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Editor in chief - Prof. **Kjiro Ivanovski**, PhD, e-mail: kiroivanovski@stomfak.ukim.edu.mk
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Одговорен уредник: Проф. д-р **Ќиро Ивановски**, e-mail: kiroivanovski@stomfak.ukim.edu.mk
Заменик одговорен уредник: Проф. д-р **Елизабета Ѓоргиевска**, е-маил: egjorgievska@stomfak.ukim.edu.mk
Секретар на списанието: д-р **Влатко Коколански**, e-mail: vkokolanski@stomfak.ukim.edu.mk

Адреса - Македонски стоматолошки преглед, ул. Мајка Тереза бр. 43 Скопје, Република Северна Македонија
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ASSOCIATION BETWEEN ANATOMICAL ANDMORPHOLOGICAL FEATURES OF THE DENTAL ROOT AND PERIODONTAL DISEASE: A COMPREHENSIVE REVIEW

АСОЦИЈАЦИЈА ПОМЕЃУ АНАТОМСКО - МОРФОЛОШКИТЕ КАРАКТЕРИСТИКИ НА КОРЕНОТ НА ЗАБОТ И ПАРОДОНТАЛНАТА БОЛЕСТ: РЕВИЈАЛЕН ПРЕГЛЕД

Dollaku Shkreta B.[1], Popovska M.[2], Georgievska Jancheska T.[3]

[1]Faculty of Medicine, University of Prishtina, Republic of Kosovo, [2]USKC “St. Pantalejmon”, Skopje, Republic of North Macedonia, [3]Center for Rehabilitation of Verbal Communication Pathology, Faculty of Medicine, Ss. Cyril and Methodius University in Skopje, Republic of North Macedonia

Abstract

Introduction. Periodontal disease, as a chronic inflammatory condition affecting the tissues surrounding the teeth, is a major health concern. Various factors contribute to the development and progression of periodontal disease, including genetic component, environmental factors, and specific anatomical and morphological characteristics of the dental root. **Aim:** To record therisk factors associated with periodontal disease focusing on the anatomical and morphological characteristics of dental roots. **Material and method:** A systematic search of databases including PubMed, Scopus and Google Scholar was conducted to identify relevant studies published up to March 2024. The keywords used in search term were “root morphology”, “root concavities”, “root grooves”, “root proximity”, “furcation anatomy” and “periodontal disease”.Selection criteria included English-language studies that provided quantitative or qualitative data on the impact of morphological variation on periodontal health. **Results:** By reviewing the current literature and numerous empirical studies, this paper elucidates how these anatomical factors contribute to the progression of periodontal disease and discusses the implications in clinical practice, emphasizing the need for tailored preventive and therapeutic approaches based on individual anatomical conditions. **Conclusion:** The anatomical and morphological characteristics of the dental root are crucial inthe diagnosis and management of periodontal disease. These features not only affect how the disease starts and progresses, but impact the success of periodontal treatments as well. Dental professionals need to consider these factors in their clinical practice in order to personalize prevention and treatment plans effectively. This can lead to better periodontal health outcomes and help preserve patients’ teeth. **Keywords:** periodontal disease, root morphology, root concavity, developmental grooves, root proximity.

Апстракт

Вовед: Пародонталната болест како една хронична воспалителна состојба во која се афектиранитквивата околу забите е голем здравствен проблем. Различни фактори придонесуваат за развој и прогресија на пародонталната болест, вклучувајќи ја генетската компонента, факторите од околината и специфичните анатомски и морфолошки карактеристики на коренот на забот. **Цел:** Да се евидентираат факторите на ризик поврзани со пародонталната болест, фокусирајќи се на анатомските и морфолошките карактеристики на корените на забите. **Материјал и метод:** Спроведено е систематско пребарување на бази на податоци, вклучувајќи ги PubMed, Scopus и Google Scholar со цел да се идентификуваат релевантни студии објавени заклучно со март 2024 година. Клучните зборови користени во пребарувањето беа „морфологија на коренот“, „вдлабнатини на корените“, „конкавитети на корените“, „блискост на корените“, „фуркациона анатомија“ и „пародонтална болест“. Критериумите за избор вклучуваа студии на англиски јазик кои обезбедија квантитативни или квалитативни податоци за влијанието на морфолошките варијации на пародонталното здравје. **Резултати:** Со преглед на тековната литература и бројни емпириски студии, овој труд разјаснува како овие анатомски фактори придонесуваат за прогресијата на пародонталната болест и ги дискутира импликациите во клиничката пракса, истакнувајќи ја потребата за прилагодени превентивни и терапевтски пристапи базирани на индивидуални анатомски состојби. **Клучни зборови:** пародонтална болест, морфологија на корен, конкавитет на корен, развојни вдлабнатини, близина на корени.

Introduction

Periodontitis is a chronic multifactorial inflammatory disease associated with dysbiotic plaque biofilms which are the causeof progressive destruction of the tooth-supporting structures that may lead to tooth loss[1].

Consideringthat periodontitis is the most prevalent chronic inflammation in humans[2], severe periodontitis is also the sixth most prevalent disease of mankind[3] and an important dental public health problem[4]. Approximately 10% of the global adult population is highly vulnerable to severe periodontitis, and 10–15% appears to be completely resistant to it, while the remainder varies between these two situations[1].The prevalence and rate of destruction increase gradually with age, showing a steep increase between the 3rd and the 4th decade of life[1].

The etiopathogenesis of periodontitis involves the complex interplay between pathogenic microorganisms in dental plaque and the immune responseof the host, leading todestruction of the supporting tissues of the teeth[2]. While bacterial plaque is the primary etiological factor, the susceptibility and severity of periodontal disease can be exacerbated by various other factors, including genetic predisposition, systemic conditions, environmental factors and specific anatomical features of teeth (Table 1). Among these, inherent anatomical and morphological factors of the dental root play a critical role in disease progression by affecting plaque accumulation and complicating oral hygiene efforts. This review aims to elucidate the impact of these anatomical risk factors on periodontal health, drawing on a wide range of empirical studies to provide a comprehensive overview.

Material and method

A systematic search of databases including PubMed, Scopus, and Google Scholar was conducted to identify relevant studies published up to March 2024. Keywords used in the search included "root morphology," "root concavities", "root grooves," "root proximity", "furcation anatomy" and "periodontal disease." The selection criteria included studies in English that provided quantitative or qualitative data on the impact of root morphological variations on periodontal health. Due to the nature of the topic, a systematic review cannot be performed and the evidence is presented in a narrative format.

Results

Several tooth-related anatomical and morphological features associated to periodontal disease have been identified in literature (Table 2). For instructive purposes we have classified them in three major categories: root morphology (which includes morphological features of the root such as root abnormality in terms of shape, width and length; root concavities; radicular grooves and furcation anatomy), root surface aberrations (which includes enamel cervical projections and enamel pearls) and root proximity.

Table 1. Determinants of clinical periodontal health (Lang & Bartold, 2018)[5]

Microbiological Determinants of Clinical Periodontal Health
Supragingival plaque composition
Subgingival biofilm composition
Host Determinants of Clinical Periodontal Health **1. Local predisposing factors** 1.1. Periodontal pockets 1.2. Dental restorations 1.3. Root anatomy 1.4. Tooth position and crowding **2. Systemic modifying factors** 2.1. Host immune function 2.2. Systemic health 2.3. Genetics
Environmental Determinants of Clinical Periodontal Health Smoking Medications Stress Nutrition

Table 2. Significant anatomic features of the teeth (Matthews & Tabesh, 2004)[6]

Tooth	Anatomic feature (ref.)	Prevalence (ref.)
Maxillary incisors	Palatal groove 98% all grooves found in lateral incisors	0.79(5)-21% (51)
Maxillary first bicuspids	Root trunk length; averages 4-14.6 mm (57) Furcal concavity on palatal aspect of buccal root Mesial root concavities Furcation entrance diameter <0.75 mm	 62% (57) 100% (14) 57% (15)
Maxillary molars	Furcation entrance diameter <0.75 Root trunk length; averages Mesial: 3.5 mm (99) – 4.2 mm (15) Buccal: 4.0 (99) – 4.8 mm (15, 93) Distal: 3.3 (12) Cervical enamel projections	63% (15) 32.6% (112)
Mandibular molars	Furcation entrance diameter <0.75 mm Root trunk length; averages Buccal: 2.4 mm (15) – 3.14 mm (70) Lingual: 2.5 mm (15) – 4.17 mm (70) Cervical enamel projections First molar Second molar Bifurcation ridges	50% (15) 80.4% (52) 48.4% (52) 65,5% (52) -76% (18)

a) Root Morphology

The dental root is a critical factor for the function, stability, and long-term retention of the tooth. There are several aspects of its morphology that have been shown in numerous studies. In relation to them, it has been proven that they influence the sensitivity and progression of periodontal disease. Such aspects include:

Root abnormality in terms of shape, width and length

A wide range of root shapes are commonly observed clinically. Meng et al.[7] categorized the most common shapes into five types: cone-root (considered the golden standard); slender root;curved root; maladjusted proportion of crown and root; and syncretic root (Table 3).

In literature, a common association between root abnormality and aggressive periodontitis has been established. Several studies, especially in Chinese patients, have documented a higher presence of root abnormalities in patients with aggressive periodontitisthan in patients with chronic periodontitis or gingivitis[8-10].

Xu et al.[8] found that the prevalence of root abnormality was higher in patients with aggressive periodontitis (14.3%) than in those with chronic periodontitis (5.0%) and periodontal healthy individuals (3.7%).In another study, Chung et al.[10] analysed the periodontal attachment loss of each tooth according to root form. In thecomparison between root shape abnormality and periodontal attachment loss regardless oftooth type, type V root shape was

Table 3. Root abnormality classification according to Meng, 2007[7]

Type	Type of root	Description
I	Cone root	Normal root
II	Slender root	Root morphology is too thin
III	Curved root	Root form is curved
IV	Maladjusted proportion of crown and root	Root form is abnormally short or long
V	Syncretic root	Two- or three-root fusion

associated with the highest periodontal attachment loss at 6.09±2.11 (P=0.01).

Luet al.[9] proved that abnormal root shape is an adverse prognostic factor in patients with aggressive periodontitis; they found that during the periodontal support therapy, patients with > 4 teeth with root abnormalities had a higher risk of tooth loss (OR=3.52, 95% CI 1.06–11.76, P=0.035).

While most studies in the past have been carried out on extracted teeth, the advent of the cone-beam computed tomography, with its multiple advantages in comparison to conventional dental radiology techniques, has made it possible to investigate in vivo the anatomical and morphological peculiarities of the dental root and their contribution in the onset and progression of periodontal disease. A very recent CBCT-based study by Aykol-Sahin et al.[11] examined the association between periodontal disease and root length and taper in single- rooted teeth.In this study, root length was identified as a potential protective parameter, as the risk of being diagnosed with periodontitis decreases when root length increases by 0.785 times (p = 0.043). Shortroot, and increased root-taper at specific teeth, were found to be important risk indicators for periodontitis.

Periodontal support is largely dependent on the surface of its attachment to the dental root.

Reduced root surface attachment area due to a congenital abnormality or disease process may compromise periodontal support. Different authors have argued that conditions such as short roots, conical roots, and syncretic roots have relatively minor surface areas of periodontal ligament compared to normally shaped roots; hence, overloading of such teeth may accelerate the process of periodontal destruction[9]. In addition, curved roots transfer adverse lateral force during physiological functioning (mastication); these lateral forces may lead to localized stress shielding and accelerated breakdown of the periodontal ligament. Mathematically, in experiencing the same amount of bone destruction, short roots lose higher proportions of periodontal support than long roots (Figure 1).

Figure 1. *Comparison of normal and abnormal root shape, Meng et al., 2000*[7]

Root concavities

Root concavities are another morphological feature of the dental root that is associated with periodontal disease. Root concavities can vary from shallow flutings to deep depressions. Typically, they are present in the proximal surfaces of the roots of the maxillary first premolars and mandibular incisors, the mesiobuccal root of the maxillary first molar and both roots of mandibular first molars.These concavities are wider in the maxillary than the mandibular teeth and since they are exposed early in the destructive disease process, theycan create niches that accumulate plaque and calculus, thereby hindering effective cleaning either by the patient or by the dentist.

According to the position of root concavities, Ong and Neo[12] classified them into five groups: Type I: no concavity on the root; Type II: concavity starting at the enamel; Type III: concavity starting at the cemento-enamel junction; Type IV: concavity starting at the cervical third; Type V: concavity starting at the apical third (Figure 2).

Many authors have reported the incidence of root concavities in different teeth,an incidence that varies between studies, not only due to the genetic diversities of the studied population, but also because of the fact that previously, such morphological peculiarities were studied in extracted teeth, whereas now, with the use of CBCT technology, they can be studied in vivo.According to Fan et al.[14], there is a high prevalence of mesial cervical concavity among maxillary first premolars (64.5% in single-root maxillary first premolars and 73.8% in two- root maxillary first premolars) with an increase of its prevalence and degree of concavity with the increase of the number of roots.

Research indicates that root concavities are associated with increased risk of periodontal disease. Using three-dimensional reconstruction by cone beam computed tomography, Zhao et al.[13] investigated the influence of first premolar root concavity on clinical indices of chronic periodontal disease and alveolar bone defect, demonstrating a significantly higher mean probing depth and clinical attachment loss in first premolars with root concavities compared with those without concavity. Moreover, in the same study, significantly different types of alveolar bone defects and plaque accumulation were observed when comparing first premolars with concavities and those without a concavity. The study concluded that root concavities may be important in contributing to local periodontal disease of the first premolars.

