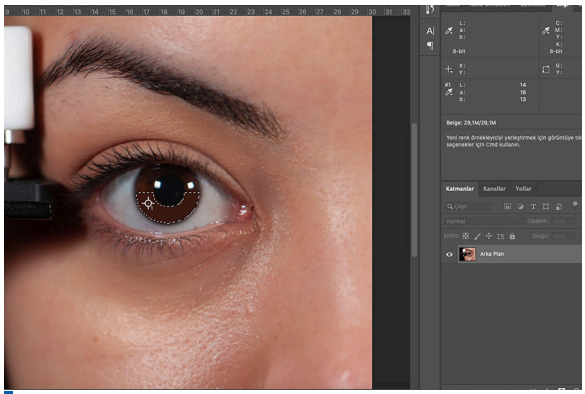

Figure 4. Determination of the reference region to measure eye color from eye photographs with Adobe Photoshop program.

The feature used to determine the average color value of a region in the Adobe Photoshop program was used for the selected reference region in all eye photographs. Thus, different pigmented areas in the iris were prevented from affecting the measurement alone. The CIEL*a*b* value of the region from which the average color value was taken was measured

using the Adobe Photoshop program and recorded on the pre-prepared forms.

2.5.3. Lip Color Analysis from Lip Photographs

All the lip photographs taken were transferred to the computer and it was checked that the ceramic block used to provide light and color standardization in all photographs gave the same CIEL*a*b* value for each photograph.

In order to analyze lip color from all lip photographs, a circular region with a width and height of 1 mm 2 mm below the philtrum was chosen as a reference (Fig. 5). CIE*L*a*b* values of the selected reference region were measured with the Adobe Photoshop program and recorded on previously prepared forms.

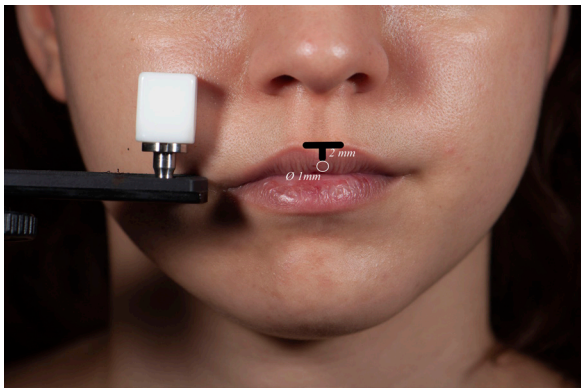

Figure 5. Reference region for lip color measurement from lip photographs.

2.6. Statictical Analysis

The average of 3 measurements made from the middle third of the labial surfaces of 11 and 21 was recorded in the excel table. The average CIEL*a*b* value of 4 regions measured on the skin from portrait photographs was recorded as skin color, eye color obtained from eye photographs, and lip color obtained from lip photographs saved in same excel table. IBM SPSS Statistics for Windows, Version 25.0 package program 2017 (IBM Corp., Armonk, NY, USA) and Microsoft Office Excel 2019 (Microsoft Office Excel 2019 ®, Redmond, WA, USA) were used for all statistical analysis. The conformity of numerical variables to normal distribution was examined using the Kolmogorov-Smirnov Test. The linear relationship between the color values measured on the teeth and 18 independent variables from 6 different regions on the face was examined by the Spearman rank correlation analysis. Since the normal distribution harmony could not be obtained in the color variables obtained in the study, the Friedman Test was first applied for the multi-group difference in comparing the L, a and b levels between different regions. Dunn's test with Bonferroni correction was used for pairwise comparisons, since the difference between regions was found to be significant as a result of this test. All hypothesis checks were performed at the 0.05 significance level.

3. RESULTS

According to the Spearman Rank Correlation made between tooth measurements and face measurements shown in Table 1; A positive, very weak and statistically significant correlation was found between the b measurement of tooth number 11 and the measurement of Y3.a with a correlation coefficient of 0.213, between the measurement of tooth no. 21 and the measurement of Y3.b, with a correlation coefficient of 0.187 ($p<0.05$). A positive, very weak and statistically significant correlation was found between the a measurement of tooth number 11 and the measurement of Y3.b with a correlation coefficient of 0.179, and the measurement of a tooth of tooth 21 and the measurement of Y3.b with a correlation coefficient of 0.187 ($p<0.05$). A positive, very weak and statistically significant correlation was observed between the L measurement of tooth 11 and the measurement of Y4.L, 0.203, with a correlation coefficient of 0.238 between the L measurement of tooth 21 and the measurement of Y4.L ($p<0.05$).

Table 1. The relationship between the measurements taken from the face and the measurements taken from the teeth.

		11. Teeth			21. Teeth3		
		L	a	b	L	a	b
Y1.L	Rho	0.036	-0.092	-0.195	0.185	-0.003	-0.099
	p	0.662	0.265	0.017*	0.023*	0.967	0.227
Y1.a	Rho	0.015	0.126	0.085	-0.044	0.084	0.038
	p	0.853	0.124	0.303	0.593	0.304	0.641
Y1.b	Rho	-0.142	0.098	0.084	-0.131	0.082	0.048
	p	0.083	0.231	0.310	0.109	0.321	0.564
Y2.L	Rho	0.143	-0.150	-0.198	0.244	-0.091	-0.128
	p	0.081	0.068	0.015*	0.003*	0.267	0.118
Y2.a	Rho	-0.020	0.167	0.140	-0.095	0.114	0.070
	p	0.812	0.041*	0.087	0.250	0.165	0.397
Y2.b	Rho	-0.171	0.184	0.170	-0.128	0.110	0.079
	p	0.036*	0.024*	0.037*	0.119	0.180	0.335

Y3.L	**Rho**	0.134	-0.200	-0.278	0.272	-0.129	-0.234
	p	0.103	0.014*	0.001*	0.001*	0.115	0.004*
Y3.a	**Rho**	-0.095	0.185	0.213	-0.163	0.136	0.180
	p	0.247	0.023*	0.009*	0.046*	0.097	0.028*
Y3.b	**Rho**	-0.195	0.179	0.175	-0.190	0.187	0.124
	p	0.017*	0.028*	0.033*	0.020*	0.022*	0.131
Y4.L	**Rho**	0.203	-0.057	-0.086	0.238	-0.072	-0.009
	p	0.013*	0.491	0.297	0.003*	0.383	0.915
Y4.a	**Rho**	0.202	-0.010	0.022	0.075	-0.050	-0.021
	p	0.013*	0.908	0.791	0.361	0.547	0.803
Y4.b	**Rho**	0.007	-0.005	-0.069	0.023	0.039	-0.060
	p	0.930	0.953	0.405	0.776	0.634	0.463
Yt.L	**Rho**	0.135	-0.140	-0.226	0.272	-0.064	-0.134
	p	0.101	0.087	0.005*	0.001*	0.438	0.103
Yt.a	**Rho**	0.037	0.178	0.177	-0.073	0.119	0.105
	p	0.653	0.030*	0.030*	0.374	0.146	0.200
Yt.b	**Rho**	-0.166	0.129	0.091	-0.144	0.118	0.051
	p	0.043*	0.115	0.266	0.078	0.150	0.535

*p<0.05

According to the Spearman Rank Correlation made between tooth measurements and eye measurements shown in Table 2, it was found that there were correlations between the L*a*b* measurements of tooth number 11 and the L*a*b* measurements of the eye; no statistically significant relationship could be obtained between the measurements of tooth number 21 and any eye measurement.

Table 2. The relationship between the measurements taken from the eye and the measurements taken from the teeth..

		11. Teeth			**21. Teeth3**		
		L	**a**	**b**	**L**	**a**	**b**
G.L	**Rho**	0.191	-0.183	-0.195	0.1445	-0.082	-0.089
	p	0.020*	0.025*	0.017*	0.079	0.318	0.281
G.a	**Rho**	0.110	-0.12	-0.163*	0.079	-0.074	-0.059
	p	0.181	0.139	0.046	0.334	0.368	0.474
G.b	**Rho**	0.163	-0.164	-0.174	0.100	-0.093	-0.063
	p	0.046*	0.045*	0.033*	0.225	0.258	0.447

*p<0.05

According to the Spearman Rank Correlation used to examine the relationships between lip measurements and tooth measurements shown in Table 3, a negative, very weak and statistically significant correlation was found between the b measurement of tooth number 11 and the D.L measurement with a correlation coefficient of -0.173 (p<0.05).

Table 3. The relationship between the measurements taken from the lip and the measurements taken from the teeth.

		11.Teeth			**21. Teeth3**		
		L	**a**	**b**	**L**	**a**	**b**
D.L	**Rho**	0.064	-0.065	-0.173	0.181	0.071	-0.088
	p	0.434	0.432	0.035*	0.026*	0.390	0.282
D.a	**Rho**	0.176	0.063	-0.178	0.190	-0.045	-0.129
	p	0.031*	0.442	0.029*	0.020*	0.583	0.116
D.b	**Rho**	-0.089	0.103	-0.037	-0.084	0.159	0.003
	p	0.279	0.209	0.655	0.306	0.052	0.971

*p<0.05

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A positive, very weak and statistically significant correlation was found with a correlation coefficient of 0.176 between the L measurement of tooth number 11 and the D.a measurement ($p<0.05$). A negative, very weak and statistically significant correlation was observed with a correlation coefficient of -0.178 between the b measurement of tooth number 11 and the D.a measurement ($p<0.05$). A positive, very weak and statistically significant relationship was found with a correlation coefficient of 0.181 between the L measurement of tooth number 21 and the D.L measurement ($p<0.05$). A positive, very weak and statistically significant correlation was obtained with a correlation coefficient of 0.190 between the L measurement of tooth number 21 and the D.a measurement ($p<0.05$).

4. DISCUSSION

The hypothesis of this study was the presence of a correlation between tooth color and the soft color of the face. According to the results obtained from our study, it was observed that there was a correlation between skin and lip color and tooth color, but there was no significant correlation between tooth and eye color. Therefore, the hypothesis that there would be a correlation between tooth color and soft tissue color of the face was partially accepted. The differences between the results of our study and similar subjects reported in the literatüre may be due to the fact that the color matching procedures were mostly performed with the help of visual methods in previous studies. Unlike other studies, a ceramic block was used in our study to ensure that all photographs were in standard color and light values. The fact that the color values of the ceramic block are the same for each photograph has been very supportive that we use a more standard and objective method.

Since it is often accepted that the concept of aesthetics determines the character of a person in modern societies, it has become a very important issue [5]. Through aesthetic dentistry, the physician can make the patient's smile more beautiful while giving a younger appearance [29]. Accepting the smile as aesthetically compatible requires a perfect integration of the hard and soft tissues of the face and the teeth and gums. A smile aesthetics should always include evaluation and analysis of both facial and tooth formations [7,30].

Today, while tooth color can be better defined with developing technologies, it is difficult to define skin tone due to the lack of a well-categorized reference scale or guideline [31]. Most studies in the literature have categorized skin color visually [31–33]. In some studies in the literature, skin color was classified according to different cosmetic indices used to compare with samples such as NIVEA, LAKME or L'Oreal [34–36].

In most studies in the literature, eye color was determined by visual methods as well as skin color. In the study of Krasniqi et al. [37] in 2018 to determine a possible relationship between tooth color and skin color and eye color, and in the study of Hassel et al. [38] in 2008 evaluating the probability of predicting tooth color in the elderly according to hair, eye, face color and gender, eye color was determined visually. categorized as brown, green, blue and dark brown. In the study of Lagouvardos et al. [18] investigating the relationship between teeth, skin, hair and color in the Greek population, eye color measurement was made by matching the iris with the colors in the iris color scale suggested by Franssen et al. [39]. It is very difficult to standardize any visually determined classification. Since these subjective methods can vary from person to person, they cannot produce reproducible and reliable results.

The focus of our study is to investigate the existence of a possible relationship between L*a*b values obtained from teeth by spectrophotometer and L*a*b* values obtained from face, eye and lip photographs using the Adobe Photoshop program. Previous studies in the literature on this subject do not have sufficient scientific information or reports that are in harmony. As a result of the findings obtained in our study, it was observed that the L* value was quite close for teeth 11 and 21. L* values taken from the malar areas of the face are close to each other, but it was found that the L* values taken from the earlobe had lower L* values, unlike the other measurement regions on the face, and the L* values taken from the forehead region were higher than the other measurement regions on the face. It is an expected result that the L* value is lower than the other measurement regions, since the earlobe is located in the background of the other parts of the face, and the L* values are higher, since the forehead region is located ahead. At the same time, a positive, very weak but significant relationship was obtained with the L* value of the teeth, the L* values obtained only from the earlobe region, and the b* values obtained from the forehead region of the face, so a negatively, very weak but significant relationship was observed. It was observed that there was a positive, very weak but statistically significant relationship between the a* values of the teeth and the b* values of the forehead region of the face, and the b* values of the teeth and the a* values of the forehead region of the face. The results obtained from our study are compatible with recent studies on this subject [25,38,40–45].

In the study of Jahangiri et al. [35], it was stated that there was an inversely proportional correlation between teeth and skin color. The methodology in this study was completely different from our study, and both tooth and skin color were measured by visual methods. In the study of Esan et al. [41], both tooth and skin color were measured by visual

methods, but no significant difference was found between tooth color and skin color. In 2018, Lila et al.'s study [44], which measures tooth color with a spectrophotometer but categorizes skin color according to visual perception, did not find a relationship between tooth color and skin color. The limitations in visual color selection may have affected the results of studies that matched colors using visual methods. In our study, digital methods were preferred when measuring both tooth and skin color and the effects of subjective factors were minimized. In the study of Haralur et al. [46] examining the relationship between teeth and skin color between different ethnic groups, skin color was measured with the help of digital cameras, similar to our study. In this study, which takes a few points as a reference when determining skin color, changes in the skin such as skin spots, mild skin inflammations and sunburn may have caused deviations in the measurement results. In our study, the mean CIEL*a*b* values of regions with a width and height of 1 mm in anatomical landmarks to be used as a reference for color measurement were measured. Thus, by measuring the average of approximately 10,000 points in these regions, it is aimed to reduce the effect of changes in the skin that will cause deviations in the measurement results. In the literature, there is no scale that categorizes skin tone as a standard. While the spectrophotometer device used in our study can convert the spectral reflectance measured on the tooth into CIEL*a*b* values, the color values measured with the help of imaging analysis used to measure skin color can also be expressed in terms of CIEL*a*b*. The existence of a standard color space in which colors are expressed by both methods provides more consistent and reliable results between the regions compared. According to the results obtained in our study, it was observed that there was a harmony between tooth and skin color parameters. Although this fit is considered statistically significant, it is thought to be useful for a rough color estimation since it ranges from very weak to weak.

