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DEVELOPMENTAL DEFECTS OF ENAMEL: MOLAR–INCISOR HYPOMINERALIZATION IN THE FOCUS OF PAEDIATRIC DENTISTRY

РАЗВОЈНИ ДЕФЕКТИ НА ЕМАЈЛОТ: МОЛАРНО-ИНЦИЗИВНАТА ХИПОМИНЕРАЛИЗАЦИЈА ВО ФОКУСОТ НА ДЕТСКАТА СТОМАТОЛОГИЈА

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Abstract

Molar–incisor hypomineralization (MIH) is a developmental enamel defect affecting one or more permanent first molars and incisors. It is characterized by demarcated hypomineralized lesions, variable discoloration, and differing degrees of enamel structural weakness. The aetiology is multifactorial, involving prenatal, perinatal, postnatal, genetic, and environmental factors. MIH poses significant clinical challenges for paediatric dentists, including hypersensitivity, increased caries risk, and reduced retention of restorative materials. Treatment depends on disease severity and may include remineralization, restorative procedures, crowns, and, in severe cases, tooth extraction. MIH also impacts the psychological and social well-being of affected children. This paper provides a structured review of the literature, diagnostic criteria, treatment approaches, and preventive recommendations. **Keywords:** MIH, molar–incisor hypomineralization, enamel, children, dental treatment.

Апстракт

Моларно-инцизивната хипоминерализација (МИХ) претставува развоен дефект на емајлот кој зафаќа еден или повеќе први трајни молари и инцизиви. Се карактеризира со демаркирани хипоминерализирани лезии, варијабилна боја и со различен степен на структурна слабост на емајлот. Етиологијата е мултифакториелна, со пренатални, перинатални, постнатални, генетски и еколошки фактори. МИХ создава клинички предизвици за детските стоматолози, вклучувајќи хиперсензитивност, зголемен ризик од кариес и ограничена ретенција на реставративни материјали. Третманот зависи од сериозноста на состојбата и вклучува реминерализација, реставрации, коронки и понекогаш екстракција. МИХ, исто така, влијае на психолошката и социјалната благосостојба на детето. Овој труд дава систематизиран преглед на литературата, дијагностичките критериуми, третманските пристапи и на препораките за превенција. **Клучни зборови:** МИХ, моларно-инцизивна хипоминерализација, емајл, деца, стоматолошки третман.

Introduction

Molar-incisor hypomineralization (MIH) is a developmental enamel defect affecting one or more permanent first molars and often the permanent incisors. It is characterized by demarcated hypomineralized lesions that may vary in colour-from white and yellowish to brown-and by varying degrees of structural weakness of the enamel[1]. This defect results from a disturbance in the enamel mineralization phase during early childhood development[2].

MIH presents a major challenge for paediatric dentists due to its unpredictable clinical presentation, associated hypersensitivity, increased susceptibility to dental caries, and significantly reduced retention of restorative materials[3]. In addition, children with MIH frequently experience pain, aesthetic concerns, and anxiety, which complicates dental treatment and negatively affects their quality of life[4]. For these reasons, MIH is considered one of the most complex conditions in contemporary paediatric and preventive dental practice[5].

The aim of this paper is to provide a structured review of the available literature related to molar-incisor hypomineralization, including its aetiology, epidemiology, clinical presentation, diagnostic methods, treatment, and prevention. By

doing so, this paper aims to support dental practitioners in the recognition and effective management of this condition, based on the most recent scientific evidence and clinical recommendations[1,2,5].

Aetiology of mih

The aetiology of molar-incisor hypomineralization (MIH) has not yet been fully elucidated; however, numerous studies suggest a multifactorial nature of this condition[1]. MIH is believed to arise from disturbances during the enamel mineralization phase, specifically during the formation period of the permanent first molars and incisors-typically between birth and the fourth year of life[2].

1. Prenatal Factors

Certain conditions during pregnancy may influence enamel formation in the fetus, including:

- Prenatal infections (viral and bacterial)
- Hormonal or nutritional dysfunction in the mother
- Maternal stress and systemic diseases
- Exposure to environmental toxins[3].

2. Perinatal Factors

Factors occurring around the time of birth may also contribute to MIH:

- Premature birth
- Impaired neonatal respiratory status
- Neonatal hypoxia
- Complicated or prolonged delivery

These conditions may affect tissue oxygenation and consequently the normal development of ameloblasts, the cells responsible for enamel formation[6].