Bhavya et al.[15] conducted a similar study that evaluated the correlation between the root concavities in premolars and mandibular molars with chronic periodontitis. They also drew the conclusion that the association between root concavities of premolars and mandibular molars and periodontal disease could be rather more significant than had

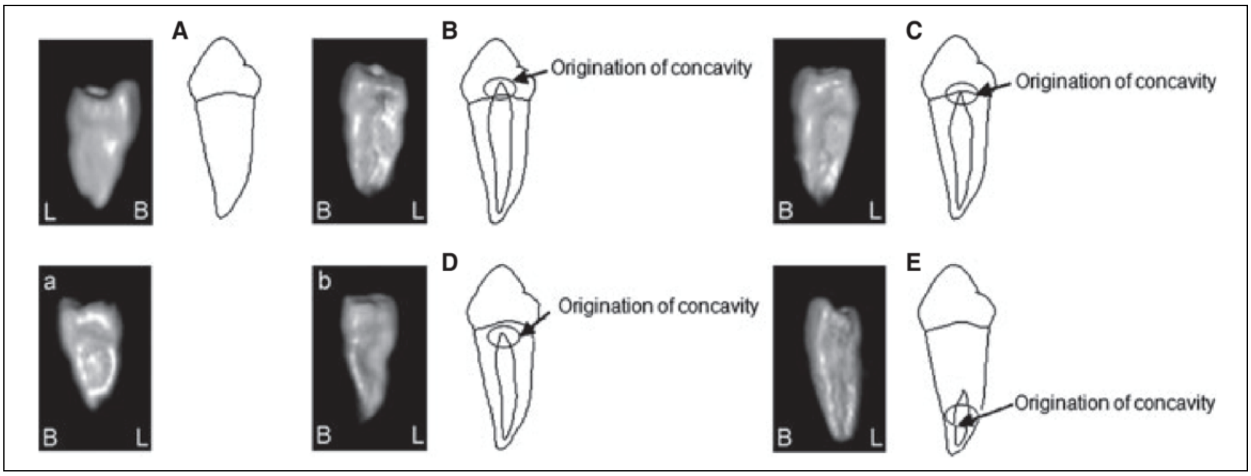

Figure 2. Three-dimensional reconstructions of root concavities from CBCT images of first maxillary premolars, representing the 5 types of root concavities according to Ong's classification and Zhao et al. 2014[12,13].

been previously thought. Similarly, evaluating in CBCT reconstructions, the relationship between mesial concavity of the maxillary premolars and their clinical indices of chronic periodontitis, Chen et al.[16] concluded thatroot concavities may be important contributing factors to the localized periodontal disease of the first premolars.

a) Rad3icular grooves

The radicular groove is a developmental anomaly in which an infolding of the inner enamel epithelium and Hertwig's epithelial root sheath creates a groove that passes from the cingulum of the maxillary incisors apically onto the root. Root grooves are most commonly found in maxillary incisors-with a higher incidence in maxillary lateral incisorsand can vary in depth and length (Figure 3). They can be found on the buccal or lingual/palatal side, located either mesially, centrally or distally. The prevalence of radicular grooves, described in previous studies, ranges from approximately 2 to 10% for palatal, and from 4 to 5% for buccal grooves[17-21]. The differences in prevalence among studies could be attributed to disparate study methodologies and/or found in, genetic diversities between the examined populations.

Type I: short groove (not beyond the coronal third of the root). Type II: long and shallow groove (beyond the coronal third of the root). Type III: long and deep groove (beyond the coronal third of the root), associated with complex root canal system - Alkhatanyet al., 2022,[22]

The presence of root grooves has been linked to localized periodontal destruction due to their role in harbouring plaque[23,24]. Lee et al.[25] described eleven cases where unilateral and bilateral defects in lateral incisors were associated with moderate/severe periodontal disease.Another study[26]

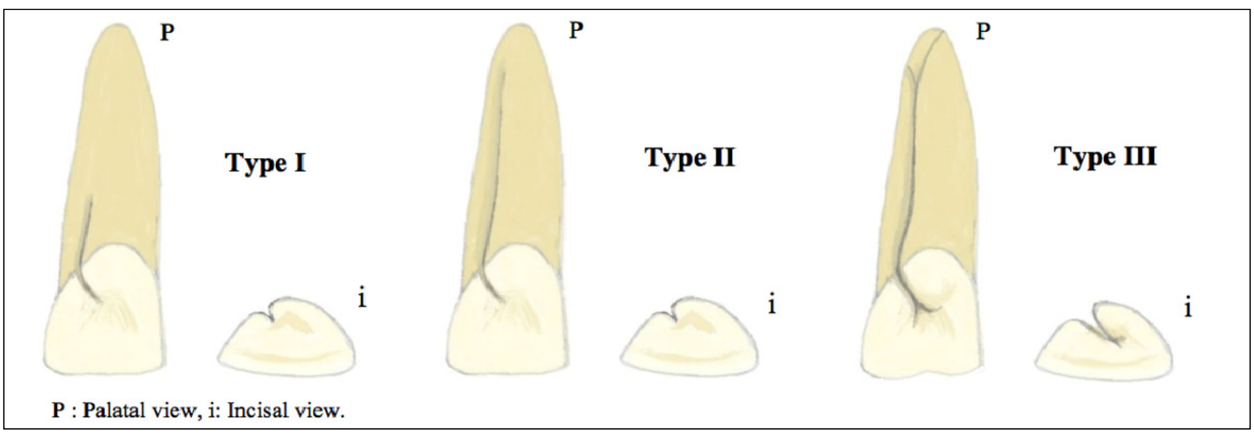

Figure 3. Gu's Classification based on the severity of the palatoradicular groove

examined the association between palatoradicular grooves and periodontal health by measuring the plaque index, bleeding index, and pocket depth in 552 maxillary lateral incisors in Saudi adults. They reported that teeth with an apical groove showed a plaque index anda bleeding index of 100%; thus, the apical extension of the groove was significantly associated with poor periodontal health.

In some cases,even the dental pulp may be affected, presenting the clinical manifestation of an endo-perio lesion that is the result of the combination of a primary periodontal lesion with secondary involvement of the pulp. This occurrence emphasizes the importance of correctly diagnosing and treating periodontal lesions associated with radicular grooves.

Furcation anatomy

Longitudinal studies have demonstrated that molar teeth, especially maxillary molars are the most affected by periodontitis, and that in these teeth the tooth survival rate is significantly related to the furcation involvement[27]. In multiradicular teeth, the progression of periodontal disease is usually higher in furcation areas. Furcation involvement, a condition where periodontal disease affects the area between the roots of multiradicular teeth, poses a significant challenge in the management of periodontal disease. The complex anatomy of furcation areas, with limited access for instrumentation and plaque control, contributes to the rapid progression of periodontal destruction. Moreover, the presence of furcation involvement is associated with a higher risk of tooth loss and a less favourable response to periodontal treatment.

Several morphological factors such as root trunk length, furcation entrance and the anatomy in the prefurcation area have been evaluated morphometrically in existing literature[28,29].

The severity of furcation involvement is highly dependent on the relationship between the amount of attachment loss and the root trunk length, a parameter used to describe the distance from cementoenamel junction to the furcation entrance. A short root trunk would result in an early development of furcation involvement, already at initial or moderate stages of breakdown of the attachment apparatus. Conversely, an apically located furcation would be more protected in the initial stages of marginal periodontitis[30]. Similar findings were reported by Madi et al.[31] who investigated, among other parameters, the length of the root trunk in the mandibular molars of periodontitis and non-periodontitis patients. This CBCT-based, cross-sectional study found that the first molars of non-periodontitis patients (4.65±0.90) had significantly longer (p=0.007) root trunks than periodontitis patients(4.09±1.02). Anyway, in spite of being more vulnerable to furcal involvement, molars with short root trunks have a better prognosis after treatment, due to the fact that it is presumed that less periodontal destruction has occurred. In contrast, molars with a long root trunk and short roots may not be a candidate for root resection, since these teeth lose more periodontal support with furcal involvement[32].

Another important factor that can influence the effectiveness of the furcation involvement therapy is also the diameter of thefurcation entrance. Bower et al.[33] found that 81% of furcation entrances were <1mm, whereas 58% were < 0.75 mm, which means that in the majority of teeth, the furcation entrance is narrower than the width of the standard Gracey curette. Narrow furcation implies an increased difficulty of access, even in a surgical approach, through furcation entrances for complete root debridement - leading to a poor periodontal outcome.A similar conclusion was also drawn by Marcacciniet al.[28] in their morphometric study of the root anatomy in furcation area of mandibular first molars.

b) Root surfaceaberrations

Cervical enamel projections

Cervical enamel projections represent a dipping of the enamel from the cemento-enamel junction towards the furcation area of the molars (Figure 4). They are more prevalent in mandibular second molars than either in first mandibular or maxillary molars. Since a connective tissue attachment is not possible on the enamel, the presence of cervical enamel projections has been considered to be a contributory factor in furcation involvement.

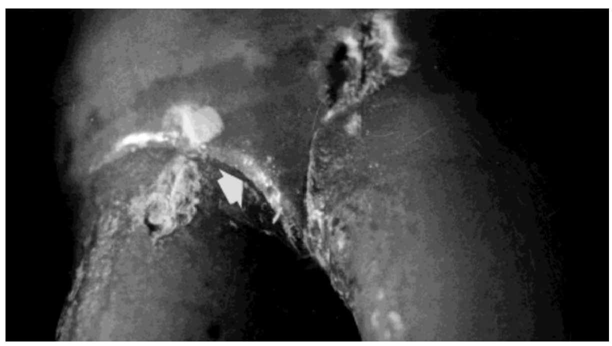

***Figure 4.** Second mandibular molar showing cervical enamel projection extending into the furcation on the buccal surface[30]*

Hou et Tsai[34] reported the prevalence of cervical enamel projections in molars with and without furcation involvement. 82.5% of molars cervical enamel projections exhibited furcation involvement, while this was true for17.5% of molars that had no cervical enamel projections.

Enamel Pearls

Enamel pearls are less common than cervical enamel projections, with a mean incidence of 2.6% and a variation

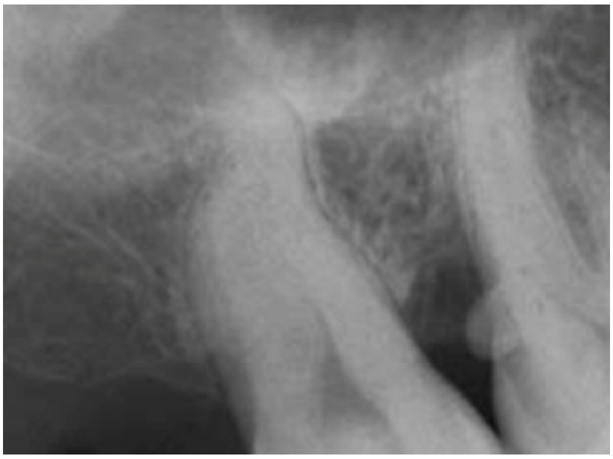

Figure 5. *Radiographic presentation of an enamel pearl on a maxillary second molar resulting from periodontal destruction Matthews &Tabesh, 2004*[6]

of 1.1% to 9.7% depending on tooth type and location, as found in a literature review[35]. They are most commonly-found in the maxillary third molar, with the mandibular third molars and maxillary second molars being the second most common position[36]. One pearl per root is the most common occurrence, but two or more pearls have also been identified[36].

Various studies have found an association between enamel pearls and adjacent localized periodontal destruction[6,36]. The presence of enamel pearls can affect mechanical control of dental biofilm, since they serve as niches which retain bacterial biofilm and dental calculus promoting the progression of periodontal disease (Figure 5).

c) Root proximity

Root proximity refers to the closeness of adjacent tooth roots, which can reduce the interdental space crucial for effective cleaning. According to Vermylenet al.[37], it is a term used to describe the situation where there is 0.8 mm or less-bone or interdental tissue present between the two involved roots, as measured radiographically. This anatomical feature is commonly observed in the posterior dentition of the maxilla between the first and the second molar,but also anteriorly, between the central and lateral incisor. In the mandible, it is more prevalent both between the central incisors and between the central and lateral incisor.

In a case-control study, Vermylenet al.[38] compared on full mouth periapical radiographs the root proximity in patients with advanced periodontal disease and controls without periodontal disease. They found that root proximity was a very common occurrence in patients with advanced periodontal disease (with 94.4% of them having at least one interdental space with root proximity and 75% of them having severe root proximity), while not so common in patients without periodontal disease (with 64% of them having at least one interdental space with root proximity and only 30% having severe root proximity). Also, their study showed that a patient with bilateral root proximity has a 3.6 times higher risk of being affected by periodontitis, concluding that root proximity must be taken into consideration as a risk indicator for periodontal disease. Close root proximity can lead to interdental bone loss and furcation involvement.They reported that root proximity was a significant predictor of furcation involvement in lower molars, independent of other factors like overall plaque levels and smoking.

Recent CBCT-based studies[39], that evaluated the association between root proximity and periodontal disease both in the anterior and the posterior dentition, confirmed the findings of previous authors and concluded that root proximity could be considered an important risk indicator for periodontal disease.

Conclusions

Anatomical and morphological characteristics of the dental root are pivotal in the risk assessment and management of periodontal disease. These features not only influence the initiation and progression of the disease but also affect the efficacy of therapeutic interventions. Dental professionals must consider these factors in their comprehensive assessment to tailor prevention and treatment strategies effectively, thereby improving periodontal health outcomes and preserving the dentition. While the current literature provides valuable insights into the relationship between anatomical and morphological factors of the dental root and periodontal disease, further research is needed to fully understand the complex interactions between these variables. Future studies should focus on longitudinal investigations to assess the long-term impact of anatomical and morphological characteristics on periodontal health.