While the relationship between tooth color and skin color has been the subject of research in most of the studies in the literature, the number of studies investigating the relationship between tooth color and eye color is very little. In existing studies investigating the possible relationship between tooth color and eye color, eye color was measured by visual methods. In our study, a reference region was created from all eye photographs to create a standard in the measurement of eye color with the help of the Adobe Photoshop program. Based on the findings in our study, it was observed that the L* values measured from the eye had the lowest median among the L* values measured from the other soft tissues of the face, and the a* values of the eye had potential endpoints. The distribution of the b* values of the eye was quite wide. The fact that the L*a*b* values of the eyes are generally concentrated in an average range can be explained by the fact that most of the individuals participating in the study have darker eye colors. In the studies of Lagouvardos et al. and Hassel et al., it was stated that there is no linear relationship between tooth color and eye color, which is consistent with our study [38,43]. In the studies of Lila et al. and Krashniqi et al., it was concluded that there is a correlation between the upper central teeth and eye color, but there is no correlation between the color of the lateral and canine teeth and eye color [37,44]. There is no consistency between the results of the studies, since there is no accepted standard method to determine eye color and the determination of eye color in studies is based on subjective perception. In the statistical results obtained in our study, it was found that there were correlations between L*a*b* measurements of tooth number 11 and L*a*b* measurements of the eye but no statistically significant correlation was found between the measurements of tooth number 21 and any eye measurement ($p>0.05$). Although we did not reach the conclusion that there is a clear linear relationship between tooth color and eye color in our study, it is thought that some associations found may give an idea to dentists.

There is no study in the literature investigating the relationship between tooth color and lip color. According to the findings obtained in our study, the measurement of a* values in the lip has the highest and the measurement of b* values has the lowest median value compared to other variables. The fact that the lip color is more reddish than the color of the other soft tissues of the face explains the higher a* values and lower b values. When the analysis between the color measurements taken from the lip photographs and the color measurements taken from the teeth is examined, it is seen that there is a statistically significant positive correlation between the L* values of the upper central teeth and the a* values of the lip. According to this result, it is understood that the teeth of individuals with more reddish lips are brighter. According to the results obtained from our study, there is a partial relationship between the L* values and b* values of the lip and the upper central teeth.

The lack of literature to compare the results of our study, the limited skin color range of the individuals participating in the study, the low number of individuals with light-colored eyes, the measurement of tooth color only in the upper central teeth, are the points of the study that should be supported by other studies in this sense. More clinical and evidence-based studies can be done to detect the presence of a more precise, reliable relationship. In further studies, with the correlations between tooth color and soft tissue color of the face, the

color of the teeth can be easily determined with the double-stage calibration photographic technique used in our study, using macro software that can be developed.

5. CONCLUSION

The results in the present study are summarized as follows.

1. Within the limitations of the current study, significant correlations were found between tooth and skin color for CIEL*a*b* values. When the components of skin and tooth color are evaluated separately, it was observed that there was a higher correlation between L* values of teeth and L* and b* values of skin compared to other relations. The results showed that CIEL*a*b* parameters of skin color can be used in the selection of tooth color in case of loss of natural teeth or discoloration of existing teeth.
2. According to the statistical results obtained in our study, a definite correlation could not be established between tooth and eye color. It is thought that some associations between these two parameters can give an idea to dentists.
3. When the analysis between the color measurements taken from the lip photographs and the color measurements taken from the teeth was examined, it was seen that there was a statistically significant positive correlation between the L* values of the upper central teeth and the a* values of the lip.

CONFLICT OF INTEREST

The authors have no financial interest in any of the companies whose products are used in this study.

AUTHOR CONTRIBUTIONS

DO: conceptualization, methodology, software, writing - review& editing. **MEÇ:** investigation, visualization. **MS:** supervision, software.

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Questions

1. Which of the following was used to determine tooth color in the study?

❑a. Classic color guides;
❑b. Spectrophotometer;
❑c. Colorimeter;
❑d. Digital camera.

2. Which of the following programs was used to determine skin, eye and lip color in the study?

❑a. Canva;
❑b. Adobe Photoshop;
❑c. PhotoScape;
❑d. GIMP.

3. Which of the following is a conclusion that can be drawn from this study?

❑a. The standardization of the color matching process with the help of digital cameras provides very objective data in the analysis of the results;
❑b. It has been shown that CIEL*a*b* parameters of skin color can be used in the selection of tooth color in case of loss of natural teeth or discoloration of existing teeth;
❑c. Within the limitations of the present study, no significant correlations were found between tooth and skin color for CIEL*a*b* values;
❑d. Spectrophotometer is not a successful device to measure tooth color.

4. What is the purpose of the study named "Evaluation of the relationship of teeth color and soft tissue color of the face"?

❑a. Choosing artificial tooth color in fully and partially edentulous patients by evaluating the relationship between the color of the soft tissues of the face and the color of the teeth;
❑b. Understanding of artificial tooth alignment in edentulous and partially edentulous cases;
❑c. Comparison of the different eye, lip and skin color in the society;
❑d. Examination of the relationship between lip, skin and eye color.

EFFECTS OF CLEFT LIP AND PALATE ON TEMPOROMANDIBULAR JOINT COMPONENTS: A CBCT STUDY

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ABSTRACT

Introduction To assess the effects of cleft lip and palate (CLP) on the temporomandibular joint (TMJ) components using cone-beam computed tomography (CBCT).

Methodology This historical cohort study evaluated 20 CBCT scans of the TMJ area of patients with unilateral CLP as the test group and 20 CBCT scans of the TMJ area of non-CLP controls with class I occlusion. The morphological properties and dimensions of the condyle, the thickness of the glenoid fossa and articular eminence, and the articular eminence angle were measured and recorded. The two groups were compared regarding the above-mentioned variables by the Chi-square or t test (alpha=0.05).

Results The left and right axial condylar angles in CLP patients were significantly lower than the corresponding values in the control group by 1.8 degrees in the left and 2 degrees in the right side (p=0.005). The mediolateral condylar dimension at both sides was significantly lower in CLP patients than in the controls (p=0.001). The differences between the two groups were not significant in the anteroposterior condylar dimension, glenoid fossa thickness, and articular eminence thickness (p>0.05). The CLP patients had significantly lower articular eminence angle in the right side (p=0.016) but not in the left side (p>0.05), compared with the controls.

Conclusion Unilateral CLP patients have lower axial condylar angle and mediolateral condylar dimension at both sides, and lower articular eminence angle in the right side than the controls.

KEYWORDS

Dental Radiology; Cone-Beam Computed Tomography; Orofacial Cleft; Temporomandibular Joint.

1. INTRODUCTION

The temporomandibular joint (TMJ) is a complex joint located between the mandible and the temporal bone [1]. The loads applied to this joint affect both of the involved skeletal components, and can cause some alterations in their shape and thickness. In case of application of excessive forces, such alterations may exceed the normal range of variations (remodeling) and necessitate elimination of the etiology [2].

Cone beam computed tomography (CBCT) has gained popularity in recent years for imaging the craniofacial complex. CBCT delivers a significantly lower dose of radiation compared to conventional CT methods and has advantages over 2D images, including providing 1:1 orthogonal representations of structures. CBCT images can be used in the area of other 2D images, such as panoramic radiographic projection and lateral cephalogram, with the software capable of creating these images from the 3D data. Caution should be exercised to minimize radiation doses to patients. Studies have shown great variability in the amount of radiation exposure between different CBCT machines and the control of the field of view and intensity can help to minimize these levels. In addition, in cases with impacted teeth, CBCT images can provide a number of advantages over periapical and occlusal films for the

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localization of these teeth, since they provide images free of distortion and overlapping structures [3].

Approximately 60% to 70% of the populations worldwide show signs and symptoms of temporomandibular disorders; however, only one-fourth of them are aware of these signs and symptoms [4]. Temporomandibular disorders are often characterized by pain at the TMJ, pain or tenderness of the muscles of mastication, mandibular movement limitation, mandibular deviation, and clicking of the TMJ.

The pathognomonic signs and symptoms include pain or tenderness of the TMJ and periauricular areas, mouth opening limitation, and TMJ sounds in function. The patients feel pain in an area anterior to the ear. Alternatively, they may complain of recurrent pain in the temporal region, neck, or shoulders [4].

Orofacial clefts including cleft lip, cleft palate, or cleft lip and palate (CLP) are the most common congenital anomalies of the head and neck region, which often involve the lips, hard palate, soft palate, and alveolar bone[5]. CLP patients have numerous problems such as dental anomalies, malocclusions, facial and nasal deformities, and nutritional, respiratory, auditory, and speech problems [6]. Several congenital and environmental factors are involved in the occurrence of CLP, such that it is considered a multifactorial disorder [7].

Since the dentomaxillofacial tissues in CLP patients have a different growth pattern than that of normal individuals, anterior and posterior crossbite are common in such patients [8]. Evidence shows that the presence of crossbite, especially posterior unilateral crossbite, is correlated with the asymmetric function of the facial muscles in involved patients [9,10]. Also, considering the dental changes related to CLP and also occlusal changes and malocclusions in such patients, alterations of the condyles are also expected since condyles are among the most sensitive areas to occlusal changes [11].

A number of studies have addressed the effects of CLP on the condylar position and dimensions, relationship of the condyle and the glenoid fossa, and mandibular ramus height. For example, Ucar et al. [12] evaluated the condylar position and temporomandibular fossa in CLP patients and found a significant difference in the condylar angle between the patients and the controls. Kurt et al. [13] assessed the mandibular asymmetry in CLP patients and found no significant difference between the patient and control groups in this respect. Considering the existing controversy in the available literature on this topic, and limited number of studies focusing on the changes in skeletal components of the TMJ in CLP patients, this study aimed to assess the effect of CLP on skeletal components of the TMJ using cone-beam computed tomography (CBCT).

2. METHODOLOGY

This historical cohort study was conducted on the available CBCT scans of 20 patients with definite diagnosis of unilateral CLP and 20 non-CLP controls. The CBCT scans had been taken for purposes not related to this study such as evaluation of impacted teeth, or orthodontic treatment in both the test and control groups.

The sample size was calculated to be 20 CBCT scans in each group according to previous studies [11-14]. The inclusion criteria for the CLP patients were aged between 15 to 22 years, and surgical closure of the lip and hard tissue before the age of 3.5 years. The exclusion criteria were history of previous orthodontic treatment, orthognathic surgery, trauma, systemic and syndromic conditions, and history of degenerative joint disease.

The patients were selected by targeted sampling such that the medical records of patients with definite diagnosis of CLP who already had CBCT of the head and neck region were retrieved from the archives of the School of Dentistry of of Azad and several private oral and maxillofacial radiology clinics until the required sample size was reached. Also, medical records of non-CLP patients with class I occlusion who already had CBCT scans of the head and neck region and matched the test group in terms of age and sex were selected as the control group. The study was approved by the Ethics committee of School of Dentistry (Number 577226984). The CBCT scans had been taken in an upright position with maximum intercuspation by NewTom CBCT scanner with a maximum voltage of 110 kVp, 17 s scanning time, and 8 x 12, 12 x 15, or 15 x 15 cm fields of view. Image reconstruction was performed by NNT Viewer 2.21 software.

All images were evaluated by an oral and maxillofacial radiologist in a mildly lit room. The observer was allowed to observe the images in all orthogonal planes (axial, sagittal and coronal). Also, the examiner was free to adjust the brightness, or zoom the images. After observation of the images, the radiologist recorded the morphological characteristics of the condyles, condylar dimensions, glenoid fossa and articular eminence thickness, and the articular eminence angle. The measurements were made using NNT Viewer 2.21 software. For this purpose, the images were reoriented in the software such that the horizontal reference plane was the Frankfurt plane (passing through the right and left porion and orbitale) and the sagittal reference plane was perpendicular to the horizontal plane and passed from the basion, mid-orbital, and nasion. The coronal plane was perpendicular to the previous two planes, and passed through the nasion. After standardization of images in terms of orientation, axial sections with 0.5 mm slice thickness were reconstructed. In the largest mediolateral dimension of the condyle on the axial section at both sides, the mediolateral and the anteroposterior dimensions of the condyles and the axial condylar angle relative to the sagittal axis (the line passing through the basion, mid-orbital, and nasion) were all measured [12,15](Fig. 1).

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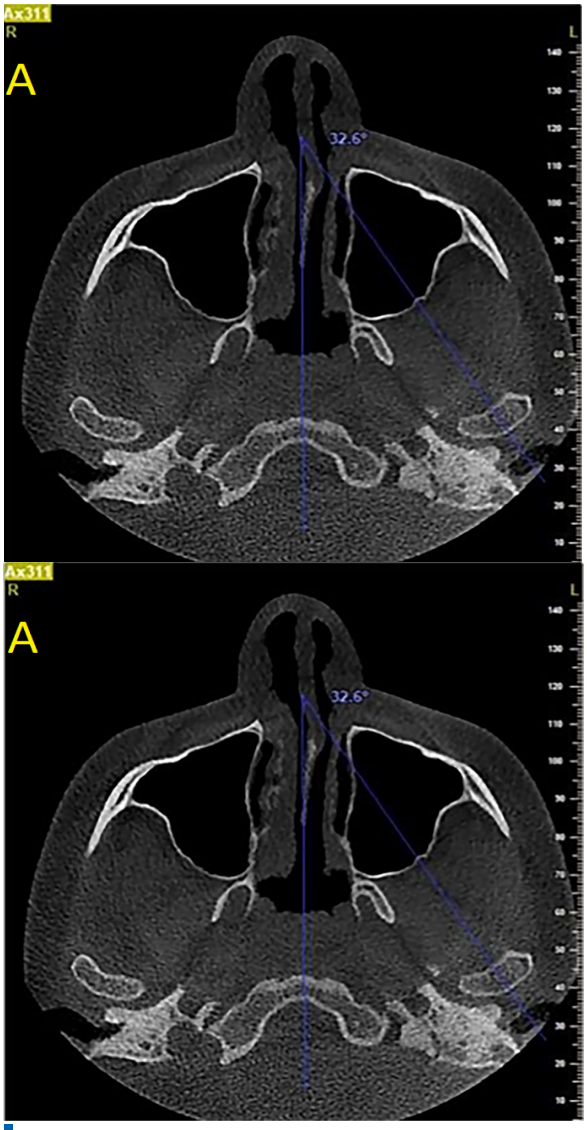

Figure 1. Reference regions for skin color measurement from portrait photographs.