3. Postnatal Factors

Most research has focused on early childhood, as this is the period during which mineralization of the permanent first molars begins. Potential factors include:

- Frequent respiratory infections, particularly bronchitis and pneumonia
- High fever (febrile episodes) during infancy
- Antibiotics use, especially amoxicillin
- Gastrointestinal diseases
- Exposures to environmental toxins (e.g., dioxins)

Some studies report an association between amoxicillin use during the first years of life and an increased incidence of MIH, although a definitive causal relationship has not been fully established[7].

4. Genetic Factors

Although MIH is not considered a classical genetic disorder, some studies suggest a possible genetic predisposition, particularly when the condition occurs among multiple family members. Genes involved in enamel development (such as ENAM, AMELX, and MMP20) are currently under investigation[8].

5. Environmental Factors

Hypotheses suggest that exposure to environmental pollutants such as dioxins and bisphenol A may adverselz affect enamel formation. These substances act as endocrine disruptors and may interfere with ameloblast function[5].

Summary

Despite extensive research, the aetiology of MIH remains nonspecific and multifactorial, with multiple factors acting synergistically, sequentially, or independently. A betterunderstanding of these potential causative factors is essential for early identification, prevention, and improved planning of dental treatment.

Epidemiology of mih

Epidemiological studies on molar-incisor hypomineralization (MIH) reveal substantial variability in prevalence among different populations and geographic regions. According to the available literature, the global prevalence of MIH in children ranges from 2.4% to over 40%, making it one of the most common enamel defects in paediatric dentistry[9,10].

1. Global Distribution

Variations in reported prevalence across different regions are attributed to several factors:

- Differences in diagnostic criteria and research methodologies
- Age of the examined populations
- Geographic, socioeconomic, and ethnic factors[11]

Examples of the reported prevalence by region:

Region	MIH Prevalence
Northern Europe	10%–20%
South America	15%–25%
Asia	5%–30%
Africa	10%–35%
Australia	11%–22%

Elfrink et al. (2015) estimated the average global prevalence at 13.1%[12], while more recent studies reported an average of 14–18%[9,13]. These findings indicate that nearly one in seven children may be affected by MIH.

2. Age Distribution

MIH is most commonly diagnosed in children between 7 and 9 years of age, when the permanent first molars and incisors have erupted and their morphology and colour can be assessed[3]. In severe cases, symptoms may be noticed immediately upon eruption due to:

- Pain during tooth brushing
- Hypersensitivity to cold
- Rapid enamel breakdown[14]

3. Sex Distribution

Most studies show no significant difference in MIH prevalence between males and females; however, some studies report a higher prevalence among females. This may be related to endocrine or hormonal factors, though further research is required to clarify this relationship[15].

4. Local Data

In the Republic of North Macedonia, there are currently no reliable national data regarding MIH prevalence in children. This lack of standardized data highlights the need for comprehensive epidemiological studies to improve diagnosis, prevention, and treatment strategies.

Summary

- MIH is a common condition with significant epidemiological relevance
- Global prevalence suggests that one in six to seven children may be affectedby MIH.
- The lack of national and regional data underscores the need for further research

Clinical presentation

MIH manifests as hypomineralized enamel lesions affecting at least one permanent first molar, often accompanied by involvement of permanent incisors. Lesions vary in colour, shape, and size and are classified as mild, moderate, or severe[3,10].

Clinical features include:

- **Demarcated opacities:** well-defined white, creamy, yellow, or brown areas[2].
- **Irregular enamel surface:** enamel may be rough, porous, or soft upon probing.
- **Post-eruptive enamel breakdown:** fragile hypomineralized enamel fractures shortly after eruption.
- **Marked hypersensitivity:** increased sensitivity to thermal, chemical, and mechanical stimuli[1].
- **Treatment and anaesthetic difficulties:** local anaesthesia is often required; patient cooperation may be reduced due to pain[16].
- **Increased caries risk:** rapid enamel breakdown and plaque retention significantly increase caries susceptibility compared with normally mineralized teeth[9].

Although incisors are less frequently affected, their involvement may result insignificant aesthetic and psychological concerns[16].