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PREVALENCE OF ORTHODONTIC ANOMALIES IN 6 YEARS-OLD CHILDREN WITH DYSLALIA

РАСПРОСТРАНЕТОСТ НА ОРТОДОНТСКИ АНОМАЛИИ КАЈ ДЕЦА НА 6-ГОДИШНА ВОЗРАСТ СО ДИСЛАЛИЈА

Georgievska Jancheska T.[1], Tosheska-Spasova N.[2], Stavreva N.[3]

[1]Center for Rehabilitation of Verbal Communication Pathology, Faculty of Medicine, Ss. Cyril and Methodius University in Skopje, Republic of North Macedonia, [2]Department of Orthodontics, Faculty of Dentistry - Skopje, Ss. Cyril and Methodius University in Skopje, Republic of North Macedonia, [3]Department of Prosthodontics, Faculty of Dentistry - Skopje, Ss. Cyril and Methodius University in Skopje, Republic of North Macedonia

Abstract

Aim of the study: The aim of our research is to determine the frequency and distribution of orthodontic anomalies in female and male children at the age of 6 who have previously been diagnosed with dyslalia. **Methods:** The frequency and distribution of orthodontic anomalies were analyzed in a selected sample (n=586) of boys and girls at the age of 6, all with dyslalia.The performed analysis is retrospective, on data for patients recorded in an outpatient clinic for carried out diagnostic orthodontic-speech examinationsin the period 2015-2019 at the Public Health Institution "Center for Rehabilitation of Verbal Communication Pathology - Skopje". The data is statistically examined, represented in tables and figures and analysed descriptively. **Results:** 15% of children with dyslalia had orthodontic anomalies of teeth and jaws. Most often, in as many as 50% of cases, it is about sagittal occlusion anomalies, followed by vertical occlusion anomalies (26.1%), anomalies in the dental arches (19.3%), etc. Among children with dyslalia, girlsare more likely to have orthodontic anomalies than boys. **Conclusion:** The findings obtained from the research can serve for better planning and implementation of diagnostic-rehabilitation activities in relation to orthodontic anomalies and the formation of speech sounds, with the ultimate goal of enabling, to as many children as possible, conditions for adopting clear and distinct speech sounds. **Keywords:** dyslalia, articulation disorders, orthodontics, open bite.

Апстракт

Цел на трудот: Цел на нашето истражување е да се утврди фреквенцијата и дистрибуцијата на ортодонтски неправилности кај женски и машки деца на 6-годишна возраст кај кои претходно е дијагностицирана дислалија. **Методи:** На избран примерок (n=586) од машки и женски деца на 6-годишна возраст, сите со дислалија, анализирана е фреквенцијата и диструбицијата на ортодонтски аномалии. Извршената анализа е ретроспективна и тоа на податоци за пациенти заведени во амбулантски дневник за спроведени дијагностички ортодотско-логопедски прегледи во периодот 2015-2019 во ЈЗУ Центар за рехабилитација на патологија на вербалната комуникација - Скопје. Податоците се статистички обработени, табеларно и графички прикажани и дескриптивно анализирани. **Резултати:** 15% од децата со дислалија имаа ортодонтска аномалија на заби и вилици. Најчесто, во дури 50% од случаите се работи за сагитални неправилности во оклузија, потоа следуваат вертикални неправилности во оклузија (26,1%), неправилности во денталните лакови (19,3%) итн. Во рамки на половите групи, женските деца со дислалија почесто имаат ортодонтски аномалии на заби и вилици, отколку машките деца. **Заклучок:** Добиените наоди од истражувањето може да послужат за подобро планирање и спроведување на дијагностичко-рехабилитациски активности во однос на ортодонтските аномалии и изговорот на гласови, а со крајна цел на што поголем број деца да им се овозможат услови за усвојување на чист и јасен изговор на гласови. **Клучни зборови:** дислалија, артикулациски нарушувања, ортодонција, отворен загриз.

Introduction

Orthodontics is a specific part of dentistry which deals with the study and monitoring of the growth and development of the dentition and the accompanying anatomical structures, from birth to dental maturity, including all preventive and curative interventions in all dental irregularities that require repositioning of teeth with functional and mechanical means, in order to establish normal occlusion and adequate facial appearance[1]. Orthodontics, as a science that deals with the study of the growth and development of the orofacial system[2], but also the sciences that monitor the properarticulation, have a common interest in the orofacial region, a region where one of the most important human functions, speech, takes place. Any anomalies of the structures of the orofacial region can affect the correct articulation, i.e., lead to speech problems. Orthodontic anomalies are one of the causes of incorrect articulation of certain speech sounds, i.e., especially of speech sound distortion.The orthodontic anomalies that most often lead to articulation disorders are bite anomalies, which include protrusion, progenia, crossbite, open bite and cleft lip and palate[3].

The incorrect articulation of one or more sounds or dyslalia is a common occurrence among school children, and if there are also orthodontic anomalies with them, it can lead to changes in the entire child's being, i.e. hinder normal psychological development, can be the cause of psychological trauma and failure at school[4].

Different studies show that the number of articulation disorders is higher in populations with orthodontic anomalies than in eugnatic patients[5]. Also, many authors agree that people with articulation disorderstend to have a proportionately high incidence of malocclusion[6] i.e. a misalignment or improper relationship between the teeth of the upper and lower dental arches as they approach each other as the jaws close. This does not necessarily mean that the malocclusion itself is the cause of the speech disorder. However, structural malformations of the maxillary and mandibular arches can impair the production of consonants and affect speech intelligibility[7]. The effect of malocclusion on dyslalia appears to be more relevant and frequent, and increases proportionally, depending on the severity of the malocclusion[8].

From the abovementioned, it is clear that there is a complex relationship between speech and the position of the teeth. Harvold suggested three mechanisms by which malocclusion and speech are interrelated: there may be an occlusal or skeletal problem and coincidently an articulating problem; there may be a genetic or metabolic disorder that affects the central nervous system, leading to poor motor control and possible malformed morphogenesis; and there may be true cause–effect where occlusal or structural anomalies could affect the articulating skills[9]. Therefore, it is of particular importance to study, from as many different aspects as possible, the conditions as well as the possible relationship between orthodontic anomalies and imprecise or incorrect articulation.

In our research, the goal is to determine the frequency and distribution of orthodontic anomalies in female and male children at the age of 6 who have previously been diagnosed with dyslalia. The obtained results should be the basis for future research to determine the possible connection of orthodontic anomalies with the incorrect articulation.

Materials and methods

A retrospective analysis of data for patients recorded in the outpatient clinic for diagnostic orthodontic-speech examination in the period 2015-2019 at the Public Health Institution "Center for Rehabilitation of Verbal Communication Pathology – Skopje" (hereinafter: the Center)was carried out. Diagnostic orthodontic-speech examinations are carried out by an expert team (specialist orthodontist; specialist in ear, nose and throat; clinical speech therapist-specialist; special educator and rehabilitator; audiometrist; social worker; psychologist) according to the adopted protocol of the Center. A sample (n=586) of male (n=389) and female (n=197) 6-year-old children, all with dyslalia, was selected from the data, in which the frequency and distribution of orthodontic anomalies was analyzed. The children have normal intellectual development, without mental retardation or impaired hearing.

The data was statistically examined, represented in tables and figures and analysed descriptively.With the descriptive method, the following parameters were analyzed: gender, type of orthodontic anomalies, other anomalies of the oral structures. The statistical analysis of the data obtained from the research was done in the statistical programs Statistica for Windows 7.0 and SPSS 17.0. Pearson Chi-square test was used to compare the analyzed variables between male and female respondents. Statistical significance was defined at the $p<0.05$.

Results

From the analyzed sample of data for children with dyslalia (n=586), children who had orthodontic anomalies of the teeth and jaws were first identified (Table 1).

It was determined that 15% of the children hadan orthodontic anomalies (n=88), of which 58% are male (n=51) and 42% are female (n=37).

Considered within gender groups, 13.1% of male childrenand 18.8% of female children had some orthodontic anomalies. The statistical analysis confirmed the difference in the distribution of children with and without orthodontic anomalies between males and femalesas non-significant ($p=0.069$).

Considered by groups of orthodontic anomalies, the results show that most often it is about sagittal occlusion anomalies (50%; n=44) (protrusion was most often registered within the group, n=19), followed by vertical occlusion anomalies (26.1%; n=23) (an open bite was most often registered within the group, n=15), anomalies in the dental arches (19.3%; n=17) (crowding in the dental arches was most often registered -mandibular crowding, n=9) and anomalies in the number of teeth (2.3%;

Table 1. Frequency and distribution of orthodontic anomalies in children with dyslalia, by gender and total

Orthodontic anomalies	Male		Female		Total		p-value
	N	(%)	n	(%)	N	(%)	
With	51	(13.1)	37	(18.8)	88	(15.0)	p=0.069
Without	338	(86.9)	160	(81.2)	498	(85.0)	
Total	389	(100.0)	197	(100.0)	586	(100.0)	

p (Pearson Chi-square test)

Table 2. Distribution of orthodontic anomalies, in children with dyslalia who have only one orthodontic anomaly, by gender and total

Orthodontic anomalies	Male			Female			Total	
	(n)	[1]	[2]	(n)	[1]	[2]	(n)	[3]
	43	**55.1%**		**35**	**44.9%**		**78**	
Sagittal occlusion anomalies	**23**	**57.5%**	**53.5%**	**17**	**42.5%**	**48.6%**	**40**	**51.3%**
Angle Class II, Division 1 Malocclusion (Protrusion)	9	50.0%	20.9%	9	50.0%	25.7%	**18**	**23.1%**
Angle Class II, Division 2Malocclusion (Deckbiss)				2	100.0%	5.7%	**2**	**2.6%**
Angle Class IIIMalocclusion	5	83.3%	11.6%	1	16.7%	2.9%	**6**	**7.7%**
Underbite	9	64.3%	20.9%	5	35.7%	14.3%	**14**	**17.9%**
Verticalocclusion anomalies	**11**	**55.0%**	**25.6%**	**9**	**45.0%**	**25.7%**	**20**	**25.6%**
Open bite	8	57.1%	18.6%	6	42.9%	17.1%	**14**	**17.9%**
Deep bite	3	50.0%	7.0%	3	50.0%	8.6%	**6**	**7.7%**
Anomalies of teeth number	**2**	**100.0%**	**4.7%**				**2**	**2.6%**
Hypodontia	1	100.0%	2.3%				**1**	**1.3%**
Hyperodontia	1	100.0%	2.3%				**1**	**1.3%**
Anomalies in the position of individual teeth	**1**	**100.0%**	**2.3%**				**1**	**1.3%**
Rotation	1	100.0%	2.3%				**1**	**1.3%**
Anomaliesof teeth shape	**1**	**100.0%**	**2.3%**				**1**	**1.3%**
Fusion	1	100.0%	2.3%				**1**	**1.3%**
Anomalies in the dental arches	**5**	**35.7%**	**11.6%**	**9**	**64.3%**	**25.7%**	**14**	**17.9%**
Crowding in the dental arches	4	36.4%	9.3%	7	63.6%	20.0%	**11**	**14.1%**
Spacing in the dental arches	1	33.3%	2.3%	2	66.7%	5.7%	**3**	**3.8%**

[1] – distribution of orthodontic anomalies between male and female children
[2] – distribution of orthodontic anomalies within the gender group
[3] – distribution of orthodontic anomalies in the total sample(n=78)

n=2). One case each with anomaliesin the position of individual teeth and anomalies in the shape of the tooth was registered. Transversal occlusion anomalies were not registered.

Among the children in whom an orthodontic anomalies were determined (n=88), the orthodontic anomaly was mostly isolated, independent (88.6%; n=78), then together with other anomalies of the oral structures (10.2%; n=9), and only one child was registered as having two orthodontic anomalies at the same time.

More specifically, depending on whether the children with dyslalia have only one or two orthodontic anomalies, or in addition to the orthodontic anomalies they also have other anomalies of the oral structures, and depending on gender, the results are as follows:

a) ***Children with dyslalia and only one orthodontic anomaly***

In the cases of children with only one orthodontic anomaly (n=78), the results for orthodontic anomalies by group (Table 2) show that most often it is sagittal occlusion anomalies (51.3%; n=40), followed by vertical occlusion anomalies (25.6%; n=20), anomalies in the dental arches (17.9%; n=14) and anomalies in the number of teeth (2.6%; n=2). One case each with anomalyin the position of the individual teeth and anomaly in the teeth shape were registered, and transversal occlusion anomalies were not registered.

Regarding the distribution of orthodontic anomalies within gender groups, more than half of males have sagittal occlusion anomalies (53.5%), followed by male children with vertical occlusion anomalies (25.6%), and anomalies in the dental arches (11.6%) (Table 2, Male - column [2]).In female children, sagittal occlusion anomalies also dominate (48.6%), followed by equally represented vertical occlusion anomalies and anomalies in the dental arches (Table 2, Female - column [2]).

Table 3. Frequency and distribution of orthodontic anomalies in children with dyslalia who, in addition to one orthodontic anomaly, also have other anomalies of the oral structures, by gender and total

Orthodontic anomalies	Otheranomalies of the oral structures	Male			Female			Total	
		(n)	[1]	[2]	(n)	[1]	[2]	(n)	[3]
		7	**77.8%**		**2**	**22.2 %**		**9**	
Sagittal occlusion anomalies		**3**	**75.0%**	**42.9 %**	**1**	**25.0 %**	**50.0 %**	**4**	**44.4 %**
Angle Class II, Division 1 Malocclusion (Protrusion)	'Gothic' palate (High-arched palate)	1	100.0 %	14.3 %				**1**	**11.1 %**
Underbite	Short lingual frenulum	2	66.7%	28.6 %	1	33.3 %	50.0 %	**3**	**33.3 %**
Verticalocclusion anomalies		**2**	**100.0 %**	**28.6 %**				**2**	**22.2 %**
Open bite	Short lingual frenulum	1	100.0 %	14.3 %				**1**	**11.1 %**
Deep bite	Short lingual frenulum	1	100.0 %	14.3 %				**1**	**11.1 %**
Anomalies in the dental arches		**2**	**66.7%**	**28.6 %**	**1**	**33.3 %**	**50.0 %**	**3**	**33.3 %**
Spacing in the dental arches	Short lingual frenulum	2	66.7%	28.6 %	1	33.3 %	50.0 %	**3**	**33.3 %**

[1] – distribution of orthodontic anomalies and anomalies of the oral structures between male and female children
[2] – distribution of orthodontic anomalies and anomalies of the oral structures within the gender group
[3] – distribution of orthodontic anomalies and anomalies of the oral structures in the total sample(n=9)

b) Children with dyslalia, orthodontic anomaly and other anomalies of the oral structures

In cases, where in addition to one orthodontic anomaly there are also other anomalies of the oral structures (n=9), and in relation to orthodontic anomalies by group (Table 3), sagittal occlusion anomalies (44.4%; n=4), anomalies in the dental arches (33.3%; n=3)and vertical occlusion anomalies (22.2%; n=2) were most often registered, while the most common anomalies of the oral structures is a short lingual frenulum (89%; n=8), and one case of 'Gothic' palate.