To obtain coronal and sagittal views of the condyles, lateral sections perpendicular to the longitudinal axis of the condyle were made with 1 mm slice thickness, and coronal sections were made parallel to the longitudinal axis of the condyle with 1 mm thickness. The condylar morphology in the coronal view was categorized into four shapes of convex, round, flat, and angulated. This view was prepared from the widest mediolateral section of the condyle in the axial view [16] (Fig. 2).

Figure 1. Reference regions for skin color measurement from portrait photographs.

In the sagittal plane, the condylar morphology was categorized as round, flat, worn (between round and flat), and with osteophytes [17] (Fig. 3).

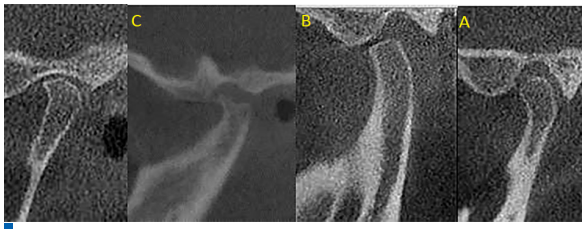

Figure 4. Reference regions for skin color measurement from portrait photographs.

The articular eminence measurements were made using the following points and lines:
Ce: The point at which line F intersects with the posterior surface of the eminence.
Cu: Peak of the condyle
Po: Porion (the highest point of the external ear)
R: The highest point of the fossa
T: The lowest point of the articular eminence
Using the above-mentioned points, the following lines were drawn:
Ebf line: The best fit of the articular eminence angle by passing through the Ce
F line: The Frankfurt plane
F1 line: A line parallel to the F line passing through the Cu point
F2 line: A line parallel to the F line passing through the R point
The articular eminence angle was calculated by measuring the angle formed between the Ebf and F lines [17] (Fig. 4).
The articular eminence height (Eh) was measured by measuring the vertical distance between the highest point of the fossa (R) and lowest point of the articular eminence (T) [17] (Fig. 4).

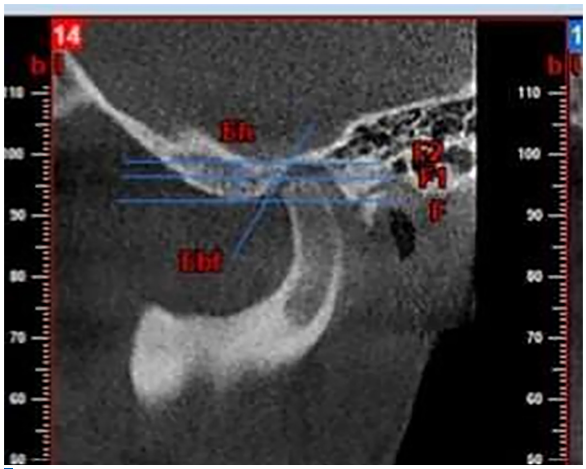

Figure 4. Reference regions for skin color measurement from portrait photographs.

The thickness of the glenoid fossa was measured at the thinnest part in the sagittal plane [16] (Fig. 4).
The above-mentioned variables were measured in the right and left sides for CLP patients and controls. To evaluate intra-observer reliability, 10 CBCT images were randomly selected from the two groups and were re-measured 2 weeks later by the same investigator, and the reliability of the measurements was ensured by test-retest reliability. Since R was found to be >0.8, the results were found to be adequately reliable.

The data were analyzed using SPSS version 25. The Kolmogorov-Smirnov test was applied to assess the normality of data distribution. The two groups were compared with the t-test for normally distributed data and Mann-Whitney test for the data with non-normal distribution. The level of significance was set at 0.05.

3. RESULTS

This study evaluated 40 participants including 20 unilateral CLP patients and 20 non-CLP controls. There were 12 females and 8 males in the CLP group with a mean age of 17.7±2.8 years, and 9 females and 11 males with a mean age of 18.7±1.9 years in the control group. The two groups were not significantly different in terms of age (p=0.215) or gender (p=0.342).

Table 1 presents the mean mediolateral dimension of the condyle, anteroposterior dimension of the condyle, glenoid fossa thickness, articular eminence thickness, articular eminence angle, and axial condylar angle relative to the sagittal plane in CLP patients and non-CLP controls. The results showed that the axial condylar angle in CLP patients was significantly lower than that in the non-CLP controls at both the right (p=0.035) and left (p=0.005) sides. The mediolateral dimension of the condyle in the CLP patients was also significantly lower than that of the non-CLP controls in both the right (p=0.001) and left (p=0.001) sides. The anteroposterior dimension of the condyle was not significantly different between the two groups in the right (p=0.308) or left (p=0.737) sides. The thickness of the glenoid fossa was not significantly different between the two groups, neither in the right (p=0.327) nor in the left (p=0.925) side. The articular eminence thickness was also approximately the same in the two groups in the right (p=0.094) and left (p=0.094) sides. The articular eminence thickness was significantly lower in the CLP group than the control group in the right side (p=0.016) but not in the left side (p=0.63).

Table 2 presents the frequency distribution of different morphologies of the condyle in the coronal view in CLP and non-CLP groups. Table 3 presents the frequency distribution of different morphologies of the condyle in the sagittal view in the CLP and non-CLP groups.

Table 2. Frequency distribution of different morphologies of the condyle in the coronal view in CLP and non-CLP groups.

Morphology	Left		Right	
	Non-CLP	CLP	Non-CLP	CLP
Round	9	5	6	4
Convex	8	14	13	13
Flat	2	0	0	1
Angulated	1	1	1	2
Total	20	20	20	20

Table 3. Frequency distribution of different morphologies of the condyle in the sagittal view in CLP and non-CLP groups.

Morphology	Left		Right	
	Non-CLP	CLP	Non-CLP	CLP
Round	18	16	17	16
Flat	1	2	2	3
With osteophytes	0	1	1	0
AWorn	1	1	0	1
Total	20	20	20	20

4. DISCUSSION

Maxillofacial clefts are the most common congenital anomalies of the head and neck region, which can affect the lips, hard and soft palate, and alveolar bone [18]. CLP patients have many problems such as dental anomalies, malocclusion, facial and nasal deformities, and nutritional, respiratory, auditory, and speech problems [6,19]. This study aimed to assess the effect of CLP on skeletal components of the TMJ using CBCT. Different radiographic modalities may be used to assess mandibular asymmetry. However, accurate measurement is not possible by using panoramic radiography due to errors related to the patients' head position and limitations such as magnification [20]. The accurate evaluation of the TMJ by conventional radiography is limited by the structure superimposition. Cone beam computed tomography (CBCT) provides high-resolution multiplanar images and delivers substantially lower radiation dose, compared with multi-slice CT. CBCT allows examination of TMJ

Table 1. Mean mediolateral dimension of the condyle, anteroposterior dimension of the condyle, glenoid fossa thickness, articular eminence thickness, articular eminence angle, and axial condylar angle relative to the sagittal plane in CLP patients and non-CLP controls.

Variable	Left			Right		
	Non-CLP	*CLP*	*P value*	*Non-CLP*	*CLP*	*P value*
Axial condylar angle relative to sagittal plane	28.5 ± 3.1	26.7 ± 2.1	0.005	29.3 ± 2.2	27.3 ± 1.9	0.035
Mediolateral condylar dimension	18 ± 1.8	15.6 ± 0.99	0.001	18.1 ± 1.6	15.6 ± 1.2	0.001
Anteroposterior condylar dimension	6.9 ± 0.8	6.8 ± 0.94	0.737	6.9 ± 0.8	6.7 ± 0.6	0.308
Glenoid fossa thickness	1.16 ± 0.4	1.2 ± 0.4	0.925	1.17 ± 0.3	1.1 ± 0.4	0.327
Articular eminence thickness	6.7 ± 0.8	6.7 ± 0.8	0.094	6.7 ± 0.7	6.2 ± 0.9	0.094
Articular eminence angle	55.9 ± 3.8	53.2 ± 5.2	0.63	56.2 ± 3.9	52.8± 4.7	0.016

anatomy without superimposition and distortion to facilitate the analysis of bone morphology, joint space and dynamic function in all three dimensions. It is good to know that the goals of TMJ imaging by CBCT are to evaluate the integrity of the bony structures when disorders are suspected, to confirm the extent and stage of progression of disorders, and to evaluate the effects of the treatment [23]. Also, posteroanterior cephalometry may yield unreliable results due to the patients' head rotation [7]. However, 3D radiographic modalities such as CBCT and MRI can overcome limitations such as magnification. CBCT can provide 3D images with higher resolution at a shorter time and lower patient radiation dose compared with computed tomography [21].

The present results revealed significantly lower axial condylar angle relative to the sagittal plane in both the right and left sides in CLP patients compared with the non-CLP controls. Ucar et al. [12] reported that the axial condylar angle in the right side in CLP patients was lower than that in the non-CLP controls, which was in agreement with the present result. Also, Kurt et al. [13] assessed mandibular asymmetry in CLP and non-CLP patients and reported that the gonial angle of the mandible in CLP patients was significantly larger than that in the non-CLP controls.

In the present study, the mediolateral condylar dimension at both sides was significantly smaller in CLP patients; however, this difference was not significant in anteroposterior dimension of the condyle. Veli et al. [11] evaluated the mandibular asymmetry in unilateral CLP patients and non-CLP controls. They reported that the mediolateral dimension of the right condyle in unilateral CLP patients was smaller than that in the non-CLP controls. This difference was approximately 0.4 mm in the left side, and not significant, which was almost similar to the present result. In the study by Ucar et al, [12] the condylar volume in bilateral CLP patients was lower than that in the healthy controls, but not significantly. Kurt et al. [13] evaluated mandibular asymmetry in vertical dimension in subjects with and without cleft palate. The condylar height in cleft palate patients was significantly higher than that in non-cleft controls. Paknahad et al. [14] showed higher prevalence of different types of mandibular asymmetries (condylar, ramal, and combined condylar and ramal) in unilateral CLP patients compared with bilateral CLP and control subjects, which was in agreement with the present findings. Veli et al. [11] reported smaller mandibular body volume in CLP patients than healthy controls, which was in accordance with the present results. Celikoglu et al. [22] found no significant difference regarding the thickness of glenoid fossa roof and the articular eminence thickness between CLP patients and healthy controls, which was similar to the findings of the present study. This topic has been rarely addressed in studies on CLP patients. However, Ucar et al. [12] reported insignificantly lower articular eminence thickness in the right and left sides in bilateral CLP patients than in the controls. Ejima et al. [16] evaluated the correlation of glenoid fossa root thickness, condylar morphology, and the number of residual teeth. The results showed that the thickness of glenoid fossa roof was not affected by the condylar head morphology in the coronal view. Joints with osteoarthritis had increased thickness of glenoid fossa roof.

In the present study, the articular eminence angle in the right side was significantly lower in CLP patients than in the controls. In the study by Ilguy et al. [17], the maximum articular eminence angle was recorded in 30-39-year-olds. In the present study, the condylar morphology was classified into different shapes according to Ejima et al. [16] and Ilguy et al. [17]. The most common morphology in the coronal view was the convex morphology in both groups while the most common morphology in the sagittal view was the round morphology. In the study by Ejima et al. [16] round morphology was the most common morphology in the sagittal view (128 out of 154 condyles) while the convex morphology was most common in the coronal view (111 out of 154 condyles). This study had a retrospective design and was based on patient records. Thus, some limitations existed with regard to the role of confounders since we did not have access to patients.

Future studies are required to compare bilateral and unilateral CLP patients with non-cleft controls with class III malocclusion since most studies have evaluated healthy controls with class I occlusion.

5. CONCLUSION

Unilateral CLP patients have lower axial condylar angle and mediolateral condylar dimension at both sides and lower articular eminence angle in the right side than controls.

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COMPETING INTERESTS

None to declare.

DATA AVAILABILITY

The authors confirm that the data supporting the findings of this study are available within the article or its supplementary materials.

AUTHOR CONTRIBUTIONS

ART: drating the manuscript. **BK, SG and FA:** data collection. **AM:** statistics. **AJ:** literature review. **AD:** manuscript revision and submission. **AJ:** study concept and design; critical revision of the manuscript for important intellectual content; administrative, technical, and material support; study supervision.

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Questions

1. Which of the following is not an exclusion criterion for this study?

❑a. History of previous orthodontic treatment;
❑b. Orthognathic surgery;
❑c. Trauma;
❑d. Malocclusion.

2. What is the aim of this study?

❑a. Assess the effect of CLP on skeletal components of the TMJ;
❑b. Assess the effect of CLP on Dental components of the TMJ;
❑c. Both;
❑d. None.

3. Which of the following is not an inclusion criterion for this study?

❑a. CLP patients age between 15 to 22 years;
❑b. Surgical closure of the lip and hard tissue before the age of 3.5 years;
❑c. CLP patients aged more than 22 years;
❑d. None of the above.

4. Which statistical test was used to assess normality of the data in this study?

❑a. Kolmogorov-Smirnov test;
❑b. T-Test;
❑c. Q-square test;
❑d. None of the above.

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DURATION AND LENGTH OF ADAPTATION TO NEW COMPLETE DENTURES: A SURVEY BASED ON PATIENTS' SELF-REPORTED OUTCOMES

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ABSTRACT

Introduction We studied the duration of adaptation to new complete dentures (CD) and changes for 5 years based on patients' self-reported outcomes.

Methodology Sixty fully edentulous patients who received new CDs and wore them for 5 years were included. A questionnaire (answers 0-10 VAS) related to self-perceived speech, chewing function, comfort of denture wearing, denture retention, and orofacial esthetics was completed on the 1st, 3rd, 8th, 15th, and 30th day after new CD delivery, and after 1, 3, and 5 years of denture wearing.

Results Self-perceived speech reached the highest scores on the 30th day; females and previous removable denture (RD) wearers adapted faster during the first days. Chewing reached the highest scores on the 30th day, remained unchanged over the 1st year, and decreased significantly afterwards; females gave higher scores during the first 15 days and previous RD wearers from the 3rd till the 30th day. A comfort of denture wearing first slightly decreased, but soon increased, reaching the highest values the 30th day, remained unchanged after one year, then decreased gradually, with no significant difference between gender and previous RD experience. Retention scores decreased after 3 and 5 years, without difference between gender and previous RD experience. Orofacial esthetics scores decreased substantially after 3 years with no effect of gender and previous experience *(p*>0.05*)*.