Diagnosis

MIH is diagnosed clinically, based on criteria proposed by the European Academy of Paediatric Dentistry (EAPD)[2], which include:

- Involvement of at least one permanent first molar
- Presence of demarcated opacities of varying intensity
- Potential post-eruptive enamel breakdown (particularly in the molars)
- Caries in atypical anatomical locations
- Hypersensitivity without obvious caries

Differential diagnosis includes:

- Dental fluorosis[17]
- Amelogenesis imperfecta (AI)[18]
- Dental caries
- Turner's hypoplasia[19]

Classification of mih

One of the most commonly used classification systems is that proposed by Weerheijm et al. (2001), which categorizes MIH severity as:

1. **Mild MIH:** Demarcated opacities without enamel loss or caries
2. **Moderate MIH:** Enamel loss without dentin involvement; limited caries
3. **Severe MIH:** Dentine involvement, atypical restorations, or tooth extraction

Additionally, the Würzburg concept introduced the **MIH Treatment Need Index** (MIH-TNI):

- 0: No MIH
- 1: MIH without hypersensitivity or defect
- 2: MIH with defect but no hypersensitivity
- 3: MIH with hypersensitivity but no defect
- 4: MIH with hypersensitivity and defect

These tools assist clinicians in prioritizing treatment and monitoring disease progression.

Treatment approach and management of mih

Treatment depends on the severity of the condition, the child's age, functional and aesthetic needs, and the patient cooperation[2,3].

1. Mild Cases

- Fluoride varnishes or gels for remineralization[1]
- Fissure sealing (GIC or composite)[9]
- Desensitizing agents (e.g., arginine or calcium phosphate)[20]
- Follow-up every 6 months

2. Moderate to Severe Cases

Restorative options:

Method	Indication
Glass ionomer cement	Temporary solution, especially in young children
Composite restorations	Cooperative patients with sufficient tooth structure
Preformed metal crowns	Extensive tissue loss in molars
Extraction	Non-restorable teeth, often with orthodontic planning[21,22]

Incisor treatment (aesthetic focus):

- Microabrasion or bleaching (older children)[16]
- Composite veneers
- Resin infiltration (ICON) for mild cases[23]

3. Pain and Hypersensitivity Management

- Desensitizing agents with strontium, arginine, or amine fluorides[9]
- Enhanced local anaesthesia techniques[24]
- Fluoride varnish application prior to invasive procedures

4. Behavioural and Psychological Management

- Behavioural guidance techniques[25]
- Sedation or general anaesthesia when necessary[26]

Summary

- MIH presents with variable severity
- Treatment requires an individualized, often multidisciplinary approach
- Primary goals are long-term function, pain reduction, and improved quality of life

Psychological and social aspects of mih

MIH, particularly in severe forms, can significantly affect a child's psychological well-being and social functioning[2,27].

1. Pain and Anxiety

- Persistent or intermittent pain leads to fear of dental treatment[3,28]
- Painful or failed treatments increase dental anxiety[24]
- Parents report avoidance of brushing, dental visits, and cold/hot drinks[3]

2. Aesthetic Concerns

When central incisors are affected, children may experience:

- Shame and low self-esteem[9]
- Difficulties with smiling, verbal communication, and social interaction[27]
- Long-term psychosocial consequences[16]

Children with visible incisal defects are more likely to experience teasing or social exclusion[29].

3. Role of Parents

Due to limited awareness of MIH, parents may:

- Delay dental visits[2].
- Mistake MIH for caries or poor oral hygiene[30].
- Experience increased family stress due to repeated dental treatments[24].

Prevention and future research directions

MIH cannot be prevented through conventional measures such as brushing or fluoridation, as the defect develops during the enamel formation stageprior to tooth eruption[1,2]. However, preventive strategies are still possible[3].

1. Early Diagnosis

- Identification of early signs in children aged 6–7 years[31]
- Education of dentists and parents to distinguish MIH from caries or fluorosis[32]
- Inclusion of MIH within national dental screening programs[10]

2. Risk Factor Reduction

- Monitoring early childhood medical history[33]
- Avoiding unnecessary antibiotic use in infancy where possible[34]
- Environmental exposure surveillance[2]

3. Future Research Directions

- Genetic susceptibility and enamel-related genes[32,33]
- Identification of biomarkers for early screening[35]
- Development of biomimetic restorative materials[36]
- Improvement of restorative longevity in MIH-affected teeth[37]

Conclusion

Molar-incisor hypomineralization (MIH) represents a significant challenge in modern paediatric and preventive dentistry. As a developmental enamel defect with multifactorial aetiology and variable clinical presentation, MIH requires early identification and a careful diagnostic approach[2,3]. Its high prevalence and global distribution make MIH a condition of public health importance[38].