Regarding the distribution of orthodontic anomalies within gender groups, 42.9% of males have sagittal occlusion anomalies, followed by males with vertical occlusion anomalies and anomalies of the dental arches with equal participation (28.6%) (Table 3, Males - column [2]). In female children, sagittal occlusion anomalies and anomalies in the dental arches are equally represented (Table 3, Females - column [2]).

c) Children with dyslalia and two orthodontic anomalies

Two orthodontic anomalies, at the same time, were registered in only one case of a male child, and it is a vertical occlusion anomaly (deep bite) and a teeth shapeanomaly (fusion).

Discussion

Several studies try to show the relationship between dyslalia and some changes in the stomatognathic system.There are different viewpoints and approaches to researching the relationship between dyslalia and orthodontic anomalies, all unique in their own way.In our research, the main goal was to determine the frequency and distribution of orthodontic anomalies in female and male children at the age of 6, who have already been diagnosed with dyslalia, in order to get a clearer picture of the possible influence of orthodontic anomalies on the proper articulation.The review of the literature, i.e. researches by other authors and the results obtained in our research, partially coincided in certain aspects, while in others they were different.

According to the results of our research, on the total sample of data relating to 6-year-old children with dyslalia (n=586), it was determined that 15% of the children (n=88) have orthodontic anomalies of the teeth and jaws.Karevska and Trajkovski 10, who conducted a research on the etiological factors that lead to speech disorders, with an orthodontic examinationdetermining that in their experimental group, which consisted of subjects with speech disorders, 60.4% had a pathological orthodontic finding.10This result is not in accordance with the result of our research, but it must be taken into account that Karevska and Trajkovski10 analyzed respondents from a wide age group, between the ages of 3 and 73, while in our research, all the respondents were 6-year-olds.Farronato et al. 8who conducted the study, which included children aged 6 to 10 years,regarding the connection between malocclusions and dyslalia, determined that only 1/6 of children with dyslalia (n=351) do not have malocclusion at the same time. These results are different from those in our research, with a note that children of a different age group were examined, and that the examinations were conducted in the department of orthodontics and the department of speech rehabilitation in the same hospital.The data from our research were obtained from diagnostic orthodontic-speech examinations carried out at the Public Health Institution"Center for Rehabilitation of Verbal Communication Pathology – Skopje", which is visited by patients with speech disorders, so perhaps this is the reason for the small percentage of established orthodontic anomalies in children diagnosed with dyslalia.The results of the study by Vranić and Hunski 11, conducted at the SUVAG Center in Zagreb (Republic of Croatia), on a sample of 51 children aged 6 to 8 years with a diagnosis of dyslalia, showed that 64.6% of them had orthodontic anomalies. Although the respondents are of a similar age group to that of our research, it is notable that there is a large difference in the frequency of orthodontic anomalies. However, it can be pointed out that our research includes ten times more data on respondents with dyslalia (n=586) than the research by Vranić and Hunski (n=51).

In their research, Vranić and Hunski11 also covered the aspect of the gender structure of children diagnosed with dyslalia and orthodontic anomalies, and their results show that orthodontic anomalies are more common in male respondents with articulation disorders.These results are in contrast to the results obtained in our study where 13.1% of male children and 18.8% of female children diagnosed with dyslalia had some orthodontic anomaly. However, it must be pointed out that in our research, statistical analysis confirmed the difference in the distribution of children with and without orthodontic anomalies between male and female children with dyslaliaas non-significant (p=0.069).

Regarding whether children with dyslalia have only one orthodontic anomaly or two, or whether they have an orthodontic anomaly together with other anomalies of the oral structures, the possibilities for making a comparison with the same or similar research by other authors were limited.The results of our research showed that in children with a diagnosis of dyslalia and an established orthodontic anomaly (n=88), the orthodontic anomaly is mostly isolated, independent (88.6%), then together with other anomalies of the oral structures (10.2%), and only one child registered two orthodontic anomalies at the same time. In their research,Farronato et al. 8 came to the conclusion that children with dyslalia with three or more forms of malocclusion are found much more often than those with two or only one form of malocclusion.

If we look at the orthodontic anomalies in children with dyslalia (n=88), by groups of orthodonticanomalies, the results of our research show that most often it is about sagittal occlusion anomalies (50%) (protrusion was most often registered within the group), followed by vertical occlusion anomalies (26.1%) (an open bite was most often registered within the group), anomalies in the dental arches (19.3%) (crowding in the dental arches was most often registered –mandibular crowding)and anomaliesin the number of teeth (2.3%).One case with anomalies in the position of individual teeth and anomalies of teeth shape was registered.Transversal occlusion anomalies were not registered. In the previous results, it was possible to make a partial comparison with the results and conclusions of other authors' research.What was notable in other authors' results is that open bite is the most frequently mentioned key orthodontic anomaly leading to speech disorders. Namely, according to Leavy, Cisneros and LeBlanc [12], who conducted a study on 150 patients, an open bite (.2 mm) was the key malocclusal factor underlying speech sound errors. The authors concluded that an open bite was the occlusal trait having the most potential to negatively impact sound production. According to the research by Didem, Neşe and Tülin 6the most consistently reported traits between the malocclusion and speech defects are anterior openbite, increased overjet and overbite, and maxillary spacing.Also Sahad et al.13found a significant relationship between open bite, anterior lisping, and/or tongue thrust during the articulation of the alveolars/t/,/d/,/n/, and/l/.On the other hand, according to Stojković and Anđelski 3, the orthodontic anomalies that most often lead to articulation disorders are the anomalies of the bite, which include protrusion, progenia, crossbite, open bite and cleft lip and palate. Farronato et al.8reported a correlation between Class III occlusion, diastema,increase in overjet, open and deep bite, and articulation disorders.

For the sake of greater relevance of the results, it is possible to include and determine the state of the dentition (primary or mixed dentition), dental anomalies (caries, tartar, etc.), other harmful habits (for example nail biting, thumb sucking, etc.), wearing an orthodontic appliance, history of orthodontic treatment in future research. In addition, it can be investigated and studied more deeply and in detail, i.e. to determine a specific connection of an articulation disorder of a certain speech sound (for example sound /s/, /r/, /l/, etc.) with orthodontic anomalies.

Conclusions

AThe findings obtained from the research can serve for better planning and implementation of diagnostic-rehabilitation activities in relation to orthodontic anomalies and the formation of speech sounds, with the ultimate goal of enabling, foras many children as possible, conditions for the formation of clear and distinct speech sounds.The findings show that timely and comprehensive diagnosis of children's articulation disorders and other anomalies in the orofacial region can be of crucial importance for one of the most important human functions - speech. At the same time, the importance of a multidisciplinary approach in the diagnosis and rehabilitation of speech disorders in children is evident. There is general consensus on the need for a combined approach involving different specialists, such as speech therapists and orthodontists.

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EXTRACTION OF MAXILLARY IMPACTED CANINE USING PIEZOSURGERY - CASE REPORT

ЕКСТРАКЦИЈА НА ИМПАКТИРАНИ МАКСИЛАРНИ КАНИНИ СО ПОМОШ НА ПИЕЗОХИРУРГИЈА - ПРИКАЗ НА СЛУЧАЈ

Gigovska Arsova A.[1], Peeva Petreska M.[1,2], Veleska Stevkovska D.[1,2], Janev E.[1,2], Petrova E.[3,4]

[1]Oral Surgery and Implantology Clinic, University Dental Clinical Centre "St. Pantelejmon" Skopje, Republic of North Macedonia, [2]Department of implantology, Faculty of Dentistry - Skopje, University Ss.Cyril and Methodius, Republic of North Macedonia, [3]Orthodontics Clinic, University Dental Clinical Centre "St. Pantelejmon" Skopje, Republic of North Macedonia, [4]Department of Orthodontics, International Balkan University, Skopje, Republic of North Macedonia,

Abstract

Aim: The aim of this study is to present a piezosurgery-assisted extraction of an impacted canine, evaluating advantages and dissadvantages compared to osteotomy with conventional rotatory instruments. **Material and Method:** A 14 year-old female visited the University Clinic for Oral Surgery and Implantology complaining for absence of the right maxillary canine, fully asymptomatic. CBCT scan revealed impacted maxillary right canine, Class III by Archer. Due to the unfavorable position and curved root, orthodontic traction treatment was considered as contraindicated, therefore we proceeded with a tooth removal using piezo surgical device. **Results:** Piezosurgery showed less damaging of adjacent soft tissue and less heating during the procedure, shortened post-operative period and patient discomfort, as well as lower inflammatory response measured according to pre-determined criteria. **Conclusion:** Taking into account most of the resulting advantages over disadvantages of using the piezo approach for extraction of impacted canines, we can recommend this method with full confidence and highly predictable outcome. **Keywords:** impacted canine, piezo surgery, tooth extraction.

Апстракт

Цел: Целта е да се прикаже екстракција на импактиран канин со помош на пиезохирургија евалуирајќи ги предностите и недостатоците во споредба со остеотомијата со конвенционални ротациони инструменти. **Материјал и метод:** 14-годишна пациентка ја посети Универзитетската клиника за орална хирургија и имплантологија со поплака за отсуство на десниот максиларен канин, целосно асимптоматски. CBCT-скенот потврди импактиран максиларен десен канин, класа III според Арчер. Поради неповолната положба и закривениот корен, ортодонтскиот третман со влечење беше оценет како контраиндициран, со индикација за екстракција на забот со помош на пиезохируршки апарат. **Резултати:** Пиезохирургијата покажа помало оштетување на соседното меко ткиво и помало загревање на коската за време на процедурата, скратен и полесен постоперативен период кај пациентот, како и помал инфламаторен одговор измерен според однапред одредени критериуми. **Заклучок:** Земајќи ги предвид предностите во однос на недостатоците од користењето на пиезо пристапот за екстракција на импактирани канини, можеме да го препорачаме овој метод со целосна доверба и високо предвидливи резултати. **Клучни зборови:** импактиран канин, пиезохирургија, екстракција на заб.

Introduction

Impacted tooth is defined as a tooth which doesn`t erupt in the dental arch within the expected age. The impacted tooth fails to pass through the gum line to grow into the right position and instead remains stuck or impacted in the gum tissue or bone. After third molars, the maxillary canine is the second most frequently impacted tooth with an incidence of 0.92-1.7%[1]. Any tooth can be impacted, but this is most frequently the case with mandibular third molars, maxillary canines, mandibular and maxillary second premolars, and maxillary central incisors, as well as supernumerary teeth[2]. The etiology of tooth impactions is often complex and has been related to disproportions between arch length and mesiodistal dimension of all teeth. There are hereditary factors leading to impaction, but also etiologic factors such as prolonged retention of primary teeth, localized pathologic lesions, and shortening of the length of the arch[2].

According to Bishara et al.[3], there are several reasons for impaction of maxillary canines: 1. primary causes: rate of root resorption of deciduous teeth; trauma of the deciduous tooth bud; disturbances in tooth eruption sequence; availability of space in the arch; rotation of tooth buds; premature root closure; canine eruption into the cleft area in persons with cleft palate; and 2. secondary causes: abnormal muscle pressure; febrile diseases; endocrine disturbances; vitamin D deficiency. In cases where there is a discrepancy between tooth size and arch length, the teeth that erupt later can be diverted or remain impacted. Maxillary canines have a longer eruption path to its correct position in the arch, and since the lateral incisor and permanent first premolar have already erupted and fill the space for the upper canine, it can remain impacted. This is due to the length of the development period and the fact that the germ of the maxillary canine is placed deepest in the bone compared to the other teeth, as well as the fact that it has the longest path of emergence between all teeth[4]. Radicular cysts of the deciduous teeth, infection, trauma at an early age, are factors that can cause dental deviation that can lead to impaction[5]. Although arch-length deficiency is known to be common etiologic factor for impaction of canines, this is not valid for palatal impactions. Rodrigues et al.[5] state that when there is less space, vestibular impaction is expected, but palatal positioned canines are usually a result of path abnormalities.

Potential complications of canine impactions are malposition of the impacted tooth, migration of the neighbouring teeth and loss of arch length, internal resorption, dentigerous cyst formation, external root resorption of the impacted tooth, as well as the neighbouring teeth, infection particularly with partial eruption, pain, as well as aesthetic problems[6].

Ideal treatment of maxillary impacted canines is its prevention. However, in cases where it is not possible, orthodontic treatment followed by surgical exposure of the canine to bring it into occlusion is preferable. After surgical exposure, the impacted canine can be allowed to erupt naturally, or orthodontic forces can be applied to move the tooth[7]. Sometimes, when treatment options are unpredictable or contraindicated, a surgical extraction of an impacted tooth is a method of choice.

Surgical treatment of an impacted maxillary canine requires removing the bone and, in many cases, odontosection as well, and these techniques may damage the surrounding tissue. In order to minimize the risks of intraoperative and postoperative complications, piezosurgery can be used.

The piezoelectric surgery is an atraumatic and revolutionary osteotomy technique which, compared to conventional surgery, offers precise and extremely selective cut, a great visibility and, most important, it is inert and doesn't damage the surrounding soft tissues. Its biggest disadvantage is the longer surgical time, even though this tends to decrease as the surgeon gains experience.

The piezosurgery device with frequency of 25-30 kHz, the created micromovements with an amplitude of 60-210 µm, and the 5W power of the handpiece allow the removal of mineralized tissue only. It is inert to soft tissue, because a frequency above 50 kHz is required to work on the soft tissues[8]. The piezo surgical extension vibrates in the range 60-210 µm which is equal to a force of 45W, thus enabling effective bone cutting with the surgical handpiece and the drill.

Aim

The aim of this study is to present a piezosurgery-assisted extraction of an impacted canine, evaluating the advantages and disadvantages compared to osteotomy with conventional rotatory instruments.

Case report

A 14 year-old female visited the University Clinic for oral surgery and implantology complaining of absence of the right maxillary canine, fully asymptomatic. CBCT scan revealed impacted maxillary right canine, Class III by Archer.