Conclusion The highest scores were obtained for orofacial esthetics and speech, the lowest for chewing function. Participants needed 30 days to adapt to new CDs. The adaptation lasted one year and decreased significantly the 3rd and the 5th year.

KEYWORDS

Complete Denture; Adaptation; Chewing; Speech; Comfort Esthetics.

1. INTRODUCTION

Edentulism represents a certain level of physical impairment, which is regarded as a chronic disability, causing many edentulous individuals to face obstacles in their everyday activities, such as eating or speaking [1]. Furthermore, it may significantly impact an individual's psychological and social functioning and the overall quality of life [2,3,4]. Global trends have shown significant differences in the rates of edentulism worldwide [1,2,3,5]. Recent data from developed countries demonstrated a slight but encouraging decline in complete edentulism [6]. However, although edentulism is becoming less frequent in developed, industrialized countries, it remains prevalent in many parts of the world, and a complete denture is still one of the most frequent treatment options in cases of edentulism, especially considering older patients [1,6-9]. Prosthodontic treatment using a complete denture (CD) aims to achieve oral rehabilitation and reestablishment of the lost function, namely speech, occlusion, aesthetics, and masticatory function. It is considered one of the main challenges of prosthodontic treatment [9-15]. It is important to obtain satisfactory retention and stability of CDs, crucial factors for successful adaptation to them [15,16]. The masticatory function, antagonistic contacts, and preservation of masticatory muscle reflexes in CD patients were negatively correlated with the development of dementia in old patients [14,17]. The success of treatment with CDs is further influenced by many other factors that are also important to secure optimal retention and

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stabilization of a denture, such as characteristics of the saliva, status of the alveolar bone, condition of the mucosa and its resilience, relations between maxillary and mandibular residual alveolar ridges and neuromuscular factors [7-11,16,18]. Besides, a new denture may cause difficulties during speaking, and time is needed for patients to reach a satisfactory level of speech [16,18]. Although the quality of a new denture depends mainly on technological, biological, and physiological factors, it also depends on the interaction between the patient and the therapist [7]. However, long time CD wearing elicits some inherent problems, such as continuous residual ridge resorption, injuries of underlying mucosa, mucosal inflammation, flabby ridge development, and even loss of a complete alveolar ridge bone with consequent loss of denture retention and stability, loss of vertical dimension of the lower third of a face, and contra-clockwise rotation of the mandible [19-24]. As the mandible is more prone to residual alveolar ridge loss, recent recommendations of a panel of experts led to McGill consensus proposing that the minimum treatment needed for completely edentulous subjects is a manufacture of maxillary complete denture and a mandibular two-implant overdenture [25, 26, 27]. In subjects with narrow alveolar ridges, rehabilitation with four mini implant retained mandibular overdenture is also an option. Unfortunately, rehabilitation of the implant retained overdenture is usually not available to many patients due to economic, social, or general health issues [7-15,27,28]. Consequently, the manufacture of conventional CDs is the only treatment option for them. A certain amount of time is needed for a patient to accept a new prosthodontic device, especially a removable denture [8-15]. This study aimed to assess how long patients need to adapt to their new conventional CDs and how long their satisfaction lasts. An additional aim was to evaluate the association between gender, previous removable denture experience, and age with adaptation to CDs and self-perceived satisfaction.

2. METHODOLOGY

2.1. Sample

The subjects recruited in this study comprised 82 fully edentulous individuals needing new CDs, unwilling to undertake implant-supported mandibular overdenture treatment for different reasons, primarily due to a fear of a surgical procedure, general health, or economic reasons. A total of 40 participants received new CDs at the Department of Prosthodontics, Dental Polyclinic, Split, Croatia, from September 2015 to June 2016. The Ethics Committee of the School of Dental Medicine in Split approved the study. Another 42 participants received new CDs at the Department of Removable Prosthodontics, School of Dental Medicine, Zagreb, Croatia, in the same period, with the approval of the Ethics Committee of the respective dental school (No. 05-PA-26-6/2015). After 30 days, one patient was not available for the recall examination, after 12 months an additional 9 patients dropped out, after 3 years 5 more patients dropped out, and another seven patients were not available after 5 years. Finally, 60 patients completed the prospective clinical study and were included in the final analysis. The flowchart of the study protocol and drop-outs is presented in Figure 1.

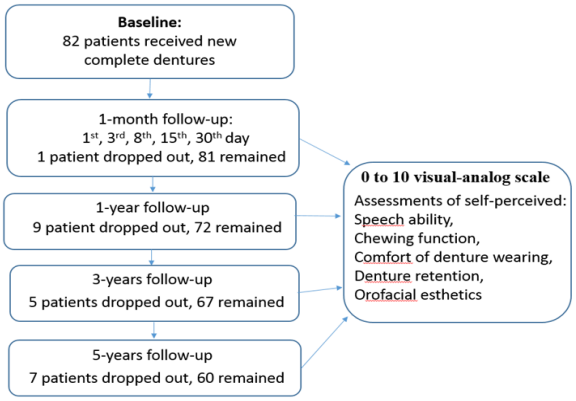

Figure 1. Flowchart of the study protocol and the participants' availability at follow-up examinations.

2.2. Complete denture manufacture

All dentures were made following the same criteria. After alginate preliminary impressions, custom trays were made, and custom (individual) impressions were obtained for everyone. After registration of the vertical jaw relation in a centric position, the occlusal rims were transferred into a semi-adjustable articulator. The semi-anatomical artificial teeth and a lingualized occlusion scheme, with no attempt of occlusal balance were applied. New CDs were processed after the artificial teeth set-up in a trial denture and verification of satisfactory esthetics and antagonistic contacts in a centric relation in the mouth. After the new dentures delivery, during adaptation, the occlusion was checked and adjusted if necessary, oral mucosa was inspected for soreness, and the denture was trimmed-off when necessary.

Two experienced specialists in Prosthodontics, who were not involved in the CD manufacture assessed the quality of new complete dentures in retention (quality of fit), flange extension, stability, esthetics, and occlusion, as described in previous studies [8,9] . The observers listed the dentures into low, average or high quality dentures. The weighted kappa statistics was calculated based on the number of matching categories between the two observes and showed satisfactory agreement (κ= 0.808). Only patients with high-quality new dentures were recruited in the study.

2.3. Study protocol

After the new CDs delivery, the patients had to fill in a small questionnaire consisting of two parts. The first part comprised data about gender, age, and previous dental status in their mouth [fixed partial denture or natural teeth (FPD); removable partial denture (RPD)].

The second part comprised five questions with the answers on the 0 to 10 visual-analog scale (VAS) for assessment of self-perceived speech ability, chewing function, comfort of denture wearing, denture retention, and orofacial esthetics. Assessments were repeated on the 3rd day after CDs delivery, 8th day, 15th day, and 30th day. Same assessments were again repeated after 9-12 months of denture wearing and in a period after 3 and after 5 years of denture wearing. The checks were made in a dental office for the 1st, 3rd, 8th, and 15th day. If the patients needed any denture adjustments, they also came to a dental office, and if not, they were assessed by telephone. The one-year, 3-year and 5-year examination was performed in a dental office. The flowchart is presented in Figure 1.

2.4. Statistical analysis

We used the IBM SPSS Statistics for Windows (Version 20.0.; IBM Corp, Armonk, NY, USA) to evaluate the descriptive statistics (medians, modal values, quartiles, means and standard deviations for the patients' self-perceived assessments of their speech, chewing ability, denture retention, the comfort of denture wearing, and their orofacial esthetics). Changes over time were estimated by the Friedman non-parametric test for related samples. Comparisons between gender and comparison between patients who previously wore removable denture and the first time removable denture wearers were performed by non-parametric Mann-Whitney test.

3. RESULTS

The patients' age was between 66 and 81 years. There were 44 females (77.3%) and 16 males (26.7%). Seven patients (3 females, 4 males) (11.66%) had natural teeth or a fixed partial denture before treatment with new complete dentures (were the first time removable denture wearers), while 53 patients (41 females, 12 males) (88.33%) already had experience with removable partial dentures.

The patients' self-perceived speech ability on the 1st, 3rd, 8th, 15th, and 30th day after complete denture delivery, and after 12 months, 3 years and 5 years of denture wearing is presented in Table. 1. The scores gradually increased till the 30th day after CD delivery, then remained almost unchanged at the 12 months and 3-year recall examinations and only slightly decreased after 5 years of denture wearing. Statistically significant difference existed between the observed periods (Friedman test; X^2=116.04, df=7, (p=<0.001), mostly due to lower grades till the 30th day. However, participants without previous removable denture experience gave lower scores during the first 15 days, but after 30 days and further on no significant difference was observed between previous CD and the first time CD wearers (Table 2, Mann-Whitney test). Females gave better scores for speech than males during the first 15 days of denture wearing (Tab. 2).

The patients' self-perceived chewing ability on the 1st, 3rd, 8th, 15th, and 30th day after complete denture delivery, and after 12 months, 3 years and 5 years of denture wearing is presented in Table 1. The scores were the lowest from the 1st to the 8th day, afterwards increased, reached the highest values on the 30th day, remained almost unchanged during the first year and afterwards decreased (the 3rd year) and reached the lowest values in the 5th year of follow-up examination (Friedman test; X^2=223.45, df=7, p=<0.001). During the first 3 days after new CDs' delivery no significant difference existed between the previous and the first time denture wearers, but after the 3rd day previous CD wearers gave significantly better scores than the first time denture wearers; that remained unchanged till the 3rd year.

Table 1. Medians, mods, means, and percentiles of self-assessed speech, chewing, the comfort of denture wearing, denture retention, and esthetics.

Speech		1st day	3rd day	8th day	15th day	30th day	1 year	3 years	5 years
Median		**8.50**	**9.00**	**9.00**	**9.00**	**10.00**	**10.00**	**10.00**	**10.00**
Mode		10	10	10	10	10	10	10	10
Mean		8.27	8.43	8.83	9.08	9.43	9.58	9.50	9.28
SD (mean)		1.89	1.84	1.28	1.09	0.81	0.67	0.70	0.96
Percentile	**25**	7.00	8.00	8.00	8.00	9.00	9.00	9.00	9.00
	50	8.50	9.00	9.00	9.00	10.00	10.00	10.00	10.00
	75	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Chewing		**1st day**	**3rd day**	**8th day**	**15th day**	**30th day**	**1 year**	**3 years**	**5 years**
Median		**7.00**	**7.00**	**7.00**	**8.00**	**9.00**	**9.00**	**7.00**	**6.50**
Mode		7	7	7	8	9	9	7	6
Mean		6.87	6.73	7.45	8.02	8.87	8.95	7.48	6.57
SD (mean)		1.70	2.00	1.73	1.51	0.87	0.81	1.07	1.73
Percentile	**25**	6.00	5.25	7.00	7.00	8.00	9.00	7.00	6.00
	50	7.00	7.00	7.00	8.00	9.00	9.00	7.00	6.50
	75	8.00	8.00	8.00	9.00	10.00	9.00	8.00	8.00

Comfort of denture wearing		1st day	3rd day	8th day	15th day	30th day	1 year	3 years	5 years
Median		**9.00**	**8.00**	**8.00**	**8.50**	**9.00**	**9.00**	**8.00**	**6.50**
Mode		10	10	10	10	10	9	9	9
Mean		8.03	7.60	8.27	8.43	9.03	8.77	7.53	6.40
SD (mean)		2.25	2.28	1.65	1.44	1.12	0.96	1.32	2.20
Percentile	**25**	7.00	6.00	7.00	7.00	8.00	8.00	6.00	5.00
	50	9.00	8.00	8.00	8.50	9.00	9.00	8.00	6.50
	75	10.00	10.00	10.00	10.00	10.00	9.00	9.00	8.00
Retention of complete dentures		**1st day**	**3rd day**	**8th day**	**15th day**	**30th day**	**1 year**	**3 years**	**5 years**
Median		**9.00**	**8.00**	**9.00**	**9.00**	**9.00**	**9.00**	**7.00**	**5.50**
Mode		10	8	8	9	10	9	7	5
Mean		8.63	8.13	8.50	8.63	9.17	8.70	6.97	5.50
SD (mean)		1.83	2.05	1.56	1.39	0.98	0.94	1.66	2.13
Percentile	**25**	8.00	8.00	8.00	8.00	9.00	8.00	6.00	4.00
	50	9.00	8.00	9.00	9.00	9.00	9.00	7.00	5.50
	75	10.00	10.00	10.00	10.00	10.00	9.00	8.00	7.00
Esthetics		**1st day**	**3rd day**	**8th day**	**15th day**	**30th day**	**1 year**	**3 years**	**5 years**
Median		**10.00**	**10.00**	**10.00**	**10.00**	**10.00**	**10.00**	**9.00**	**8.00**
Mode		10	10	10	10	10	10	9	9
Mean		9.40	9.63	9.70	9.73	9.80	9.72	8.60	7.58
SD (mean)		1.09	0.66	0.65	0.58	0.48	0.58	1.12	2.05
Percentile	**25**	9.00	9.00	10.00	10.00	10.00	10.00	8.00	7.00
	50	10.00	10.00	10.00	10.00	10.00	10.00	9.00	8.00
	75	10.00	10.00	10.00	10.00	10.00	10.00	9.00	9.00

Table 2. Significance of the differences for the self-perceived speech ability between gender, and between participants with previous removable denture experience and the first time complete denture wearers over the observed period.

SPEECH	PREVIOUS RPD EXPERIENCE	N	MEAN RANK	P
1ST DAY	no	7	7.36	<0.001 **
	yes	53	33.56	
3RD DAY	no	7	8.93	<0.001 **
	yes	53	33.35	
8TH DAY	no	7	10.64	0.001 **
	yes	53	33.12	
15TH DAY	no	7	12.36	0.001 **
	yes	53	32.90	
30TH DAY	no	7	19.64	0.08 NS
	yes	53	31.93	
1 YEAR	no	7	18.86	0.061 NS
	yes	53	32.04	
3 YEARS	no	7	20.86	0.25 NS
	yes	53	31.77	
5 YEARS	no	7	24.29	0.33 NS
	yes	53	31.32	

**= $p<0.01$; *= $p<0.05$; NS=not significant.

	GENDER	N	MEAN RANK	P
1ST DAY	female	44	34.91	0.001 **
	male	16	18.38	
3RD DAY	female	44	34.86	0.001 **
	male	16	18.5	
8TH DAY	female	44	34.55	0.002**
	male	16	19.38	
15TH DAY	female	44	32.98	0.051 NS*
	male	16	23.69	
30TH DAY	female	44	32.98	0.25 NS
	male	16	26.75	
1 YEAR	female	44	32.39	0.09 NS
	male	16	25.31	
3 YEARS	female	44	31.66	0.33 NS
	male	16	27.31	
5 YEARS	female	44	31.05	0.66 NS
	male	16	29.00	

**= $p<0.01$; *= $p<0.05$; NS=not significant.

Afterwards no significant difference existed (Table 3). Females gave better scores to chewing than males for the first 15 days and at the one-year observation (Table 3).