Clinical management should focus on preserving function, eliminating pain, and improving aesthetics, while also addressing the psychological and social impact of the condition, particularly in children with affected incisors[1,2]. Despite advances in knowledge, further multidisciplinary research is required, especially in the fields of genetics, environmental exposure, and biomarker identification[32,33,35]. Education of dental professionals, parents, and educators remains essential for improving oral health outcomes in affected children[27].

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A COMPARATIVE EVALUATION OF LASER ASSISTED AND ULTRASONIC IRRIGATION IN ROOT CANAL DESINFECTION DURING ENDODONTIC TREATMENT – A REVIEW ARTICLE

КОМПАРАТИВНА ПРОЦЕНКА НА ЛАСЕРСКИ АСИСТИРАНА И УЛТРАЗВУЧНА ИРИГАЦИЈА ВО ДЕЗИНФЕКЦИЈА НА КОРЕНСКИ КАНАЛИ ВО ТЕК НА ЕНДОДОНТСКИ ТРЕТМАН – РЕВИЈАЛЕН ТРУД

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Abstract

Aim: This review article aims to provide a systematic analysis and comparison of laser-assisted and ultrasonically activated irrigation in endodontics, with the objective of determining their clinical effectiveness in root canal disinfection and mechanical debridement. **Materials and Methods:** A systematic search of scientific literature published in English over a ten-year period (2015–2025) was conducted using the following databases: PubMed, Scopus, Web of Science, and Google Scholar. The search strategy incorporated the following keywords and their combinations: diode laser, ultrasonic irrigation, root canal treatment, laser-assisted irrigation, ultrasonically activated irrigation, and endodontics. This review includes studies reporting findings from both clinical and laboratory research that investigated and compared the effects of laser-assisted and ultrasonically activated irrigation on root canal systems. **Results:** Following the analysis of the selected studies, several parameters were evaluated, including antimicrobial efficacy, smear layer removal, disinfection of lateral canals, postoperative pain, operational safety, and clinical applicability. The evidence gathered in this systematic review indicates that laser-assisted irrigation demonstrates superior efficacy compared to ultrasonically activated irrigation in the elimination of microorganisms, dentinal debris, andthe smear layer from the root canal system. Laser activation generally exhibits a higher antimicrobial potential, particularly when combined with chemical irrigants. **Conclusion:** Diode lasers stand out due to their ability to achieve deeper penetration into dentinal tubules and their pronounced antimicrobial effect. In contrast, ultrasonic activation offers advantages in mechanical cleaning, smear layer removal, and enhanced irrigant flow, particularly in lateral canals and complex anatomical regions of the root canal system. **Keywords:** laser-assisted irrigation, diode laser, ultrasonic irrigation, endodontic treatment.

Апстракт

Цел: Целта на оваа ревијална студија е систематска анализа и споредба на примената на ласерска и ултразвучнаиригација во ендодонцијата, со цел да се утврди нивната клиничка ефикасност во однос на дезинфекцијата на коренските канали и нивно механичкото чистење. **Материјали и методи:** Се спроведе систематско пребарување на научна литература објавена на англиски јазик, со временски опсег од 10 години (од 2015 до 2025 година), во следниве бази на податоци: PubMed, Scopus, Web of Science и Google Scholar. Пребарувањето беше спроведенопреку користење на следниве клучни зборови и на нивните комбинации: diode laser, ultrasonic irrigation, root canal treatment, laser-assisted irrigation, ultrasonically activated irrigation, endodontics. Во овој преглед се содржани статии во кои се објавени резултати од клинички и лабораториски студии, во кои е испитуван и е спореден ефектот на ласерска и ултразвучна активирана иригација на коренските канали. **Резултати:** По обработката на вклучените студии, беа анализирани неколку параметри на испитуваните техники и тоа: антимикробен ефект, отстранување на smear layer, дезинфекција на латерални канали, постоперативна болка, безбедност при работа и нивната клиничка примена. Во рамките на овој систематски преглед, тековните докази укажуваат дека ласер-асистирана иригација има супериорна ефикасност во однос на ултразвучно-активирана иригација во елиминацијата на микроорганизми, дентински остатоци и размачкан слој од системот на коренскиот канал. Ласерската активација генерално покажува повисок антимикробен потенцијал, особено кога се комбинира со хемиски ириганси. **Заклучок:** Диодниот ласер се издвојува по својата способност за подлабока пенетрација во дентиналните тубули и изразен антимикробен ефект, додека ултразвучната активација покажува предност во механичкото чистење, отстранувањето на smear layer и подобрување на протокот на иригантот, особено во латералните канали и во комплексните анатомски делови од коренските канали. **Клучни зборови:** ласер-асистирана иригација, диоден ласер, ултразвучна иригација, ендодонтски третман.