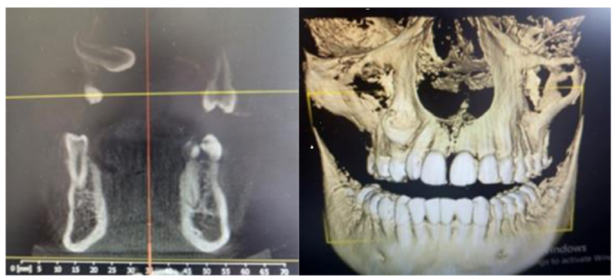

Figure 1. *Position of the impacted right maxillary canine*

The impacted canine was positioned horizontally in the alveolar processus of the maxilla between the roots of the upper lateral incisor and first premolar, with the root placed

Figure 2. *Position of the impacted right maxillary canine*

buccally, and the crown was placed palatally, and it also had a 90 degree curvature of the root (Figure 1. and Figure 2.).

Due to the unfavourable position and the curved root, in consultation with an orthodontist, orthodontic traction treatment was considered as contraindicated, so we proceeded with a tooth removal using piezo surgical device. The patient had no other symptoms and was classified as ASA I. The patient underwent surgery under local anaesthesia (mepivacaine hydrochloride 3%). The buccal and palatal as well the flaps with full thickness (mucoperiosteal) were detached, and partial visualisation of the impacted canine was allowed. We proceeded with piezosurgical osteotomy of the surrounding bone with piezosurgical device Woodpecker surgic Touch LED (Figure 3.), Guilin Woodpecker Medical Instruments Co. Ltd, Guilin, Guangxi, P.R. China and then odontosection, after which the root was extracted from the buccal side, and the crown from the palatal.

Figure 3. *Piezosurgical device*

After tooth extraction, curettage and irrigation, both flaps were sutured using non absorbable suture threads (silk 3-0) (Figure 4. and Figure 5.). The patient received instructions regarding the post-operative care and was prescribed antibiotics (amoxicillin + clavulanic acid 875/125mg every 12 hours for 7 days).

Figure 4. *Extraction of the impacted maxillary right canine*

Figure 5. *Sutures in place*

The patient reported mild pain, no oedema or infection.

Discussion

When selecting a proper treatment plan for impacted maxillary canines, oral surgeons, together with an orthodontist, should take into account several factors in order to appropriately manage each case. When the impaction is very deep in the bone, when the root is completely formed, as well as when there is angulation (root dilaceration) present, too little space in the dental arch, unfavourable position of the canine between the roots of the central and lateral incisor, or if the orthodontist estimates that the neighbouring teeth will be damaged by the orthodontic movement of the canine, then, orthodontic traction is contraindicated[9]. If the orthodontic traction is found to be impossible or unpredictable depending on the angulation of the tooth, another method is autotransplant. This procedure depends on the degree of tooth development and is more effective in cases where the impacted tooth has an incompletely developed root (rhizogenesis). Also, the tooth that needs to be extracted and transplanted in the right position in the dental arch has to be whole. Very extensive osteotomy is necessary for full extraction of the impacted tooth and its placement, which will compromise the neighbouring vital tissue. This was not possible in this case and these options were not taken into account[5].

Surgical extraction was performed as a prophylactic measure against the formation of pathologic structures, as well as for the future orthodontic treatment of the patient to be accomplished successfully. When dealing with impacted teeth, osteotomy and odontosection are required and they can damage the surrounding tissue. The low pressure that is applied when using piezosurgery allows precise and selective cut of the bone only and it does not damage the surrounding soft tissue[10].

Trauma is minimal with piezosurgical osteotomy compared to conventional osteotomy performed with rotatory instruments and burrs which causes more trauma because of the applied pressure and heating to the bone and soft tissues[11].

Conclusions

Impacted maxillary canine extraction had good clinical outcome, with no intraoperative or post-operative complications. Piezosurgical osteotomy minimized the trauma of the hard and soft tissues, and this approach proved to be the most efficient.

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SCREW RETAINED VS. CEMENTED RETAINED FIXED PROSTHODONTIC CROWNS AND BRIDGES OVER DENTAL IMPLANTS - LITERATURE REVIEW

ЗАШРАФЕНИ НАСПРОТИ ЦЕМЕНТИРАНИ ФИКСНИ КОРОНКИ И МОСТОВИ НАД ЗАБНИ ИМПЛАНТИ - ЛИТЕРАТУРЕН ПРЕГЛЕД

Fetahu B.[1], Elencevski S.[2]

[1]Dental Clinic "BF", Fushë Kosovë, R. Kosova, [2]Department of Dental Prosthetics, Faculty of Dentistry – Skopje, Ss. Cyril and Methodius University in Skopje, Republic of North Macedonia

Abstract

Aim of the study: To determine the similarities, differences, advantages and disadvantages between the two different techniques of restorations over dental implants. **Material and methods:** Published articles in different journals were reviewed: Pub Med / MEDLINE; "Scopus", "Web of Science", "Google Scholar", "Science Direct", "Research Gate" etc. In this retrospective study, collecting of the literature was done by searching the key words: screw retained, cemented retained, FDP, dental implants etc. **Results:** These types of restorations are both methods of restorations over dental implants, but neither one of them is a definitive answer to all cases of restorations. As in almost all of the time in medicine, there is no one-size-fits-all rule for each case. **Conclusions:** Both techniques are similar in restoring the problem over dental implants but are very different in the way they do that. Determining factor in deciding which of the techniques will be used is the interaction between the technical factor and the clinical case. **Key words:** Screw Retained, Cemented Retained, Dental Implants, Prosthodontic.

Апстракт

Цел на трудот: Да се утврдат сличностите, разликите, предностите и недостатоците помеѓу двете различни техники на реставрација над забните импланти. **Материјал и метод:** Прегледани беа објавени статии во различни списанија: Pub Med / MEDLINE; „Scopus", „Web of Science", „Google Scholar", „Science Direct", „Research Gate" и др. **Резултати:** Овие типови реставрации се двете методи за изработки на надоместоци над импланти, но ниеден од нив не представува идеално решение кај сите случаи на реставрации. Како и за се во медицината, не постои едно единствено решение за сите случаи. **Заклучок:** Двете техники се слични во решението кај надоместоците над импланти, но многу различни во начинот на изведувањето. Детерминирачкиот фактор за избор на техниката која би се користела е поврзаноста помеѓу техничкиот фактор и самиот клинички случај. **Клучни зборови:** зашрафени, цементирани, дентални импланти, протетика.

Introduction

Implants placed during the development era had high failure rates and as a consequence, easy and frequent removal of the prostheses was of paramount importance[1-3]. Screw retention in implant-supported prostheses was developed in response to the need for retrievability even though occlusion and aesthetics were sacrificed. As knowledge increased and techniques advanced, implant survival rates moved rapidly from 50% to 90% success[1-5].

With this dramatic increase in survival rates, the issue of retrievability has not been as clinically significant. However, the use of screw retention, with all of its disadvantages, still remains the retention mechanism of choice for many practitioners, which can be seen by the product lines of implant manufacturers. Many practitioners do not consider cement retention an option in implant-supported restorations because they believe that cemented restorations are not retrievable[6]. Cement, when used appropriately, can retain implant supported prostheses[7].

The process of choosing between screw retained and cemented retained is a long debate. Clinical studies and literature review tried to answer the question "Which of the solutions will provide best long-term stability, retrievability, retention and all the other factors?", but in time, the screw retained restorations were favoured.

Most of the authors agree that there is no definitive answer for all the clinical cases and the advantages and disadvantages should be taken into account before choosing one option or the other. Both types of restorations have their limitations, but if executed correctly both of them should be giving correct and predictable results.

Fixed partial dentures (FDP) present a very good treatment option for patients with single or multiple teeth loss[8]. This predictable and good option has had exponential growth and usage due to the osseointegration process of the implants, refined surgical techniques, clean implant surfaces and accurate fit of the implant abutments. These days, the main focus is on manufacturing of the individual abutments via digital methods[9].

In a retrospective analysis, the number of cases treated, that are related to a cemented manner or screw retained, can be easily identified.

A careful analysis identified the trend of cases with the advantages and disadvantages of one technique or the other.

The evaluation of majority of the authors was leaning towards the advantages and disadvantages, and in making comparisons in relation to the factors that affect results and the final success [9,10].

Aim of the study: To determine the similarities, differences, advantages and disadvantages between the two different techniques of restorations over dental implants.

Material and methods

In order to achieve our goal of best possible literature review, our search focused on collecting literature from: Pub Med / MEDLINE, "Scopus", "Web of Science", "Google Scholar", "Science Direct", "Research Gate" etc. Similar platforms include a huge number of scientific articles and different medical journals.

In this retrospective study, collecting of the literature was done by searching the key words: screw retained, cemented retained, FDP, dental implants etc.

Based on these key words, 95 abstracts were identified. The first selective method has the possibility of selecting corresponding articles with interest in quality for our study. Duplicate articles were removed from the process of analytic review. Comparison method was used for two different FDP techniques.

Results and discussion

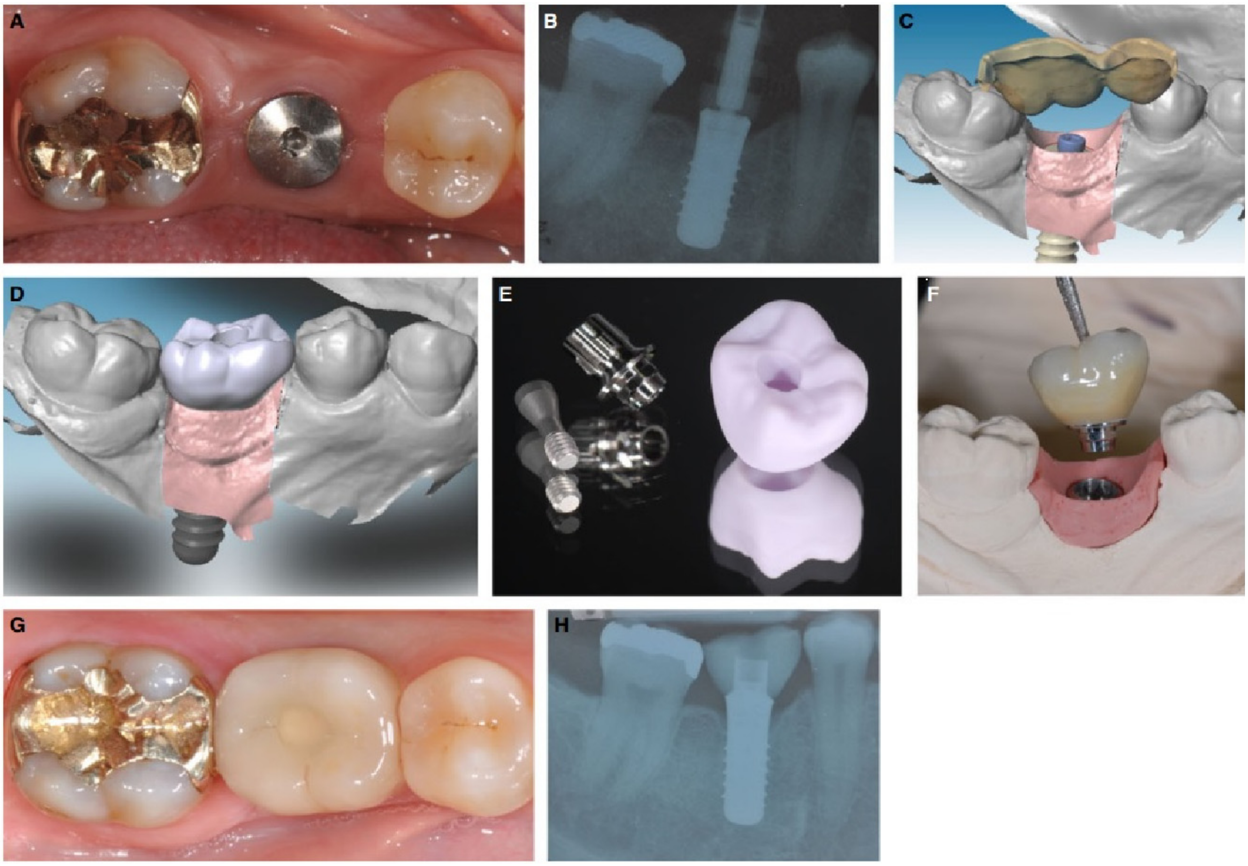
Long-span prostheses should preferably be screw retained for easier maintenance – it has been discussed in the literature that long-span restorations have a higher risk of complications. However, if the implant is not placed in a prosthetically ideal position – with the future access hole of the planned crown below the planned incisal edge position – cement retention is often the only treatment option. Therefore, proper treatment planning and prosthetically-driven implant placement should be mandatory for implant therapy[11].

A major disadvantage of cement retention is the difficulty of removing excess cement, which has been associated with the development of peri-implant diseases such as peri-implant mucositis and peri-implantitis. Consequently, this adds an additional risk factor to the overall treatment[11]. Screw retained implant-supported prostheses were initially used when implants were invented, especially supporting full-arch prostheses for edentulous patients with the 'ad modem Branemark' protocol. The invention of the UCLA (The UCLA Abutment is a castable abutment offered with a machined gold alloy base or in a fully castable version) gold custom abutment in 1988 allowed an easier workflow for screw retention, as it permitted the retention of a prosthesis directly on or inside the implant without the use of a transmucosal abutment[11]. However, the reconstruction was cost-intensive, and according to Taylor et al.[12] & Agar et al.[13] classic publication on 'implant prosthodontics' in 2002, screw retained restoration involved nearly four times the component cost of cemented restoration. With the evolution of prosthetic components' designs and digital workflow, the costs have decreased in the meantime.

A combined approach with an individualized abutment that is bonded to a prefabricated titanium or zirconium dioxide base offers a cost-efficient solution; however, this abutment type lacks long-term documentation. A case with the use of his abutment is illustrated in Fig. below. Cementation can be achieved with provisional or definitive cement. Provisional cementation allows retrievability to a certain extent, while the risk for leakage and loss of retention may be higher compared with definitive cementation. In order to maintain retention during its use, basic mechanical parameters are crucial: these factors include height, diameter, conicity, indexing, surface roughness of the abutments, number of abutments related to number of teeth to be replaced, alignment of abutments in the dental arch, straight or angled configuration, and the presence of extensions.