Table 3. Significance of the differences for the self-perceived chewing ability between gender, and between participants with previous removable denture experience and the first time complete denture wearers over the observed period.

CHEWING	PREVIOUS RPD EXPERIENCE	N	MEAN RANK	P
1ST DAY	no	7	20.71	0.119 NS
	yes	53	31.79	
3RD DAY	no	7	21.07	0.113 NS
	yes	53	31.75	
8TH DAY	no	7	17.14	0.030 *
	yes	53	32.26	
15TH DAY	no	7	18.21	0.046 *
	yes	53	32.12	
30TH DAY	no	7	16.86	0.026 *
	yes	53	32.30	
1 YEAR	no	7	14.79	0.009 **
	yes	53	32.58	
3 YEARS	no	7	21.50	0.150 NS
	yes	53	31.69	
5 YEARS	no	7	22.29	0.194 NS
	yes	53	31.58	

**= p<0.01; *= p<0.05; NS=not significant.

	GENDER	N	MEAN RANK	P
1ST DAY	female	44	34.55	0.003 **
	male	16	19.38	
3RD DAY	female	44	35.58	<0.001 **
	male	16	16.53	
8TH DAY	female	44	34.31	0.004 **
	male	16	20.03	
15TH DAY	female	44	33.43	0.027 *
	male	16	22.44	
30TH DAY	female	44	32.43	0.134 NS
	male	16	25.19	
1 YEAR	female	44	33.65	0.011 *
	male	16	21.84	
3 YEARS	female	44	31.88	0.286 NS
	male	16	26.72	
5 YEARS	female	44	32.39	0.156 NS
	male	16	25.31	

**= p<0.01; *= p<0.05; NS=not significant.

The patients' self-perceived comfort of denture wearing is presented in Table 1. It decreased after the 1st day till the 8th day, then increased till the 30th day remained unchanged at the 1-year follow-up and again decreased after 3 and 5 years (Friedman test; X^2=223.45, df=7, p=<0.001). There was no significant differences between males and females, and between those without or with previous removable denture experience (Table 4).

Table 4. Significance of the differences for the self-perceived comfort of denture wearing between gender, and between participants with previous removable denture experience and the first time complete denture wearers over the observed period.

COMFORT	PREVIOUS RPD EXPERIENCE	N	MEAN RANK	P
1ST DAY	no	7	29.07	0.822 NS
	yes	53	30.69	
3RD DAY	no	7	32.79	0.718 NS
	yes	53	30.20	
8TH DAY	no	7	27.64	0.652 NS
	yes	53	30.88	
15TH DAY	no	7	21.93	0.171 NS
	yes	53	31.63	
30TH DAY	no	7	23.93	0.296 NS
	yes	53	31.37	
1 YEAR	no	7	22.50	0.202 NS
	yes	53	31.56	
3 YEARS	no	7	27.57	0.652 NS
	yes	53	30.89	
5 YEARS	no	7	29.93	0.928 NS
	yes	53	30.58	

**= p<0.01; *= p<0.05; NS=not significant.

	GENDER	N	MEAN RANK	P
1ST DAY	female	44	32.23	0.188 NS
	male	16	25.75	
3RD DAY	female	44	30.45	0.973 NS
	male	16	30.63	
8TH DAY	female	44	30.77	0.836 NS
	male	16	29.75	
15TH DAY	female	44	31.14	0.629 NS
	male	16	28.75	
30TH DAY	female	44	31.59	0.392 NS
	male	16	27.50	
1 YEAR	female	44	33.02	0.067 NS
	male	16	24.75	
3 YEARS	female	44	31.09	0.196 NS
	male	16	28.88	
5 YEARS	female	44	28.86	0.499 NS
	male	16	35.00	

**= p<0.01; *= p<0.05; NS=not significant.

The results were similar with the self-perceived assessment of denture retention, with a more emphasized decrease after one year (Friedman test; X^2=218.65, df=7, p=<0.001) (Table 1) Also, no significant differences were found between gender and previous or the first time denture wearers (Table 5).

Table 5. Significance of the differences for the self-perceived complete dentures' retention between gender, and between participants with previous removable denture experience and the first time complete denture wearers over the observed period.

RETENTION	PREVIOUS RPD EXPERIENCE	N	MEAN RANK	P
1ST DAY	no	7	32.64	0.735 NS
	yes	53	30.22	
3RD DAY	no	7	30.79	0.964 NS
	yes	53	30.46	
8TH DAY	no	7	29.93	0.928 NS
	yes	53	30.58	
15TH DAY	no	7	23.93	0.296 NS
	yes	53	31.37	
30TH DAY	no	7	23.64	0.276 NS
	yes	53	31.41	
1 YEAR	no	7	21.21	0.152 NS
	yes	53	31.86	
3 YEARS	no	7	29.71	0.152 NS
	yes	53	30.60	
5 YEARS	no	7	21.50	0.150 NS
	yes	53	31.82	

**= p<0.01; *= p<0.05; NS=not significant.

	GENDER	N	MEAN RANK	P
1ST DAY	female	44	28.59	0.095 NS
	male	16	36.50	
3RD DAY	female	44	29.23	0.095 NS
	male	16	34.00	
8TH DAY	female	44	28.86	0.211 NS
	male	16	35.00	
15TH DAY	female	44	29.18	0.313 NS
	male	16	34.13	
30TH DAY	female	44	28.41	0.098 NS
	male	16	36.25	
1 YEAR	female	44	28.68	0.157 NS
	male	16	35.50	
3 YEARS	female	44	28.77	0.196 NS
	male	16	35.25	
5 YEARS	female	44	29.59	0.499 NS
	male	16	33.00	

**= p<0.01; *= p<0.05; NS=not significant.

Self-perceived orofacial esthetics did not change from the 1st day till the 3-year examination, when it decreased and continued to decrease till the 5-year follow-up (Friedman test; X^2=234.05, df=7, p=<0.001) (Table 1). Although females gave slightly lower scores, no significant differences were found for any of the observation stages (Table 6).

The same results were seen with previous and the first time removable denture wearers (Table 6).

Table 6. Significance of the differences for the self-perceived esthetics between gender, and between participants with previous removable denture experience and the first time complete denture wearers over the observed period.

ESTHETICS	PREVIOUS RPD EXPERIENCE	N	MEAN RANK	P
1ST DAY	no	7	25.93	0.469 NS
	yes	53	31.10	
3RD DAY	no	7	33.50	0.636 NS
	yes	53	30.10	
8TH DAY	no	7	31.79	0.839 NS
	yes	53	30.33	
15TH DAY	no	7	31.64	0.857 NS
	yes	53	30.35	
30TH DAY	no	7	30.64	0.982 NS
	yes	53	30.48	
1 YEAR	no	7	37.00	0.307 NS
	yes	53	29.64	
3 YEARS	no	7	32.57	0.752 NS
	yes	53	30.23	
5 YEARS	no	7	34.00	0.588 NS
	yes	53	30.04	

**= p<0.01; *= p<0.05; NS=not significant.

	GENDER	N	MEAN RANK	P
1ST DAY	female	44	29.55	0.400 NS
	male	16	33.13	
3RD DAY	female	44	28.82	0.110 NS
	male	16	35.13	
8TH DAY	female	44	29.55	0.314 NS
	male	16	33.13	
15TH DAY	female	44	29.59	0.337 NS
	male	16	33.00	
30TH DAY	female	44	30.00	0.570 NS
	male	16	31.88	
1 YEAR	female	44	29.41	0.264 NS
	male	16	33.50	
3 YEARS	female	44	29.81	0.570 NS
	male	16	32.41	
5 YEARS	female	44	29.30	0.366 NS
	male	16	33.81	

**= p<0.01; *= p<0.05; NS=not significant.

3. DISCUSSION

The treatment of complete or partial edentulousness has always been a major challenge. Although dental implants enable better and longer-lasting adaptation to removable dentures, they are still unavailable to most of the population due to health issues and economic reasons. Therefore, we aimed to study how long it is necessary to adapt to new CDs considering

self-perceived speech function, chewing ability, the comfort of CD wearing, denture retention, and orofacial esthetics. We also aimed to monitor the duration of the peak of patients' satisfaction and the influence of gender, and previous dental status. The study was designed as a longitudinal clinical prospective study in a cohort of edentulous patients receiving new CDs. Most patients gradually adjusted to complete dentures over 30 days. Self-perceived chewing ability, speech and comfort of denture wearing reached the highest scores only after 30 days. However, self-perceived chewing function, and the comfort of denture wearing, first decreased from the 1st to the 8th day and then increased until the 30th day, then remained unchanged through the first year, and decreased after 3 years. Orofacial esthetics and denture retention did not change significantly from the first day to the first year but the scores decreased significantly after 3 years, and even more after 5 years of CD wearing. Speech significantly and gradually increased over 30 days. It seems that the period of 30 days can be considered sufficient for CD adaptation due to speech, chewing and comfort of denture wearing. However, this applies for patients who received high-quality new CDs, as insufficient denture quality has been one of the risk factors for non-adaptation to removable dentures [8,9,29].

It is not surprising that previous RPD wearing influenced a self-perceived speech function, as patients with previous RPD experience adapted faster [8,9,29]. They had already adapted to speaking with a palatal coverage. With first time CD wearers, adjustment to new complete dentures took the longest. When analyzing speech, it is important to have in mind that older patients are more likely to suffer from xerostomia and have difficulty speaking clearly due to insufficient saliva flow, therefore they need to adapt longer [29]. Decrease of a self-perceived speech ability after 5 years of CD wearing can be attributed to the loss of maxillary and mandibular denture retention, mainly due to alveolar bone atrophy over time [19-22], which is significantly higher in CD wearers than in mandibular complete implant-supported overdenture patients [20,31].

During the first days of wearing new CDs, dentures may cause pain and discomfort. That was probably the reason why participants' scores for chewing ability, the comfort of denture wearing, and denture retention first decreased after the 1st day and increased only after the 8th day. The scores peaked on the 30th day, when all occlusal and denture adjustments were finished and patients learned how to speak more clearly. These results remained throughout the 1st year of denture wearing. The results coincide with the results of other studies [11,12,32,33]. No influence of gender and previous denture status was observed on a self-perceived comfort of denture wearing and denture retention. This is in line with the results of some previous research [33-36]. However, gender and previous removable denture experience significantly influenced chewing function, as females and previous RPD wearers gave better scores. The results were the same for the self-perceived speech ability. Better sores obtained from female patients can be probably explained by their happiness about esthetic outcome. Although males were also almost equally satisfied with esthetics, the accepted cultural and personality standards probably played a role in the fact that females scored some other domains better than men [6,37,38].

The already experienced denture wearers adapted faster, which is in line with other studies [8,9,28,29,39], although it has also been reported that greater overall improvements after complete denture therapy were observed in participants without than in those with previous denture experience [10,40]. First time CD wearers were probably uncomfortable with palatal coverage, which could be a reason for their lower scores immediately after delivery. Previous CD wearers had already adapted to palatal coverage. It has been reported that previous denture wearers also adapted faster as their discrimination of tactile ability significantly increased faster over the first 30 days than in the first time denture wearers [39].

Orofacial esthetics scored highly as in other studies [8,9,38], but the score started to decrease significantly after three years of denture wearing. There could be many reasons. The vertical dimension of the lower third of the face decreases gradually over time due to alveolar ridge atrophy and artificial teeth wear [19-22, 30,31], accompanied by a counterclockwise rotation of the mandible and the appearance of emphasized wrinkles and a decreased lip volume. The CD patients probably noticed that problem. Moreover, artificial teeth and denture materials also absorb colors from drinks and food and stain over time.

All new complete dentures delivered in this study were made without balanced occlusion, as it has been proved that no occlusal scheme is superior regarding chewing ability [11,41,42].

One article reported that 38.0% of patients showed non-adaptation to CDs. Non-adaptation was significantly associated with the absence of previous mandibular denture experience ($p = 0.042$), ulcerations after 15 days of rehabilitation ($p < 0.001$), and a reduced posterior mandibular ridge ($p = 0.035$). After 6 months, this incidence decreased to 14.1% [43]. Our study sample had in the most cases previous CD experience, only 7 of them were the first time CD wearers, which is also the limitation of the study. The strength of the study is the duration of observation up to 5 years.

Our longitudinal prospective clinical research confirmed that the process of adapting to new CDs is usually completed within a month. The patients' satisfaction remained unchanged during the first year and significantly decreases after 3 years of CD wearing in all domains: function, speech, comfort, retention, and esthetics, reaching the lowest scores after 5 years.

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AUTHOR CONTRIBUTIONS

RP: study concept and design; critical revision of the manuscript for important intellectual content; administrative, technical, and material support; study supervision, writing some parts of article; **TP:** acquisition of data, writing article's draft, literature collection; MG: drafting of the manuscript; **AČ:** study concept and design, analysis and interpretation of data, technical and material support, critical revision

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Questions

1. How long does a patient need to adapt to new complete dentures?

❑a. One day;
❑b. Two weeks;
❑c. Four weeks;
❑d. Six month.

2. How long does the adaptation to new denture last (based on the data in this manuscript)?

❑a. One week;
❑b. One month;
❑c. One year;
❑d. 4-5 years.

3. Which two categories received the highest grades after one month of new complete denture wearing, based on patients' self-reported outcomes??

❑a. Chewing and retention;
❑b. Comfort of denture wearing and chewing;
❑c. Retention and speech;
❑d. Speech and esthetics.

4. Which category did not significantly change within one-month period of new denture wearing?

❑a. Comfort of denture wearing;
❑b. Esthetics;
❑c. Speech;
❑d. Chewing ability.

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DENTIN DEGRADOMICS IN DENTIN EROSION

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ABSTRACT

Background Dentin degradomics are the enzymes found in dentin endogenously and are aimed at attacking organic compounds of the relevant tissue. During dentin demineralization, these enzymes could turn into the reaction phase and may step up the degradation. Thus, their connection with dentin erosion and tissue loss should be explained.

Objective The aim of this review was to describe the mechanisms of dentin degradomics, their relation to dentin erosion, and recent approaches on inhibiting their action.

Data sources A narrative review was performed with a literature search in the PubMed and Google Scholar electronic databases.