Introduction

Endodontic treatment of the root canal system aims to establish a microorganism-free environment while simultaneously shaping the canals to create optimal conditions for long-term therapeutic success. The primary etiological agents of root canal infections are microorganisms that invade the dental pulp and subsequently colonize the root canal system. These microorganisms produce metabolic by-products that rapidly penetrate periradicular tissues through apical and lateral foramina, triggering a cascade of inflammatory reactions accompanied bylysis of both soft and hard periradicular tissues[1].

Primary infections are predominantly associated with 40–50 Gram-negative obligate anaerobic species, particularly from the genera *Fusobacterium, Prevotella, Porphyromonas, Tannerella,* and *Treponema*. In contrast, secondary or persistent infections typically consist of less diverse microbial communities, mainly composed of Gram-positive facultative anaerobes, including species of *Streptococcus*, *Lactobacillus, Actinomyces,* and *Enterococcus*[2,3].

Enterococcus faecalis is one of the most frequently detected microorganisms in persistent secondary infections, while it is less commonly found in primary infections. This highlights its remarkable ability to survive under unfavorable conditions, especially in inadequately treated root canal systems[4,5,6].

Effective debridement and disinfection of the root canal system fundamentally depend on the use of appropriate irrigants and disinfectants. Sodium hypochlorite, chlorhexidine, EDTA, and MTAD are among the most commonly used agents in contemporary endodontic practice. Sodium hypochlorite remains the gold standard due to its broad-spectrum antimicrobial activity, whereas chlorhexidine is valued for its lower cytotoxicity and reduced risk of tissue damage. Continuous research in this field has led to the development of advanced approaches, including the use of nanoparticles, photodynamic therapy, and low-frequency ultrasound, all of which aim to enhance the efficacy of root canal disinfection[7].

Ultrasonic irrigation, as a viable adjunct in root canal therapy, can be applied in two distinct ways: in combination with simultaneous instrumentation or as a standalone technique without concurrent instrumentation, known as passive ultrasonic irrigation (PUI). In clinical practice, the former approach has largely been abandoned due to difficulties in controlling the removal of infected dentin and the increased risk of creating aberrant canal morphologies. Consequently, the literature supports the preferential use of passive ultrasonic irrigation, which ensures safer canal preparation while minimizing the risk of iatrogenic irregularities within the root canal system[8,9].

In modern endodontics, diode lasers occupy a prominent role in root canal disinfection. Operating within a wavelength range of 810 to 980 nm (infrared spectrum), they are capable of deep penetration into dentinal tubules, enabling effective elimination of bacteria residing in deeper tooth structures. Laser energy activation induces thermal effects that lead to the destruction of bacterial cells, including resistant species such as *Enterococcus faecalis*[10,11]. Additionally, diode lasers have been associated with a reduction in postoperative pain following endodontic treatment[12].

Aim

The aim of this review study is to systematically analyze and compare current scientific evidence regarding the application of laser-assisted and ultrasonically activated irrigation in endodontics, in order to determine their clinical efficacy in terms of root canal disinfection, mechanical debridement, and overall treatment outcomes in patients.

Material and methods

A systematic literature review was conducted to examine and compare the various characteristics of laser-assisted and ultrasonically activated irrigation, highlighting their role in root canal disinfection as part of endodontic treatment. A comprehensive search of scientific literature published in English was performed, with a time restriction of ten years, including publications from 2015 to 2025. The following databases were used: PubMed, Scopus, Web of Science, and Google Scholar.

The search strategy incorporated the following keywords and their combinations: diode laser, ultrasonic irrigation, root canal treatment, laser-activated irrigation, ultrasonically activated irrigation, and endodontic treatment.

This review includes studies reporting results from both clinical and laboratory research, in which the effects of laser-assisted and ultrasonically activated irrigation on root canal systems were investigated and compared. In certain studies, in addition to comparing these two techniques, comparisons were also made with other conventional methods.