1. Aesthetics

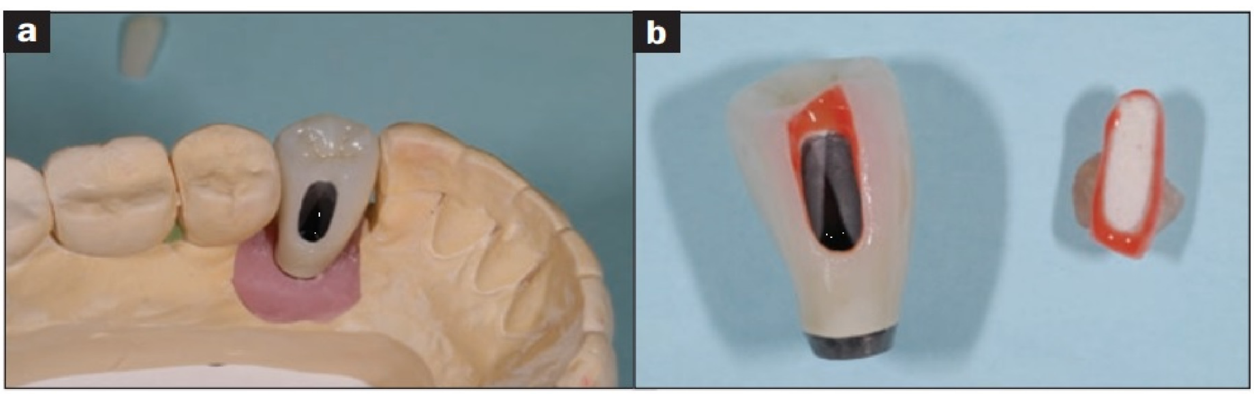
When the implant is placed in the ideal position, predictable aesthetics can be achieved with either screw- or cement-retained restorations[14]. One of the debates regarding using screw retained restorations is the screw access



Picture 1.

channel that may be placed in an aesthetic area. When there is difficulty in placing the implant in an ideal position for any anatomic limitation, the pre-angled or custom abutments can be used so that the screw access channel is relocated away from aesthetic area. The use of an opaquer in combination with a resilient composite offered a significant aesthetic improvement of implant restoration [15].

With patients demanding more aesthetic restorations today, clinicians are continually seeking the most biomimetic techniques or materials. It is well documented in literature that clinicians believe cement retained restorations are more aesthetic[16]. This thought arises solely from the lack of a visible screw access hole. However, selecting a cement retained restoration exclusively based on aesthetic outcome is unfounded; the aesthetic outcome



Picture 2.

has little to do with the method of retention to the implant. Rather, aesthetics is multifactorial and depends on patient selection, tissue volume, tissue type, and implant position. The trajectory of the implant will only determine the type of retention method, whether it be cement or screw retained. For anterior restorations, the use of pre angled abutments, angulated screw channels (ASCs), or dynamic abutments can redirect a screw access opening to the cingulum area where it is not visible. For posterior restorations, several aesthetic techniques exist to blend the screw access hole with the restoration, utilizing a silicone plug and resin opaque or a pressed ceramic plug[2]. Cement-retained restorations offer easier access to the posterior of the mouth, especially in patients with limited jaw opening. In addition to the difficulty of access, the use of screw-retained restorations in the posterior part of the mouth may carry a risk of swallowing or aspirating the screw or screwdriver.

2. Occlusion

Hebel and Gajjar[17] stated that the size of the occlusal access is determined by the retaining screw diameter which, for larger implants (for example, in the posterior regions of the mouth) obliterate a large portion of the occlusal table. In addition, the screw access hole is often in the central fossa of the crown where centric contact should be. Since the access hole can often involve up to 50% – 60% of the occlusal table, Vigolo et al.[18,19] argued that the opposing occlusion is usually developed with the head of a retaining screw or on composite restorative material instead in the screw hole. Jivraj[3] and Chee[20] stated that the importance of building opposing contacts on the restoration itself versus the screw access filling material. In their opinion, no untoward wear or instability to the occlusal contacts occurs, provided that the screw access filling material is not needed to maintain the occlusion. The major argument against using screw-retained restorations is dealing with the screw access hole. Another technique is to fabricate a porcelain plug and the porcelain used on the restoration can be etched easily with hydrofluoric acid, and then silane should be applied. This allows for resin bonding of the 2 surfaces. Colours are easy to match and resin options are available to provide an indiscernible margin. This technique is similar to the one used with porcelain veneers on natural teeth.

This can be also seen clinically, as reported in a study by Nissan et al.[11] where 221 implants were followed for over 15 years; ceramic fracture occurred at a statistically significantly higher rate in screw retained (38%) than in cement retained (4%) metal ceramic restorations. Utilization of a screw access channel modifies the position of the center of mass of the ceramic bulk, and occlusal forces must be redirected to the peripheries of the occlusal table. The result is often local failure of the metal ceramic bond and detachment of the porcelain. Interestingly, Sailer et al.[21] performed a systematic review of 59 clinical studies and found that chipping of the veneering ceramic tended to occur more frequently with the screw retained restorations for single crowns. Yet, for full arch restorations, ceramic chipping was observed more frequently with cement retained prostheses. This led others to question whether the screw access channel is the primary cause for weakened porcelain and increased fracture incidence. In their 10 year randomized controlled trial, Vigolo et al.[18,19] reported a lack of prosthetic complications related to porcelain fracture in their screw retained metal ceramic restorations. Although only a small sample size of thirty implants was used, they ensured accurate evaluation of the occlusal scheme and provided appropriate variations to the occlusal contacts (both static and dynamic) to reduce technical failure rates. Similar results have been found in a recent in vitro

Picture 3.

study using newer materials (zirconia and lithium disilicate). The researchers found no significant differences in fracture rates between the crowns with or without an occlusal screw access channel.

3. Interocclusal space and retention

There are several factors that affect the retention of cement-retained restorations such as taper of abutment, surface area and height, surface roughness, and type of cement[15].

Taper greatly affects the amount of retention in cement-retained restorations. Regarding surface area and height, the subgingival placement of the implants provides longer implant abutment walls and usually a larger surface area than prepared natural teeth[15]. The minimum abutment height for using cement-retained restorations with predictable retention was documented to be 5 mm[15]. Therefore, when the interocclusal space is as little as 4 mm, screw retained restorations may be used, since these restorations can be attached directly to implants without intermediate abutment. Increased surface roughness will offer increased mechanical retention for cements, therefore, roughening the implant abutments using diamond burs or grit blasting will provide higher retention. However, because of the ideal taper and long surface provided by implant abutments, there will usually be no need for roughening the abutment surface to increase retention.

Cement application techniques appear to be used arbitrarily with little understanding by clinicians regarding how or where to apply the cement. Many studies report phrases such as "the cement was loaded into the crown," but advice is not given as to how this procedure was performed. In addition, protocols for the amount of cement that should be used are lacking. Wadhwani et al.[22] found that for the same crown form to be cemented, clinicians used cement weights ranging from 3.2 mg to 506.4 mg. A formula was created to determine the actual amount of cement needed (assuming 40 µm cement space) and was calculated to be 13.6 mg, or 3% of the crown's total volume. Clearly, some crowns were underfilled and many were overfilled resulting in cement extrusion. To prevent extrusion into sulcular peri implant tissues, Wadhwani[22] suggests performing a pre-extrusion step extraorally before cementing. Excess cement is removed extraorally from the crown using a custom copy abutment, then cemented intraorally. Using a computational fluid dynamics model, Wadhwani et al.[22] were able to demonstrate that the ideal location to place cement was a small bead circumferentially around the crown margin for ideal cement coverage. Other techniques (circumferential placement at the occlusal third, brush on application, and gross fill) demonstrated inferior results in comparison. They also found that seating the crown slowly was more ideal as rapid seating would cause too rapid a flow due to the shear thinning properties of the cement and leave an incomplete sealing of the margin. Abutment modification with internal vent holes resulted in less air trapping and less cement extrusion.

4. Provisionalization and gingival molding

Jivraj and Chee[3,20] reported that a screw retained provisional restoration can be used with ease to incrementally expand the peri implant tissues until fully seated. In addition, following implant surgeries where the provisional restoration is to be placed immediately, a screw retained option is the preferred method; it is difficult to manage the bleeding and to cement a restoration in a clean environment for ideal tissue health. Another advantage of a screw retained provisional restoration is that it can be used as a pick up type impression coping.

A soft tissue cast is poured around the exposed provisional after an impression coping is attached, yielding a soft tissue cast identical to the soft tissue form intraorally. This provides the laboratory with a model of an exact replica of the emergence profile that should be transferred to the definitive restoration.

5. Passivity

In a screw retained prosthesis, torque that is applied to a screw forces the mating screw threads together until the shaft of the screw begins to elongate[23]. This produces a clamping force within the system known as preload. Not all torque that is applied to the screw is converted into preload. Slight discrepancies between the two mating components will create frictional and misfit resistance within the screw. The screw bends and deforms to compensate for the strain at the interface and results in a lower clamping force. Ultimately, a lower clamping force will occur, leading to future screw loosening or fatigue fracture. Passivity refers to a state of existing without resistance, and when applied to implant prosthetics, it translates into a lack of any misfit forces being generated within the prosthetic system[24]. It is technically very difficult to achieve a completely passive framework in a screw retained prosthesis.

In the cemented version, individual abutments are screwed onto the implants and the superstructure is cemented overtop. The cement layer (typically about 40 µm) compensates for unintended dimensional discrepancies between the abutment and the restoration, successfully acting as a buffer space[2].

Most of the frameworks being used currently may not be totally passive, yet are functioning normally. Passivity is listed as an advantage of a cement retained prosthesis.

In a systematic review that evaluated the 5 year survival rates of screw retained implant supported single crowns, abutment screw loosening was reported at 12.7%. Other studies have shown similar screw loosening rates of 5.8% and 6.7%.

Screw fractures appear to be less common in screw retained prostheses occurring at 1.5% in one study, and 3.9% in another study by Sailer et al.[21]. It has been observed that screw fractures occur primarily at the first occlusal screw thread.

Freitas et al.[25] proposed that the failure occurs in this region because bending forces are concentrated the most at this level of the screw. Screw retightening has been reported to be necessary, especially within the 1st year of functional loading. The goal is to re-establish the optimum preload stress on the abutment screw to counter the possibility of screw loosening. This should be performed with caution as Yilmaz et al.[26] found that second torques applied to the screws can rotationally displace abutments as much as 9 µm. A rotation >5° can cause a reduction of 63% in screw joint stability. If a patient has a loosened abutment screw, Assenza et al.[27] stress the importance of replacing the screw entirely instead of simply retightening the existing one. The old screw has most likely undergone deformation changes due to misfit stress and a re torqued screw may experience fatigue fracture if the same preload stress is applied. The majority of technical failures in the past were blamed on the inaccuracy of the fitting components which allowed for micro movement. With the introduction of more precise abutments and screws which improved the abutment to implant ratio, fewer technical complications are being seen with both screw and cement retained crowns.

In fact, a recent systematic review reports that they found no statistically significant difference between cement and screw retained restorations for technical outcomes.

6. Biological complications

In natural teeth, the barrier of collagen limits bacterial ingress and can damage from physical trauma[2]. The arrangement of the fibres results in compartmentalization that localizes diseases and limits their spreading[28]. Implants do not have inserting Sharpey's fibres, instead, they have circumferential fibres that sling around the implant and attach through hemidesmosomes (a weak attachment mechanism)[29]. This creates a single "compartment" so any disease will affect the entire implant. Bacterial infection is a major factor leading to bone loss and implant failure in healthy individuals. Any subgingival irregularity (such as calculus or residual cement) may assist in the microbial colonization of implants and may lead to peri implant disease.

Recent studies have demonstrated that peri implant tissues around screw retained restorations have fewer biological complications. In vitro studies demonstrate that cement retained prostheses luted (coated) to titanium abutments with simulated margins have shown to leave a surprisingly large quantity of cement remnants. Clinically, Wilson[30] found an 81% correlation between excess cement left in the peri implant tissue and the occurrence of sulcular bleeding or suppuration.

Weber et al.[31] found that after 6 and 12 months of implant loading, cement retained crowns consistently demonstrated a higher degree of sulcular bleeding and plaque accumulation than screw retained crowns. When restorations are luted to the implant abutment, extruded cement has enough hydraulic pressure to tear the delicate tissues surrounding the implant instead of being deflected out. Even on smooth surface implants, Agar et al.[13] demonstrated that it was not possible to completely remove a resin cement.

Some researchers have found the opposite, more soft tissue complications around screw retained prostheses. However, the problem was associated only with screw retained single crowns that had loose abutment screws creating a micro gap. The inflammation healed soon after the retightening of the screws once the gap was closed.

7. Retrieval of cemented restorations

Retrieval of cemented implant restorations is often more difficult than the one from natural teeth[18]. Despite the use of a provisional cement, it may function more like a definitive luting agent between a metal–metal interface. If the crown must be removed due to a loosened abutment screw, any force applied to the restoration on a loosened abutment has the potential for damaging the internal threads of the implant and it often becomes safer to simply cut off the crown[32].

Several techniques have been proposed to increase the ease of retrievability of cement retained implant crowns.

- A lingual access channel extending through the crown and into the abutment near the cervical crown abutment interface is made. The crown is then cemented and the channel is filled with resin to serve as a locking mechanism. If the removal is warranted, the resin is simply removed and an ultrasonic device or crown remover is used to lift the crown[33].
- A drilling template can be fabricated based on an angulation analysis from a radiograph as a way to more accurately locate the screw access hole[34].
- Unique surface stains can be applied on the occlusal surface at the location of the screw access channel to identify its location[35].

- Finally, a combination implant crown utilizes principles from both a screw and cement retained prosthesis. The definitive crown is cemented to the abutment extraorally where excess is easily removed. Then, the cemented unit can be screwed onto the implant intraorally through a screw access channel which is later closed with composite resin[36].

In spite of all the proposed techniques for improving the retrievability of cement-retained restorations, screw retention becomes more necessary in extensive cases where prosthesis needs more maintenance, so cantilevered prostheses and full arch implant reconstruction are best restored with screw retention.