Study selection Reference lists included full papers of any study design, published in peer-reviewed journals in English till November 2021.

Data extraction Current literature indicates the term of dentin degradomics, and the mechanism of dental erosion of both enamel and dentin tissues. The inhibition of matrixmetalloproteinase (MMP) enzymes, which constitute the subgroup of dentin degradomics, was gained from the recent papers listed in the reference section.

Data synthesis Biocorrosion covers more of the pathological process of the tissue loss however, most of the dentin degradomics such as MMPs are not covered by the term, biocorrosion. So, the definitions of biocorrosion and dentin degradomics were discussed in detail. Green tea, chlorhexidine and fluorides have the ability to inhibit the reaction of MMPs during dentin demineralization with a different state of mechanisms. Nowadays, other naturally-derived compounds were included in studies such as polyphenols and flavonoids. Still, more studies are necessary to clarify their mechanism of action and rates of efficiency.

KEYWORDS

Dental Erosion; Dentin Degradomics; Biocorrosion; MMP İnhibitors; Polyphenols.

1. INTRODUCTION

With the transformation of lifestyle dynamics and dietary habits, dental erosion has become an increased concern recently. Erosive tooth wear is an important oral health problem when considering the prolongation of human life and the survival of healthy dentition with the overall wellness approach. Regarding the ultraconservative dental concept, updated preventive strategies, and the recent technological improvements in the evaluating methods of enamel surface characteristics at both elemental and physical levels, dental researchers and clinicians have spent significant efforts to clarify the mechanisms of dental erosion. While only a few articles were available during the 1970s, today there are dozens of researches either *in vivo* or *in vitro* about dental erosion [1]. Dental erosion was previously defined as a sole substance loss by exogenous or endogenous acids without bacterial involvement. However, it was revealed in 2012 that dental erosion was not only a surface phenomenon but it showed a mineral dissolution beneath the surface [2-4]. It was proved that surface wear in the erosion process was heightened with the friction of acidic solution thus, dental erosion was not only a chemical dissolution but also a pathodynamic surface alteration [5]. Including the whole chemical, biochemical, and electrochemical changes within the dental tissues, 'bio-corrosion' was recommended to be used in terms of dental erosion [6]. The term bio-corrosion, which is used in the same sense as the term "microbiological corrosion" in engineering branches, has entered the field of dentistry in its broadest sense under its definition. While corrosion alone describes the chemical, electrochemical, and physicochemical dissolution of inanimate substances, the definition of bio-corrosion includes all the chemical, biochemical, and electrochemical changes seen in both hard and soft tissues and body fluids in living organisms. These changes are seen as either dissolution of the tissue or cell apposition

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by inducing tissue growth. Ulcers, vascular ruptures, or muscle injuries in living organisms as a result of tissue dissolution or induction of tissue growth, even cancer cases may develop [7]. In the field of dentistry, pathologic stages of bio-corrosion reveal mostly on the development of dental caries and erosion. In the following parts of the current review, the term "bio-corrosion", its relation to dentin degradomics, and recent updates on inhibiting endogenous etiologies of dentin erosion are clarified in detail.

2. METHODOLOGY

The article search for this literature review utilized PubMed and Google Scholar, and the selection included articles published in peer-reviewed journals in English. The terms used for the introduction part were "Dentin Erosion" and "Dentin Degradomics". Due to explaining the terms in detail and to the terms being highly up-to-date, no time limit was applied and published articles were looked through till November 2021. To reach a clinical point of action, a branch of dentin degradomics, matrix metalloproteinase (MMP) enzymes, which have been appearing in many studies for a while, and recent chemical compounds used to inhibit MMPs were also considered. The search excluded: monographs and case reports.

3. RESULTS

Dental caries is a pathology caused by bacterial acids that have settled and grown in the biofilm of the dental–mostly enamel- hard surfaces. Dental caries begin with the dissolution of hydroxyapatites of enamel, and a small amount of destruction (proteolysis) occurs in the proteins in the enamel. Simply, the pathology of dental caries is again a bio-corrosion process, as it includes a biochemical beginning (acid production of bacteria) and protein degradation (proteolysis).

The term "erosion" does not include material losses caused by biochemical and electrochemical processes on dental hard surfaces. The biochemical changes induced by "proteolysis" and the electrochemical reactions that occur as a result of the piezoelectric effect on the surface are better defined by the term "bio-corrosion". To sum up, bio-corrosion is caused by acids coming from both internal and external sources, proteolytic enzymes (pepsin and trypsin), piezoelectric effects - in the dentin because of releasing Ca^{+2} ions from the tooth surface during dentinal wear- [5], and factors that cause dissolution in the inorganic and organic matrix of dentin after enamel degradation.

Enzymes such as matrix metalloproteinases, which are endogenously found in the structure, are not included in the bio-corrosion mechanism. The biochemical events covered by bio-corrosion are shown in Table 1. This pathodynamic process begins subsurface by dissolving minerals likewise caries lesions. In the sequel, ionized H+ ions are released from the enamel tissue by acid attacks and non-ionized H^{+} ions pass through deeper layers of both enamel and dentin tissues [1]. With the non-ionized acidic exposure, the inorganic part of dentin dissolves and collagens of the organic structure are revealed. Thus, the pathodynamic process of the erosion continues with the surface alterations leading to wear and substance losses. Although it was reported that "bio-corrosion", which reveals all pathological changes comprehensively, has not yet replaced the term "dental erosion" but is thought to become widespread in the fields of dentistry [6].

Table 1. Processes in bio-corrosion.

Processes in Bio-corrosion	
1) Endogenous acid intake	Dental plaque (biofilm) & Gingival crevicular fluid
	Gastric hydrochloric acid
2) Exogenous acid intake	Diet /Nutrition style
	Profession/Occupation
3) Proteolysis	Enzymatic lysis (In dental caries formation)
	Proteases (Pepsin and Trypsin)
4) Electrochemical effect	Piezoelectric effect on dentin

Just as the histology of erosion differs from caries, the morphology of dentin is mainly varied from enamel. Thus, the responses of the two tissues with different contents against acid attacks are highly distinctive. Compared to enamel, the mineral content of dentin diminished, and its organic content is higher. The major component of its organic matrix is Type 1 collagen and other components that are contributed to trace are non-collagenous phosphoprotein, glycoprotein, lipid, and proteoglycan. While the amount of carbonate is approximately 3% in the enamel, this value is 5-6% in dentin, therefore dentin dissolves more easily with acids. On the other hand, the crystals in dentin are smaller than those in enamel; thus, the surface area of dentin exposed to acid attacks is relatively higher [8]. Erosion in enamel tissue, which has 95% inorganic structure, starts with a softening on the surface by the dissolution of the structure and results in permanent loss of demineralized tissue with ongoing acid attacks (Fig. 1) [9]. However, erosion comprises two separate events in dentin, the dissolution of the existing inorganic structure and the realization of proteolytic destruction with the endogenous enzymes (Fig. 2).

Figure 1. Dental erosion limited to enamel tissue of teeth #21 and slight changes in the surface of teeth #11.

The beginning of dentin erosion, inorganic struc-ture, because of their structural differences, acts distinctively as well. At first, peritubular and intertubular dentin begin to dissolve at the same rate. However, after the first minute, the intertubular dentin area remains

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more stable, but the peritubular dentin continues to dissolve rapidly, and the dentinal tubules expand.

Figure 2. Dental erosion passed through dentin and loss of structure.

As the acid attack continues, the mineral loss is significantly reduced due to the decreasing demineralization rate and the demineralized area reaches a certain thickness [10]. The degree of mineral loss is supplied by the buffering feature of collagens so that further loss of substance is prevented by the dissolved minerals, which brings the ionic level of the environment to the approximate saturation level. While acid attacks continue to a clinically significant concentration and time, the inorganic part dissolves easily as well. Depending on the potential and duration of action of the erosive agent, at first, a completely demineralized layer and then a partially demineralized layer of dentin appears, followed by a completely sound dentin layer. However, the partially demineralized area in the middle is not present in every case [1].

Although the inorganic content dissolves away with the erosive attack, the organic matrix remains intact and forms a barrier against acid attacks, preventing further mineral release from the dental tissue and stopping the progression of the erosive lesion as mentioned above [11-13]. However, it is thought that some of the proteolytic enzymes in the dentin structure are activated by acidic pH and these enzymes increase the rate of erosion by causing the dissolution of the demineralized organic matrix (DOM). For this reason, a new field has emerged to investigate the functions and mechanisms of these enzymes called "Dentin Degradomics" [14]. Subsequently, many studies have been developed to clarify the role of the organic matrix in the stages of erosive demineralization by also considering the histological structure of dentin [15,16]. Ganss et al. (2014) reported that when the organic matrix is chemically removed by either enzymes or mechanical forces (abrasion) [16], the erosive agent directly encounters the mineralized tissue, which dissolves quickly. However, in the presence of an organic matrix, the pH decrease in the environment slows down, and accordingly, the erosion rate reduces as well. Thus, the organic matrix has the feature of limiting the mineral outflow (ionic diffusion) towards the external environment from the tooth surface [17]. For these reasons, it is clear that the organic matrix has a protective role in erosive wear.

DOM is resistant to brushing forces up to 4 Newtons (N) so that it can protect the remaining dentin surface against mechanical trauma such as toothbrush abrasion [18]. However, although this layer is resistant to physical factors, it can be dissolved by enzymatic reactions [16]. Considering that erosive demineralization does not occur in the presence of bacteria, it is certain that host-derived enzymes are responsible for the destruction of DOM, which has been proven by clinical studies [14,19].

Recently, a new category of enzymes has been found and named "Dentin Degradomics" which were aimed to degrade the organic matrix, the collagen layer, endogenously [20]. It was shown in the studies that degradomics consist of collagenolytic enzymes and MMPs which are stable in the organic matrix from the formation of dentin tissue. These enzymes are mainly responsible for the catabolic reactions of the organic matrix and their mechanism of action depends on the pH of the environment [21,22]. When the pH decreases at erosive demineralization, these enzymes become activated and when it turns neutral, they start to degrade the collagens of the organic matrix and contribute to the improvement of erosive demineralization [23]. These MMPs are found in various tissues of the body and they have been secreted when tissue remodeling is needed without any pathological circumstances. MMPs are divided into 6 groups according to their structural properties and substrate specificity: Collagenases, Type IV collagenases (gelatinases), stromelysins, matrilysins, membrane-type MMPs (MT-MMP) and others such as enamelysine (MMP-20) [24]. Not all of these enzymes are found in dentin but the ones which are presented in the dentin are shown in Table 2.

Table 2. Classification of various degradomic enzymes (Endogenous collagenolytic dentinal enzymes).* [14,24]

Group	Enzyme	Nomenclature	Function
Collagenases	Neutrophile collagenase	MMP-8	It is found frequently at dentinal levels and related highly to carious activity in dentin.
Gelatinases	Gelatinase A Gelatinase B	MMP-2 MMP-9	Telopeptidase activity to Type I collagen in organic matrix. Odontoblasts may express these gelatinases.
Stromelysins	Stromelysin 1	MMP-3	It has the proteoglycanase activity which may affect the activity of some of the cathepsins.
Other MMPs	Enamelisin	MMP-20	It has shown to process dentinsialophosphoprotein* and found in dentinal tubules of caries-affected dentin.
Cysteine cathepsins	Cathepsin	Cathepsin B Cathepsin K	They show the gelatinolytic activity.

Not related to carious or erosive demineralization.

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Another family of collagenolytic enzymes, cysteine cathepsins (CC), are activated at neutral pH, unlike MMPs. However, they need slightly acidic pH to function [25]. Because of these properties, it is known that MMPs start to function at the point where CCs lose their functions. Since acidic pH is only durable for a while in dentin erosion, MMPs are thought to play a superior role in collagen degradation than cathepsins [26]. Cysteine cathepsins found in the dentin are also shown in Table 3.

Table 3. Matrixmetalloproteinase (MMP) inhibitors.

MMP inhibitor	Type	Function
Polyphenols	Epigallocatechin-3-gallate (EGCG)	Found to have inhibitory properties against MMP-2 and-9 and the activation of MMP-8 [1,26,27].
	Theaflavin	Reported to inhibit MMP-2 and -9 [50].
Phenolic acid	Anacardic acid	Showed collagenolytic activity against MMP-2 [52].
Natural flavonoids	Quercetin	Reported to inhibit MMP-2 and -9 [54].
Non-flavonoid polyphenol	Resveratrol	Has the ability to reduce MMP-9 expression [56].
Chlorhexidine (CHX)	Bisbiguanide	Has the ability to inhibit MMP-2 and -9 at the concentration of 0.03% completely, and MMP-8 at the concentration of 0.01-0.02% [27].
Fluorides	Some of the fluoride compounds (eg. NaF)*	Inhibit the activation of MMPs by ion-blocking [32].

** Not all of the fluoride compounds are enlightened to contribute MMP inhibition.*

In the acidic environment, dentin demineralization occurs, collagen fibrils are exposed, and the MMPs in dentin and saliva are activated simultaneously. However, when the pH rises to neutral, MMPs degrade the triple helix structure of collagens, start to dissolve organic matrix and increase the rate of dentin loss [26]. In addition, these enzymes cause structural changes in existing collagens. The parts called "telopeptides" at the ends of the collagens are dissolved and removed, thus, spaces are created in the internal structure of the molecule. The relevant structural dissolution prevents interfibrillar remineralization, which is crucial for strengthening the mechanical properties of dentin. It also causes the loss of non-collagen matrix proteins, which act as nuclei for remineralization. Still, the exact contribution of these highly collagenolytic enzymes to the progression of erosion is not known so far. Using specific inhibitors for these distinct classes of enzymes may be better in order to understand their role in the progression of erosive lesions.

4. DISCUSSION

The protection of DOM by MMP inhibitors is the recent approach to the prevention of dentin erosion [26]. Among the different types of MMP inhibitors, chlorhexidine (CHX), and epigallocatechin gallate (EGCG) as a polyphenolic compound, have been the most common compounds evaluated as part of preventive strategies to reduce erosive dentin demineralization. Indeed, their mechanism of action is yet to be estimated. MMP inhibitors that have recently been reported in studies are summarized in Table 3.
Polyphenols are used frequently in many research projects and specifically polyphenols isolated from green tea, especially epigallocatechin-3-gallate (EGCG) that was found to have inhibitory properties against MMP-2 and -9 [27] and the activation of MMP-8, which acts for the remineralization in demineralized dentin [1,28]. According to the information obtained, these catechins accumulate on the organic material in dentin [29] and run by masking the catalytic site of MMP-2 or cause structural changes with its hydrogen bonds and hydrophobic linkages to collagenase [28]. The effect of EGCG against degradomics was proven in previous studies [23,29,30,31] and its effectiveness was compared usually to various formulae of fluorides or CHX. These compounds have also shown efficiency against MMPs but with distinctive targeting procedures. To better explain, MMP enzymes are zinc-activated and calcium-dependent enzymes. By chelating these cations, chlorhexidine binds to the sulfhydryl groups and/or cysteines in the active parts of MMPs and inhibits the enzyme activity [32]. However, the inhibitory activity of chlorhexidine is directly related to its concentration. CHX can cause protein denaturation at saliva concentrations above 0.2%, reduce the solubility of dentin collagen and prevent the progression of dentin erosion. Besides, chlorhexidine could completely inhibit MMP-2 and -9 at the concentration of 0.03%, and MMP-8 at the concentration of 0.01-0.02% [28]. Furthermore, it was reported that fluorides, thanks to their high electronegativity, prevent Zn^{2+} and Ca^{2+} ions, which are necessary for the activation of MMPs, from entering the catalytic activities as similar as the inhibitory activity of CHX [33].
The effect of different types of ion-containing fluoride compounds (such as stannous fluoride, titanium tetrafluoride, amine fluoride) on dental erosion is attributed to the protective layer formed on the dentin surface, it is not yet clear whether or not they perform MMP inhibition. Since sodium (Na+) ion does not form a layer similar to other ionic fluoride components on dentin surface, the most widely used fluoride compound in studies is NaF. In a study, it was found that by using the gelatin zymography ,may inhibit the activity of MMP-2 and -9 in a dose-dependent manner [34]. 200 ppm fluoride can inhibit pro and active forms

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of MMP-2 and active forms of MMP-9 by 100%. If these rates are constant at 225 ppm, the pro-form of MMP-9 could be inhibited approximately by 85%; pro and active forms of salivary MMP-9 were inhibited by 55%. While the inhibitory activity of NaF against MMP-2 and -9 is reversible at low concentrations, it has been reported that it is irreversible at high concentrations such as 5000 ppm [34].

There have been studies comparing the effect of fluorides (especially sodium fluoride, NaF), on EGCG, and CHX [35,36]. Regarding the variances differed highly in the methodological section of the studies, most of them could not be compared directly with one-to-another. One of the differences encountered in the studies is the frequent application of the contact profilometer to measure dentin loss [30,36,37]. However, some controversies have arisen regarding its usage at erosive dentin surfaces because of the tip of the profilometer that could cause damage by pressing the DOM [38]. Thus, to overcome this problem, some studies have used non-contact [39,40] or digital microscopy [41]. As another solution, to minimize the shrinkage of DOM, some analysis of the contact profilometer had been done at 100% humidity [38]. Another variation among studies with respect to the method is that the erosive cycles. Most of the cycles were done with Cola [35,42,43] but some studies have used various acidic solutions, such as citric acid [40,44] or hydrochloric acid [45,46]. Moreover, many of the studies have used not only the erosive cycle but also 'erosive+abrasive' cycles [38,45] so, within the changes in the methodology, the scores of dentin losses highly vary. Besides, the concentrations of the active ingredients or the ratios of the extractions have varied following the type of formula, such as gels [30], toothpaste [37], and mouthwashes [28,35], as well. Still, the main outcome of these studies is that MMP inhibitors play an active role in reducing dentin loss by protecting DOM.

Within the differences among studies evaluating EGCG, CHX, and NaF, one point is described that EGCG had slightly more action against dentin erosion in another different way. Previous studies [30,47] suggest that the protease inhibitors have the ability to minimize the degradation of DOM against dentin demineralization. Besides, polyphenols are reported to improve the mechanical properties of the organic matrix and resist enzymatic degradation [42]. So recently, plant polyphenols have been investigated against dentin erosion so that potential benefits could be gained. One of them is 'theaflavin', which is the most frequent polyphenol in black tea, formed by the oxidation of catechins during manufacturing [48]. Aside from the antifungal [48], antioxidant, and antimutagenic effects of theaflavins, they were also reported to inhibit MMP-2 and MMP-9 [49,50]. In an *in vitro* study, the aflavins showed similar dentin losses to EGCG and commercial green tea with no significant difference [46]. Anacardic acid is also one of the phenolic acids obtained from the shell of the cashew nut. Accompanied by the antioxidant capacity [50], the collagenolytic activity of anacardic acids against MMP-2 had also been proven by zymographic analysis and *in vitro* evaluation revealed reduced dentinal wear compared to EGCG and NaF [51,52].

On the other hand, another approach to inhibit erosive wear has exhibited promising results which aimed to enhance protecting properties of acquired pellicle. The adsorbtion of polyphenolic compounds (EGCG, epicatechin-3-gallate (ECG), and theaflavin) onto the pellicle may lead to stabilize the structure [38] and increase its thickness [53] resulting in an anti-erosive effect. So that, dental materials such as gels or varnishes including polyphenols were demonstrated in studies [33,38] which were tested against both enamel and dentin erosion. However, due to the structural variations of enamel and dentin, such as the higher porosity of dentin, the preventive effect of the acquired pellicle could be reduced. Methodologies involving gels usually engage polyphenolic compounds as active compounds and compare their effect against a fluoride gel [30,38]. However no commercial products have figured yet, except the mouthwashes with green tea aromas. For instance, gels containing EGCG and CHX showed to increase a protein (Statherin) in the acquired pellicle, which increased the saturation of oral fluids by releasing Ca^{+2} and PO^{-4} ions following acid attacks [38]. Another study reported that resin materials containing EGCG increased basic isoforms of salivary proteins which may perform to improve the acid resistance of demineralized surfaces [54].

More recently, flavonoids, which are from the subgroups of polyphenolic compounds, have been frequently investigated in studies comprising MMP inhibition [44,55]. Quercetin is one of the natural flavonoids which is found highly in fruits and vegetables and has been reported to have the potential to protect against degradation of the collagen matrix by inhibiting MMP-2 and MMP-9 [56]. An *in vitro* study showed that quercetin showed significantly lower microhardness loss than CHX, EGCG, and NaF groups and revealed a thicker DOM than control dentin [44]. This dose-dependant outcome of quercetin was explained by its improving effect on collagen resistance as a result of inhibiting both free- and collagen-bound degradomics (MMPs) in dentin [57]. On the other hand, previous studies have shown that resveratrol significantly reduces MMP-9 expression [58], which is a non-flavonoid polyphenol found in many of the plants. Since there is no study that has investigated its protective effect against MMPs, there are studies reporting its benefit on dentin bonding durability [55,59] and as anticaries agent [60].

5. CONCLUSION

Since dental erosion is a complex situation, there are debates on terming it as "bio-corrosion" in order to explain the process more comprehensively. Besides, endogenous enzymes called degradomics have

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also detrimental effects on the process if they reach exposed dentin surfaces. There have been inhibitory materials such as fluorides, chlorhexidine, and green tea extracts that were proved to protect demineralized collagen matrix. Studies are being carried out on the novel polyphenolic compounds that could be beneficial to collagenolytic processes. Their effect should be further investigated and comparably evaluated with recently known MMP inhibitors in various concentrations. So that, research may solve the inhibition mechanism and clinicians may benefit from the enhancement of their process.

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CONFLICT OF INTEREST

The authors have certified that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

GO: conceptualization, resources, writing-original draft preparation, visualization, project administration. **GO,MB:** methodology, software, investigation, data curation. **GO,MB,HSS:** formal analysis, writing-review and editing. **MB,HSS:** validation. **HSS:** supervision.

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Review Article

Review Articles

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cv

Günçe Ozan received her DDS in 2011 from the Faculty of Dentistry at Istanbul University, Istanbul, Turkey. She immediately started her PhD at the Restorative Dentistry Department of the same university. After studying on the fields of dental erosion and preventive dentistry, she had her PhD degree in 2017. She worked at the Young Dentists' Commission of the Turkish Dental Association for 2 years. She is now continuing her career at the Istanbul University as a Research Assistant.

Questions

1. The difference between the terms, "Dental erosion" and "Bio-corrosion" distinguishes from the certain reactions that were occurred during dental erosion?

❑ a. Piezoelectric effect;
❑ b. Proteolysis;
❑ c. Piezoelectric effect & Proteolysis;
❑ d. Electrochemical effect.

2. Demineralization occurs... in dental erosion.

❑ a. Subsurface;
❑ b. Surface and subsurface;
❑ c. Surface;
❑ d. Beneath the surface.

3. Which of the enzyme groups of degradomics are not localized in the "dentin"?

❑ a. Enamelisin;
❑ b. MT-MMP;
❑ c. MMP-2;
❑ d. MMP-3.

4. MMP enzymes activated at … ph but, functioned at… ph.

❑ a. Acidic / basic;
❑ b. Basic / neutral;
❑ c. Neutral / acidic;
❑ d. Acidic / neutral.

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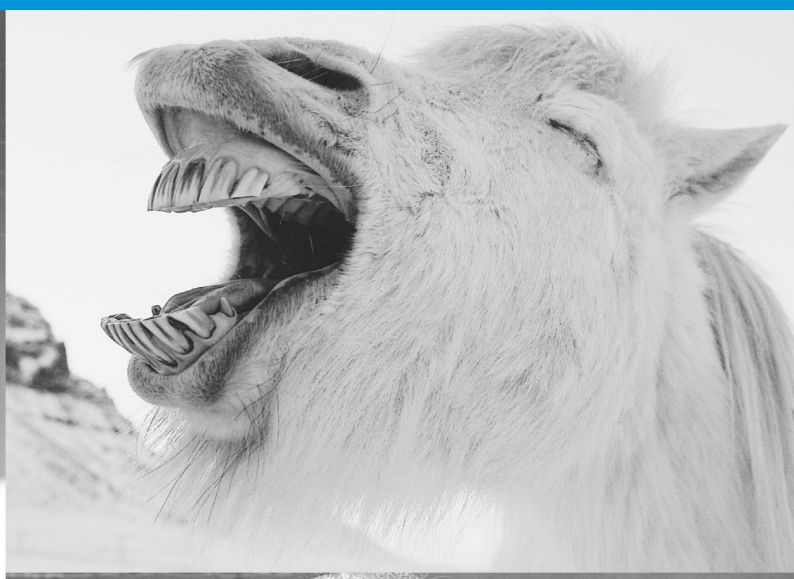

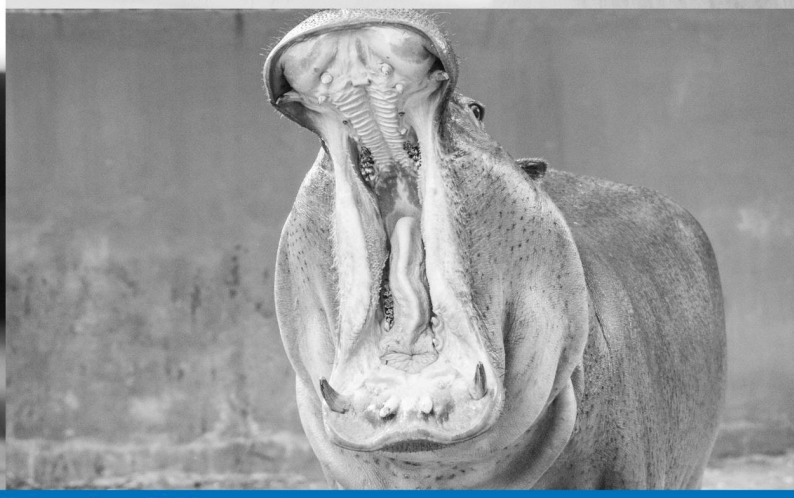

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PREVENTION OF PERI-IMPLANTITIS AND BONE RECESSION USING THE ELECTRONIC STEM GENERATOR

The scientific community recognizes there is no efficient treatment nowadays for the already installed peri-implantitis. As 34% of implanted patients show peri-implantitis, the use of preventive treatments remains the only efficient approach.
Bone recession is the common disease in peri-implantitis, periodontal disease, grafts recession, periapical granuloma and orthodontic treatment. The cause of bone recession is the activation of osteoclasts, caused by microbes present in the oral cavity and occlusal forces. Scientific literature proves ratio receptor activator NF-kappa B ligand (RANKL) and its decoy receptor, osteoprotegerin (OPG) - RANKL/OPG as the bone recession indicator, which is higher as long as osteoclasts are activated.
In order to reduce the RANKL/OPG ratio, the certified 2A class medical device Electronic Stem Generator was created, based on long waves electromagnetic field to be applied in the patient's home for a long time, and required for an efficient stimulation of deep bone progenitor cells in order to increase osteoblasts and OPG.

Technology

The Electronic Stem Generator is the only electromagnetic medical device that stimulates the bone by improving the activity of osteoblasts. New bone cells proliferate slowly and can take a considerable time to trigger.
Used at home as adjuvant for classical therapies (scaling and root planning, orthodontic treatment, endodontic treatment), the ESG therapy helps ensure for the duration of one's life a cellular balance within the deep bone which might prevent bone recession in case of future possible dental implant and bone graft.
This simple, home-based treatment can improve bone structure, prevent and treat teeth mobility, gum recession and bone resorption. Patients wear either an external face applicator or a U-shaped mouthguard which are connected to the signal generator.
Patients only need to switch the device on and follow the on-screen instructions, while reading, watching TV or walking in the garden.
It must be noted that even if the affected teeth are extracted and root planning are carried out, the bone cellular destruction will continue because the osteoclasts remain activated and the RANKL/OPG ratio remains high. Thus, any possible future dental implant will be affected by peri-implantitis if the ESG is not used prior to the implantation process.

Clinical benefits

The Electronic Stem Generator provides a number of clinical benefits:
- as adjunctive treatment to hygiene procedures.
- a low RANKL/OPG ratio to stimulate the healing of the periapical granuloma after the endodontic treatment.
- to be used after restorative treatment with ceramic crowns in order to prevent gum recession and change of bridges.
- in cases where bone grafting or immediate loading of implants is carried out, 20 days before implantation and 30 days following implantation are recommended.
- helps strengthen the bone and maintain tooth stability quickly either during orthodontic treatment or directly after.

Alternatively, because the ESG treatment is home-use and non-traumatic, the osteoblast triggering can be repeated often in order to initiate appropriate cell regeneration for the reduction of bone recession characterized by low RANKL/OPG ratio.
The clinical results obtained after the certification of the Medical Device with 1000+ patients recommend the Electronic Stem Generator as an adjuvant to classical dental procedures for any patient above 30 years of age.