Conclusions

After careful studying of the collected literature, we reached the following conclusion:

- Both techniques are different, but each one has their advantages and disadvantages.
- In the end, the decision depends on the clinicians and the case.
- The determining factor for using one or the other technique depends on the interaction of technical factors-clinical one and vice versa.

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CONTEMPORARY ASPECTS OF AUTOTRANSPLANTATION OF TEETH (WITH SPECIAL REFERENCE TO PRF-ASSISTED AUTOTRANSPLANTATION) - REVIEW ARTICLE

СОВРЕМЕНИ ПОГЛЕДИ НА АВТОТРАНСПЛАНТАЦИЈА НА ЗАБИ (СО ПОСЕБЕН ОСВРТ НА ПРФ ПОТПОМОГНАТА АВТОРАНСПЛАНТАЦИЈА) – ЛИТЕРАТУРЕН ПРЕГЛЕД

Gjurcheski J.[1], **Veleska-Stevkovska D.**[2]

[1]PHO "Lege Artis – d-r Jordan Gjurcheski" – Skopje, [2]Faculty of Dentistry – Skopje, University „Ss. Cyril and Methodius" in Skopje, Republic of North Macedonia

Abstract

Introduction. ATT is defined as surgical transposition of a tooth from its original place in the alveolar ridge, to a new place in the ridge. The tooth-donor can be erupted or impacted, vital or non-vital, with completed or uncompleted root formation. The recipient bed can be a fresh extraction socket, with or without infection, it can have all 4 bony walls, or less than 4, ATT can be finished later (after couple of weeks following extraction) or in newly formed socket (prepared bed). **Aim.**The aim of this review is to summarize the contemporary aspects of the autotransplantation of teeth, review the latest published articles, and also to review the role of PRF in the treatment plan for autotransplantation of teeth. **Material and method.** To accomplish our goalof reviewing the contemporary aspects of autotransplantation of teeth, we reviewed existing papers in the PubMed medical database as our main source as well as Web of Science, and Google Scholar search that covers wider variety of publications offering easier access to full-text documents, searching for the studies written in the last 10 years (30 analyzed articles). **Results.** A presentation and comparison of modern aspects of autotransplantation was made. **Concslusion.** Autotransplantation is a reliable treatment option in patients that need tooth replacement due to tooth loss or partial edentulism, especially in young patients where the processes of bone growth are still active and it is an accepted and predictable procedure for replacing an irreparable tooth. Following the strict criteria for patient selection and following the steps of the therapeutic protocol greatly improves the outcome of the therapyand increasesthe percent of survival and success rate of the transplanted tooth. Also, including the latest therapy modalities can make a positive impact on the therapy outcome. **Key words:** Autotransplantation, periodontal ligament, PRF, A-PRF.

Апстракт

Вовед: АТТ претставува хируршко преместување (пресадување) на заб од своето оригинално место во алвеоларниот гребен, на друго место во алвеоларниот гребен. Забот донор може да биде изникнат или импактиран, витален или авитален, со завршен или незавршен раст на корен. Местото-примател може да биде свежа екстракциона алвеола со или без присутна инфекција, може да ги има сите 4 ѕидови интактни или да недостасува некој од нив, автотрансплантацијата може да биде одложена трансплантација (после неколку недели од екстракција) или трансплантација во новоформирана алвеола (препарирано лежиште). **Цел:** Целта преку овој преглед е да ги сумираме современите аспекти на автотрансплантација на заби, да ги прегледаме најновите објавени статии, а исто така да ја разгледаме улогата на PRF во третманотсо автотрансплантација на заби. **Материјал и метод:** За да ја постигнеме нашата цел да ги разгледаме современите аспекти на автотрансплантација на заби, ги прегледавме постоечките трудови во медицинската база на податоци PubMed како наш главен извор, како и пребарувањето на WebofScience и GoogleScholar што опфаќа поширок спектар на публикации кои нудат полесен пристап до целосни текстуални документи, барајќи ги студиите напишани во последните 10 години (30 анализирани статии). **Резултати:** Направен е приказ и споредба на современите аспекти на автотрансплантација. **Заклучок.** Автотрансплантацијата е сигурна опција за третман кај пациенти на кои им е потребно надоместување на заб поради губење на заб или делумна беззабост, особено кај млади пациенти каде што растот на коските е сè уште активен и е прифатена и предвидлива процедура за замена на безнадежен заб. Следењетона строгите критериуми за избор на пациент и следењето на чекорите од терапевтскиот протокол, значително го подобруваат исходот од терапијата, и го подигнуваат процентот на преживување и стапката на успех на трансплантираниот заб. Исто така, вклучувањето на најновите модалитети на терапија може да има позитивно влијание на исходот на терапијата. **Клучни зборови:** Автотрансплантација, периодонтален лигамент, PRF, A-PRF.

Introduction

Autotransplantation of a tooth represents the surgical relocation (transplantation) of a tooth from its original place in the alveolar ridge, to another place in the alveolar ridge. Of course, this definition is not complete, so its explanations complete the picture for this procedure. The procedure is performed by avulsion (removal with minimal trauma) of the donor tooth, and moving it into an already existing or newly created alveolus (place-recipient). The donor tooth can be erupted or impacted, vital or non-vital, with completed or unfinished root growth. The recipient site can be a fresh extraction alveolus with or without infection present, it can have all 4 walls intact or one of them missing, autotransplantation can be performed as a delayed transplantation (after several weeks of extraction) or a transplantation into a newly formed alveolus (prepared bearing)[1,2].

According to Bauss et al.[3] ATT is an accepted and predictable procedure for replacing an irreparable tooth. Contrary to implants, the transplant adapts to the eruption of the surrounding teeth and developmental changes in the oral region, but it can also be orthodontically moved. It is therefore considered an ideal tooth replacement treatment for growing patients. Furthermore, given the regenerative potential of the periodontal ligament (PDL), the graft itself stimulates the regeneration of the soft tissue attachment (epithelial and connective tissue), leading to restoration of the normal alveolar ridge and preservation of the gingival architecture[3].

On the other hand, several authors give preference to other indications for ATT, emphasizing that it is a therapeutic option in cases of tooth loss due to trauma, caries, periodontal disease, endodontic problems, but also in cases of impaction or agenesis. They emphasize that, unlike implants, transplanted teeth keep their periodontium alive, thus providing the above-mentioned advantages in terms of bone and soft tissue preservation, as well as the possibility of orthodontic or physiological movement. However, one of the biggest advantages of this procedure is that it can be performed in young patients who are still growing, in whom, on the other hand, the incidence of tooth loss due to trauma is relatively high[1-3].

Tooth ATT was performed many years ago, but with varying degrees of success. Even in the time of the pharaohs, attempts were made to transplant teeth from the slaves of the pharaohs, but due to histocompatibility, those interventions, as expected, ended in failure. If the procedure is performed carefully, with a full understanding of the biological principles involved, and if appropriate clinical techniques are implemented, the procedure can be very successful[2,4].

Subsequently, the foundations of the modern dental AT were laid by M. L. Hale, who in 1954 documented the first AT of teeth (4), and Slagsvold and Bjercke in 1960 at the University of Oslo established the first surgical protocol for this procedure (5). With that, the predictability and success of this treatment rose to a much higher level than before, which was proven by numerous long-term studies on the subject. The predictive factors for graft survival are directly related to the preservation of cell viability of the periodontal ligament of the donor tooth. Improper handling of the tooth during the intervention and its extraoral time can lead to damage to the ligament structure, which leads to postoperative complications of various kinds. Therefore, this procedure requires very gentle, atraumatic tooth extraction and careful handling during the procedure[6].

Several authors deal with this problem. In their paper, Yong Yoon et al.[7] state that despite the widespread use of dental implants and the experience gained, however, ATT of teeth can be a very difficult procedure to perform. A number of factors affect the success rate, including: developmental stage of the donor tooth root, tooth anatomy, surgical trauma, time the tooth spends outside the alveolar socket, shape and size of the recipient alveolus, condition of the recipient alveolus (the diagnosis of the tooth being extracted) and the blood supply of the bearing. The outcome of autotransplantation also depends on careful patient/case selection, delicate surgical technique, and understanding of the biological principles at work.

The survival and prognosis of autotransplanted teeth is similar to that of dental implants. However, it must be emphasized that certain complications can undermine the clinical outcome of these teeth. These include complications such as: root resorption which can be inflammatory resorption or replacement resorption which will lead to ankylosis, pulp necrosis, impaired periodontal healing, etc.[1,3,6].

In literature, various numerical data can be found about the percentage of survival/success/complications, but for the purpose of this paper, we decided to single out the data of a meta-study that has summarized the data of 32 other studies, considering that it shows the most objective picture. The author Evelyn C. et al.[1] found in his meta-analysis that the survival rate of these teeth, shown after 1, 5 and 10 years, was 97.4, 97.8 and 96.3 % respectively. They also show the one-year success rate of the intervention, which is 96.6%, but also the rate of complications such as ankylosis (2.0%), root resorption (2.9%) and pulp necrosis (3.3%).

Andreasen J.O et al.[4], in their study of patients aged 7-35 years with a total of 370 autotransplanted teeth, examined root resorption in these teeth. According to their results, root resorption was observed in 52 of the examined teeth. They found that root resorption is significantly related to the degree of root development of the donor tooth, as well as to the degree of eruption of the donor tooth. According to them, trauma to the periodontal ligament is a key factor in the development of root resorption later.

1. *Platelet-enriched fibrin (with special reference to A-PRF)*

By definition, Platelet-Rich Fibrin (PRF) is defined as an autogenous fibrin plug enriched with platelets and leukocytes that can be used as a biomaterial in the form of a plug or pressed membrane. It belongs to the second generation of platelet concentrates obtained by simple physical procedures on autologous blood taken from the patient, as products are obtained that are proven to accelerate the healing of soft and hard tissues during guided tissue and bone regeneration. The method is developed by J. Choukroun et al. in 2001 (Kumar and Shubhashini, 2013)[8].

The essence of the second generation is in the protocol for obtaining PRF that is created and directed to cause the accumulation of platelets and released cytokines in the fibrin plug[9], which means that a concentrate of a multitude of promoters of wound healing are obtained in one place, and which are usually diluted in the initially collected blood. The slow polymerization of fibrin during the processing and obtaining of PRF leads to the incorporation of platelet-derived cytokines inside the fibrin network. This indicates that PRF, unlike other platelet concentrates (first generation), will gradually release the trapped cytokines during fibrin remodeling, which in turn explains the positive impact on the speed of tissue healing that we can clinically register[9].

The mechanism of action of PRF is through its structure and its composition. It represents a network of densely distributed fibrin fibers with a tri- and tetramolecular structure in which a huge number of platelets and leukocytes are incorporated. By degranulation of platelets from their dense α-granules, plasmin proteins, pro- and anti-inflammatory cytokines (IL-1, IL-6, IL-4, IL-8) and growth factors (TGF, VEGF, PDGF, IGF) are released[10].

Because of such properties of PRF, it finds application in a large number of medical branches as an autologous biomaterial in oral and maxillofacial surgery, ear, nose and throat surgery, plastic surgery, orthopedics, etc. In oral and maxillofacial surgery, it can be used alone or in combination with graft materials in: periodontal surgery, sinus floor elevation[11,12], ridge augmentation[13], jaw reconstruction[13], regeneration after cyst enucleation[11], guided bone regeneration[13], alveolar preservation[14], MRONJ[15], autotransplantation[16] etc.

2. *Surgical protocol*

Before the oral-surgical intervention itself, antibiotic prophylaxis is administered (Tabl.Amoxicillinum+acidi clavici a' 2g per os, one hour before intervention, or Caps. Clindamycin a 600 mg per os, 1 hour before the intervention, in patients with a history of previous allergic reaction to penicillin). If the patients have an infection in the donor site,we administer antibiotic therapy one week before the intervention, in standard prescribed doses, in order to calm all the symptoms of infection and inflammation around the tooth, and at the same time, for several days before the intervention, we give advise to rinse the mouth with Cetylpyridinum chloridum 0.05%.

On the day of the intervention, patients rinse their mouth with Cetylpyridinum chloridum 0.05% for 2 minutes. Further procedures are performed according to all principles of asepsis and antisepsis. Anesthesia is applied using the necessary anesthetic technique depending on the region of the donor tooth and the recipient bed.

2.1 Autotransplantation of a tooth in an already existing extraction alveolus

At the beginning, extraction of the damaged tooth is performed with the help of elevators and appropriate pliers. Care is taken to ensure that the extraction is as trauma-free as possible, with maximum preservation of the bone walls. This is followed by preparation of the extraction alveolus, which entails vigorous curettage of all pathological tissues from the inside, breaking of the interdental septum if necessary, and osteotomy, if necessary.

Furthermore, the impacted tooth is extracted. If the donor tooth has erupted, it is extracted without raising the mucoperiosteal flap, but by sharply cutting the fibers of the epithelial

Figure 1. *Placing and splinting the donor tooth*

attachment using a scalpel. Extraction is done carefully with a suitable elevator and forceps. If the tooth is partially or fully impacted, it is approached with a classic surgical procedure. In doing so, care must be taken not to damage the crown of the tooth, but much more importantly, not to damage the root and the periodontal ligament on it. A triangular incision is made and a mucoperiosteal flap is raised. Furthermore, a more extensive but very careful osteotomy is made around the crown of the tooth (vestibulally and distally), in order to allow an unobstructed path of the tooth during extraction, without crushing or injuring the PDL. The tooth is carefully extracted and immediately placed in its new socket. If the tooth enters easily, without pressure and is placed in infraocclusion, we continue with the procedure (Picture 1.).

If the tooth does not fit the bearing, it is necessary to make an additional adjustment to the bearing, and finally to the occlusal surface of the tooth. During this time, it is very important, if possible, to return the tooth to its original alveolus, and if not, to complete the adjustment as quickly as possible. The extra-alveolar time of the tooth is extremely important and related to the prognosis of the tooth. Once the tooth is placed in its socket, it should be in infraocclusion, and not put under pressure.