Electronic Stem Generator device

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Dental Meetings

2022 European Dental Meetings

Date	Meeting	Location	Contact
29.04	Quintessence Live Aid 8:45-19:15 (MESZ) Zoom	Berlin, Germany	https://www.quintessence-publishing.com/deu/en/event/quintessence-live-aid
29.04 - 30.04	ERO Plenary Session	Bucharest, Romania	https://www.erodental.org/about-us/congresses-and-seminars/ero-plenary-session-2022/
12.05 - 14.05	19th International Conference of Esthetic Dentistry	Bucharest, Romania	https://www.sser.ro/contact
13.05 - 14.05	Italian Academy of Osseointegration	Rome, Italy	https://www.iao-online.com/contatti
20.05	Radboudumc Dentistry Congress	Nijmegen, Netherlands	https://www.radboudumc.nl/onderwijs/events/a0128245-congres-tandheelkunde-radboudumc/over
26.05 - 29.05	Roots Summit 2022	Prague, Czech Republic	https://www.roots-summit.com/login/
30.05 - 03.06	97th European Orthodontic Society Congress	Limassol, Cyprus	https://eos2022.com/congress-registration/
02.06 - 03.06	Congress Occlusion 2022	Marseille, France	https://cno-provence.com/inscription
09.06 - 11.06	XI AIO International Congress	Chia Laguna, Domus De Maria, Italy	segreteriaecm@aio.it
15.06 - 18.06	EuroPerio10 Congress	Copenhagen, Denmark	https://fi.dental-tribune.com/news/europerio10-kongressin-paivamaarat-julkistettu/
01.07 - 02.07	European Aligner Society The 2nd Summer Meeting	Porto, Portugal	https://www.eas-aligners.com/2nd-summer-meeting-porto-2022/
11.08 - 13.08	13th International Symposium on Dental Hygiene 2022	Dublin, Ireland	https://isdh2022.com/registration/
29.09 - 01.10	8th ARIA CAD/CAM 2022	Lyon, France	https://aria-cadcam.net/contact/
06.10 - 08.10	5th International Sofia Dental Meeting	Sofia, Bulgaria	sofiadentalmeeting@gmail.com

Short Implants

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Recently, the field of oral implantology has undergone a change in orthodoxy with the innovation of using the approximately 6 mm-long short implant without the need to augment bone grafting to gain vertical height for optimal implant restoration.
Clinical Associate Professor Boyd J. Tomasetti, BA, DMD at the School of Dentistry of the University of Colorado, USA and Professor Rolf Ewers, MD, DMD, PhD, Chairman of the CMF Institute for Cranio-Maxillofacial and Oral Rehabilitation, Navigation Surgery and Telemedicine in Vienna, Austria, as editors, together with 26 contributors provide the readers with a comprehensive guide to short implants.
"Short Implants" has 14 chapters which define the clinical indications and present restorative and laboratory considerations based on these types of implants.
The history of dental implants, the indications and contraindications of short implants are presented in the first chapters. The following chapters address short implants and early Brånemark team developments, the possibility of reduced grafting without restorative compromise and historical perspectives of the short implants.
The significance of bone–implant contact in short implants and clinical impact and the survival of short and ultrashort plateau root form implants are convincingly recorded in the following chapters.
Readers also have the opportunity to find an extensive description of the short and ultra-short implant role in reconstruction in both cleft patients and cancer patients who have lost portions of their mandible and/or maxilla, minimally invasive sinus lift and in the atrophic jaws.
The last chapters present in detail restoration techniques based on Bicon short implants and the development of personal practice by using a new type of implant.
Professor Boyd J. Tomasetti and Professor Rolf Ewers and the 26 contributors managed to present the readers with a comprehensive guide to short and ultrashort implants for practitioners interested in learning a new opportunity to stand out from those who use only traditional long implants.

https://doi.org/10.25241/stomaeduj.2022.9(1-2).bookreview.1

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

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Books Review

Orthodontics and Periodontology

Combined treatments and clinical synergies

Authors: Roberto Kaitsas, Maria Giacinta Paolone
Publisher: Edra S.p.A., Milan, Italy
Language: Italian
ISBN: 978-8-821-45366-3
Edition: 1/e
Publish Year: 2021
Pages: 272, Illustrated
Price: € 79.00

The increasing demand for complex rehabilitative dental treatment in adult and developmental patients raises the need for multidisciplinary orthodontic, periodontal and surgical therapies.
The book entitled ***"Orthodontics and Periodontology. Combined treatments and clinical synergies"*** by Dr. Roberto Kaitsas and Dr. Maria Giacinta Paolone aims to trace the interrelationship between orthodontics and periodontology, analyzing how orthodontic treatment can enhance the periodontal treatment plan.
In the 11 chapters of the book, the authors explain the different phases and sequences of orthodontic, periodontal and surgical treatment and how they can interconnect with each other through a step-by-step flow.
An ortho-perio risk assessment is carried out to identify and determine what risk factors exist as early as possible. It also shows the reader how to recognize and apply a diagnostic screening protocol not only to the full-blown ortho-perio patient, but also to patients with initially apparently pure orthodontic growth.
Via the accompanying clinical cases performed in the labial and lingual orthodontic technique, the phases of orthodontic and surgical mechanics are described analyzing how orthodontics enhances conventional and implantological regenerative periodontal surgical procedures.

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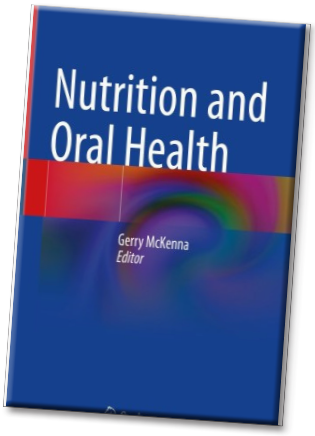
Nutrition and Oral Health



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Editor: Gerry McKenna
Publisher: Springer Nature, Switzerland
Language: English
ISBN: 978-3-030-80525-8
Edition: 1/e
Publish Year: 2021
Pages: 82, Illustrated
Price: € 139.09

A healthy diet is essential for good health and the maintenance and retention of natural teeth as people age. Dr. Gerry McKenna, a clinical reader and principal investigator in the Centre for Public Health, Queen's University Belfast, Belfast, UK, as editor of this book, explores the relationships between oral health and nutrition in the 8 chapters of the book entitled ***"Nutrition and Oral Health"***.

The book starts with nutritional considerations in children because good nutrition is essential for optimal growth, development and maintenance of all tissues and organs in the body, including the oral cavity. It also presents the most common cause of poor oral health in children and how nutrition could help or worsen the situation.

The next chapters describe the ageing population and nutritional requirements of older adults and how this could affect their oral health.

This book also discusses the relationship between periodontal disease and nutrition and helps practitioners provide dietary advice to their patients.

At the end, the authors present the impacts of oral rehabilitation on nutritional status and strategies for changing dietary behavior.

Dr. Gerry McKenna and his co-authors successfully achieves the aim of the book to present the association between nutrition, diet and dental diseases and to deliver clear dietary recommendations for their prevention.

Books Review

https://doi.org/10.25241/stomaeduj.2022.9(1-2).bookreview.3

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

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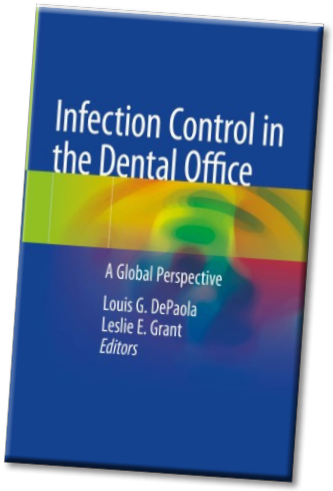
Books Review

Infection Control in the Dental Office

A Global Perspective



Editors: Louis G. DePaola, Leslie E. Grant
Publisher: Springer Nature, Switzerland
Language: English
ISBN: 978-3-030-30084-5
Edition: 1/e
Publish Year: 2020
Pages: 216, Illustrated
Price: € 139.09

It is our responsibility as health care providers to ensure that our practices and environments follow proven scientific guidelines to eliminate or reduce all types of infection. Elimination of cross contamination and infection in dentistry is important for overall patient and operator safety. Dr. Louis G. DePaola, Associate Dean of Clinical Affairs and Professor in the Department of Oncology & Diagnostic Sciences, School of Dentistry, University of Maryland, Baltimore, MD, USA and Dr. Leslie E. Grant, Examiner for the Commission on Dental Competency Assessment (CDCA) Linthicum, MD, USA deliver a new book on ***"Infection Control in the Dental Office"*** from a global perspective.

The book acquaints dental practitioners with the principles of infection control and the guidelines and standards of care in the context of contemporary dentistry practice, being structured in 15 chapters.

The book starts with an overview of infectious diseases of concern to dental practitioners such as: blood-borne pathogens, oral viral infections and bacterial infections.

The following chapters provide a global perspective on infection control standards of care and guidelines for specific countries to minimize the risk of infection transmission.

This book also presents the two tiers of infection control: standard precautions and transmission-based precautions, respiratory hygiene and cough etiquette, safe handling of sharps and proper disposal, exposure control plan and how to manage an occupational exposure incident, dental unit waterlines, surface disinfection, sterilization of dental instruments and dental care during catastrophic events.

The book aims to help dental practitioners around the globe to understand the importance of infection control in the dental office and incorporate the principles of infection control.

"Infections Control in the Dental Office" is an invaluable and welcome guide for all dental practitioners, including dentists, dental specialists, dental hygienists, and dental assistants.

https://doi.org/10.25241/stomaeduj.2022.9(1-2).bookreview.4

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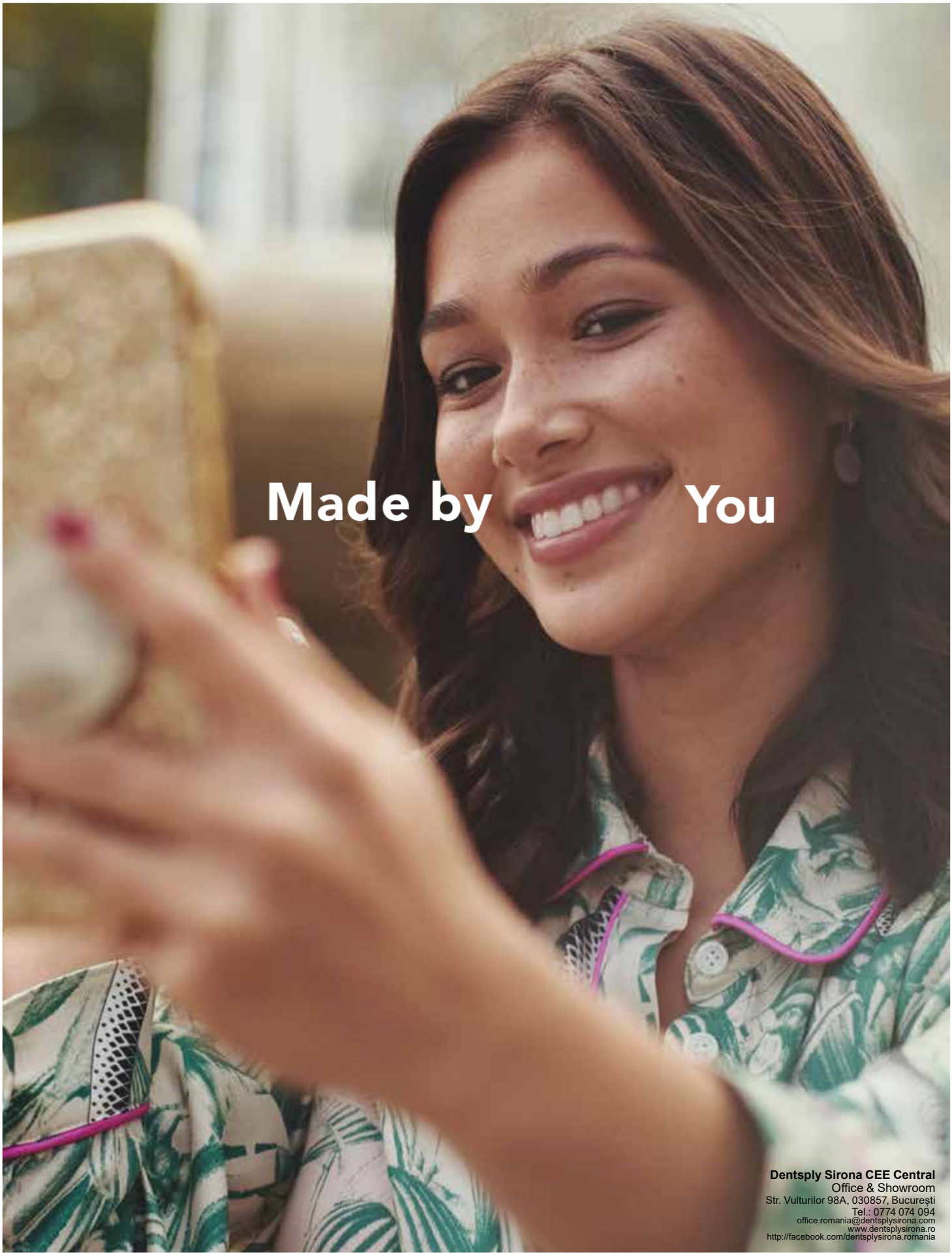

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http://www.icmje.org/icmje-recommendations.pdf

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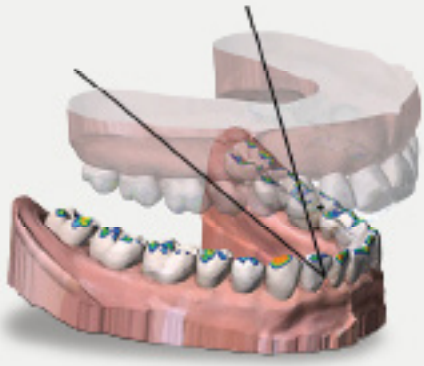

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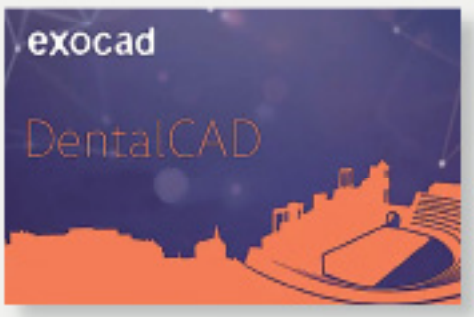

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