Figure 2. *Splinting the donor tooth*

Furthermore, sutures are placed on the soft tissue, but also over the occlusal surface of the tooth, with the aim of its initial stabilization. After that, an elastic splint must be placed (an elastic wire that is glued with composite material to the vestibular surface of the tooth and two other adjacent teeth) in order to immobilize the transplant. (Picture 2)

The splint remains for 2-3 weeks, and then it must be removed, to prevent ankylosis of the tooth. The sutures are removed after 7-14 days. In teeth with complete root growth, endodontic treatment of the tooth starts after 1 month, and teeth with incomplete root growth are checked for vitality subsequently after 1-3-6 months. The patient is prescribed antibiotic therapy for one week postoperatively as well as vitamin supplementation (Vit C a 1000 and Vit D a 2000) for several months, maintenance of exceptional oral hygiene as well as scheduled check-ups.

2.2. Autotransplantation of a tooth in a newly prepared alveolus

In case when the tooth transplant is performed at a recipient site where there is no previous presence of a tooth, i.e. on an edentulous alveolar ridge, then a new transplant bed preparation must be performed. The osteotomy/preparation is done using drills from any implant set. In doing so, it is necessary to have data on the length and width of the donor tooth beforehand. The best way to get that data is through a 3D image of both jaws. In relation to the obtained data on the dimensions of the tooth, we use the implant drills and prepare the space in the bone.

2.3. Autotransplantation of a tooth using A-PRF

Since it is the same procedure, only those parts of the therapy protocol that are different from the previous case will be described below. Immediately before the start of the surgical intervention itself, venous blood is collected from the cubital vein, from which the platelet derivatives will be made. (Picture 3)

Once the donor tooth is extracted, it is set to sit submerged in the collected PRF exudate for as long as necessary while other preparations are made.Before placing the donor tooth in its socket, the socket is lined with a chopped PRF membrane, and the tooth is pushed through it, in order for the membrane to act as a physical shock absorber to protect against excessive pressure, but also as a biological substrate for assisted healing.

The rest of the procedures were identical to the first case.

2.4. Postoperative care of the patient

Postoperatively, for 7 days, the patient is prescribed antibiotic therapy, as well as vitamin supplementation (Vit C a 1000 and Vit D a 2000) for several months. The patient is

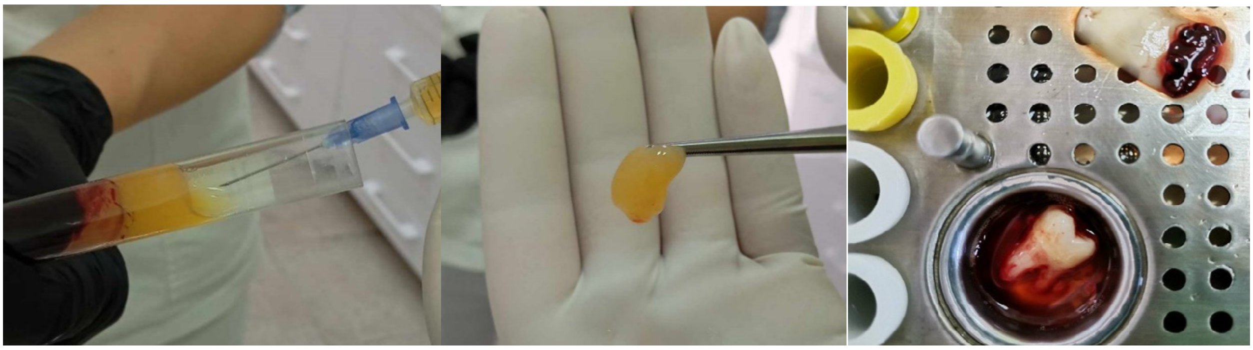

Figure 3. *Preparation of PRF products*

instructed to maintain excellent oral hygiene and to regularly rinse the wound with neutral fluids, saline or alcohol-free mouthwashes (Cetylpyridinumchloridum 0.05%). If necessary, patients are prescribed analgesic therapy from the NSAIL group. It is important to emphasize that patients who have received PRF therapy must not receive enzyme drugs to reduce edema (Chymoral, Serapeptaze) because breakdown of PRF preparations may occur. Frequent postoperative controls are performed, and the sutures are removed in 1-2 weeks.

2.5. A-PRF preparation protocol

Venous blood collection begins with venipuncture from the cubital vein, into two specially designed, patented, glass-coated A-PRF tubes of 10 ml of blood each. They are placed in parallel in a centrifuge BIOBASE LC-H4K, BIOBASE, Jinjan, Shandong, China and centrifuged at 1300 revolutions per minute (rpm), for 8 minutes, noting that the time from venipuncture to the start of centrifugation should not be longer than 2-3 minutes.

After the centrifugation process is completed, the test tubes are left open, covered with sterile gauze, to stabilize for 5 minutes. For manipulation of the PRF coagulum, a specially designed PRF set with instruments and PRF-box is used, which has a grid for obtaining membranes, Teflon molds for obtaining plugs, and a tub for mixing with other graft material and forming sticky bone.

After the stabilization of the coagulum in the test tubes, the collection of the supernatant from the PPP is started, in a sterile syringe of 5 ml with anatomical tweezers, the PRF coagulum is collected together with the erythrocyte sediment. With sterile scissors and the specially designed spatula, gently remove the erythrocyte sediment to the border with the fibrin coagulum, taking care to preserve the entire coagulum, at the expense of the erythrocyte sediment, so that a minor part of the sediment is left on the lower, distal part of the fibrin coagulum. Subsequently, the formation of the PRF membranes and/or the PRF plug (PRF cloth) is approached, depending on our needs. When manipulating the PRF material, a PRF exudate is obtained, which is collected in a sterile syringe and a suitable container. (Picture 3)

The aim of this review is to summarize the contemporary aspects of the autotransplantation of teeth, review the latest published articles, and also to review the role of PRF in the treatment plan for autotransplantation of teeth. Summarizing these information can be a step forward in choosing the most adequate treatment plan and including the new treatment varieties in order to improve the treatment and the outcome in these patients.

Material and method

To accomplish our goal to review the contemporary aspects of autotransplantation of teeth, we reviewed existing papers in the PubMed medical database as our main source as well as Web of Science, and Google Scholar search that covers wider variety of publications offering easier access to full¬-text documents, searching for the studies written in the last 10 years (30 analyzed articles). We used specific search query for every part of our research. For analyzing the contemporary aspects of autotransplantation of teeth, we used this search query: “autotransplantation of teeth, new methods, news, and development of the procedure”, with the only filter applied: “in the last 10 years”. For analyzing the use of PRF in autotransplantation of teeth we used: “autotransplantation of teeth, PRF”.

Results and discussion

In the literature covering this field of research, several criteria are cited as key factors in performing successful autotransplantation.

Ray Lescure et al.[17] state that the recipient bed must be free of any infections and with a sufficient amount of bone that will provide good support and stabilization for the transplanted tooth. Regarding the donor tooth, the ideal candidate is the teeth with incomplete root growth, because they have the potential to form the root and preserve the vitality of the pulp. Some other prognostic factors that may influence the success rate are: atraumatic tooth extraction, limited root injury and PDL, minimal root manipulation, and reduced extraoral time. All of the above factors are associated with a reduction in the risk of PDL damage, which would lead to the most common complications of the autotransplanted tooth, such as internal/external root resorption and ankylosis[17].

The criteria for successful autotransplantation are similarly described and divided in a number of papers, but as the most appropriate we will take the division of Andreasen et al. (18). Regarding the clinical examination, it is managed according to the following criteria: 1) physiological mobility; 2) no pain on percussion; 3) probing depth <3mm; 4) no signs of inflammation; 5) normal chewing function. Regarding the radiological criteria, they take into account the following: 1) normal spatiumperiodontale; 2) there is no progressive resorption of the root; 3) presence of lamina dura. ATT is considered unsuccessful when there is prolonged inflammation of the recipient cavity or when the transplanted tooth appears clinically unhealthy with persistent grade 3 mobility, ankylosis, or progressive root or bone resorption[18].

Keranmu et al.[19] in their study of 52 patients with ATT, divided the patients into two groups of 26 subjects, one of which performed the interventions in a classical way, and the other with the use of PRF. The initial stability of the graft in the PRF group is better immediately after the intervention. Periapical lesions in 23 of 26 subjects with PRF healed completely with new alveolar bone within 3 months, whereas in the control group, only 9 cases showed complete lesion healing after three months. In the PRF group, all patients showed satisfactory mastication, no abnormal mobility, periodontal pockets, and root resorption or ankylosis. In the control group, deep periodontal pockets were observed in some of the subjects[19].

Jorge González et al.[20] in their study presented 10 cases of ATT using PRF. All 10 patients have a functional and asymptomatic transplanted tooth with physiological mobility even after 1 year. All 10 have a positive test for vitality and all transplants show positive root growth (on average 2.01mm per year). The probing depth is not greater than 4 mm during the first year[20].

The use of A-PRF is thought to be a promoter of wound healing and angiogenesis processes. Use in autotransplantation cases is thought to possibly enhance the natural revascularization process of the transplanted tooth. Also, keeping the donor tooth in a PRF exudate while outside the alveolus may have an effect in preserving the vitality of cells from both the pulp and the PDL, thus improving the clinical outcome[21,22].

PRF stimulates angiogenesis through migration, division and phenotypic switching of endothelial cells. It also stimulates cell mitosis and induces osteogenesis without an inflammatory reaction. These effects work through a slow process that lasts at least a week[23] and up to 4 weeks[24].

PRF can induce strong and prolonged differentiation and stimulation of osteoblasts together with fibroblasts within 14 days[25].

After 12 months of follow-up, Bakhtiar et al. showed radiological evidence of prolonged root loom and closure of the apex in 4 teeth with incomplete growth and necrotic pulp[26].

These "miraculous" powers of PRF are described and explained by various authors in literature. Thus Alkofahi et al.[27] state that this is due to the fact that PRF contains a dense network of fibrin network and a concentration of many growth factors such as platelet-derived growth factor and vascular endothelial growth factor. An important factor is transforming growth factor b1 (TGFb1), which is simultaneously secreted by Hertwig's coat and positively affects the differentiation of dental papilla cells to transform into odontoblasts, providing a suitable environment for PDL cell proliferation and extracellular matrix synthesis. Finally, the authors conclude that the benefit of using PRF in autotransplantation of teeth with incomplete root growth is great in the early and late stages of the regenerative process[27].

1. New trends in science

The goal of modern science is to discover new innovations, to introduce new methods and techniques of work, but also to improve the existing ones, in a way that will enable the removal of the negative aspects of a procedure, improvement of epidemiological data in terms of improving the performance of one technique, as well as reducing the rate of complications. As in every field, in this field as well, modern science is trying to improve these parameters. In recent years, new work methods have been researched, implemented and introduced, and work protocols have been modified. In the following, some of those novelties will be briefly described.

1.1. Use of 3D technology in planning and performing autotransplantation of teeth

The introduction and daily use of CBCT in oral surgery greatly facilitates the process of diagnosis and therapy planning. Combining this diagnostic technology with various software that offers 3D design, planning, transfer of files, as well as their 3D printing has led to completely new views in the therapeutic plan, and thus in increasing the success of surgical techniques. These technologies, used in the planning process of autotransplantation of teeth, find application in several places.

Park S. et al.[28] in their paper give a simple explanation of the procedure. Namely, the width and length of the donor tooth can be predicted according to a digital image obtained during CBCT 3D recording in the form of DICOM files. With the help of advanced software systems, a virtual reconstruction of the donor tooth is made and as an STL file it can be transferred, manipulated, and thus can be printed on a 3D printer, which results in a computer-guided prototype of the tooth that needs to be transplanted, made of artificial material (resin). Such a tooth model can be used to adjust and prepare the alveolus that will be the bed for the transplant, without having to manipulate the real tooth at all. The very fact that the donor tooth can be extracted after the recipient alveolus is prepared is an extremely important step forward and a revolutionary moment in the autotransplantation protocol, because it allows minimizing the possibility of damaging and drying the cells of the periodontal ligament of the donor tooth.

On the other hand, imitating the use of a surgical-prosthetic guide during implant surgery, the same procedure is successfully transferred to the autotransplantation procedure. Namely, in implantology, with the help of CAD/CAM technology, a surgical guide that determines the exact depth, direction and angulation of the implantis often created. Considering the fact that when transplanting, it is best to have 1-2 mm of free space between the root of the tooth and the walls of the alveolus to be filled with blood, it is extremely important to place the donor tooth without pressure on the walls of the alveolus so that the cells of the PDL would not be damaged, but so that the revascularization of the pulp would be promoted. For this purpose, surgical guides are created that are virtually planned, 3D printed and which determine the extent of the osteotomy during alveolar bed preparation. This method provides atraumatic work and a precise surgical approach during autotransplantation[6,28].

1.2. Guided block autotransplantation

Krasny et al.[29] introduce a new technique of tooth transplantation which they call "en bloc autotransplantation". This surgical technique involves dissecting a block of bone that contains the bottom tooth and then transplanting the bone and tooth in one block into the recipient socket. This method is introduced in order to preserve the PDL and the bone, which enables easier and faster revascularization and continuation of the growth of the transplanted tooth. Surgical osteotomy of the bone is recommended to be done with a piezo device, in order to minimize potential complications, considering that this is a more complex intervention compared to the classical transalveolarautotransplantation[29].

1.3. Use of platelet-rich fibrin (PRF) in autotransplantation

Literature data indicate numerous case reports, but a lack of systematic research on this topic. Robindro Singh et al. used PRF in ATT of an impacted central incisor after odontoma removal. They wrapped the membrane around the root of the transplanted tooth, and a 6-month follow-up indicated successful regrowth of the root. Devi et al. They indicate positive radiological and clinical results at 2 and 3 year follow-up after the use of PRF in ATT of an impacted third molar with incomplete root growth in a fresh extraction alveolus[19,27,30,31].

Conclusions

Autotransplantaton is a reliable treatment option in patients that need tooth replacement due to tooth loss or partial edentulism, especially in young patients where the processes of bone growth are still active and it is an accepted and predictable procedure for replacing an irreparable tooth. Following the strict criteria for patient selection and following the steps of the therapeutic protocol, greatly improves the outcome of the therapyand increases the percent of survival and success rate of the transplanted tooth. Also, including the latest therapy modalities can make a positive impact on the therapy outcome.

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