The study was conducted using predefined inclusion and exclusion criteria, as outlined below:

Inclusion criteria

- Randomized controlled trials
- *In vitro* and *in vivo* studies
- Studies comparing laser-assisted and ultrasonic irrigation, either with each other or with other disinfectants

- Studies analyzing postoperative pain, antimicrobial efficacy, and smear layer removal following the use of laser or ultrasonic irrigation

Exclusion Criteria

- Studies not published in full text
- Studies that did not investigate the effects of laser-assisted and ultrasonic irrigation
- Studies without direct comparison between the techniques
- Studies published before 2015
- Studies published in languages other than English

A total of multiple studies were initially identified, of which 18 studies were ultimately selected for final inclusion, as they were directly relevant to the aim of this review.

Results

In this study, multiple relevant clinical and in vitro investigations were analyzed, comparing the efficacy of laser-assisted and ultrasonically activated irrigation in root canal disinfection as part of endodontic treatment. The data derived from the analyzed studies are presented in Table 1.

Table 1. Comparative analysis of the effects of laser-assisted and ultrasonically activated irrigation in root canal systems

Authors		Disinfection Method	Superior Effect (Outcome)	Journal
Sahar-Helft S et al.	2015	Laser-activated irrigation vs Passive ultrasonicirrigation (PUI)	Lasersuperior effect for smear layer removal	Journal of Endodontics
Sohrabi K et al.	2016	Diode laser vs NaOCl	Diode laser shows superior antimicrobial effect	Iranian Endodontic Journal
Amin Ket al.	2016	Diode laser vs ultrasonic irrigation	Diode laser more effective as monotherapy	J Conserv Dent
Dai S et al.	2018	Diode laser	High antimicrobial efficacy	BMC Oral Health
Rajakumaran A et al.	2019	Diode laser vs Ultrasonic irrigation	Laser shows better penetration into dentin	Journal of Clinical and Diagnostic Research
Verma A et al.	2020	Ultrasonic vs Laser vs Conventional	Both methods superior to conventional techniques	Journal of Clinical and Experimental Dentistry

Authors		Disinfection Method	Superior Effect (Outcome)	Journal
Pereira TC et al.	2021	Ultrasonic irrigation	Ultrasonic technique superior for biofilm removal	International Endodontic Journal
Jambagi N et al.	2021	Diode laser vs Ultrasonic vs NaOCl	Diode laser shows greatest bacterial reduction (~60.9%)	Journal of Contemporary Dental Practice
Liu C et al.	2022	Ultrasonic vs Laser vs Sonic irrigation	Similar effects (ultrasonic and laser superior in apical region)	Journal of Applied Oral Science
Badami V et al.	2023	Laser vs Ultrasonic irrigation	Laser superior (antibacterial + smear layer); combination most effective	Cureus
Almohareb RA et al.	2023	Diode laser vs Ultrasonic irrigation	Both methods equally effective	Australian Endodontic Journal
Shirani Lapari S. et al.	2024	Two diode lasers vs three irrigation methods	Greatest reduction of *Enterococcus faecalis* with diode laser	J Lasers Med Sci
Abaza MM et al.	2025	Diode laser vs Ultrasonic irrigation	Ultrasonic superior for smear layer removal	Lasers in Medical Science
Karimzadeh S et al.	2025	Laser vs Ultrasonic irrigation	Similar efficacy (focus on safety)	Journal of Conservative Dentistry & Endodontics
Ahmad L et al.	2025	Ultrasonic vs Laser vs Sonic irrigation	Ultrasonic technique superior for canal cleanliness	Clinical/SEM Study Journal
Nagadi E et al.	2025	Diode laser vs Ultrasonic vs Sonic irrigation	Diode laser shows superior antimicrobial effect	Clinical, Cosmetic and Investigational Dentistry
Gulhane A et al.	2025	Laser vs Ultrasonic irrigation	Laser associated with reduced postoperative pain	Cureus
Al-Jaberi M et al.	2025	Different diode laser wavelengths	Effective against *Enterococcus faecalis*	Rev Recent Clin Trials

Following the analysis of the included studies, the primary focus was directed toward comparing the effects of laser-assisted techniques versus ultrasonic irrigation on root canal disinfection and mechanical cleaning, which are critical determinants of the overall outcome of endodontic treatment. Several key parameters were evaluated, including antimicrobial efficacy, smear layer removal, disinfection of lateral canals, postoperative pain, operational safety, and clinical applicability.

Antimicrobial Effect

According to the analyzed studies, diode lasers demonstrate a superior antimicrobial effect compared to ultrasonic activation and conventional irrigation methods in root canal treatment. This superiority is primarily attributed to the deeper penetration capability of diode lasers into dentinal tubules and their photothermal effect, which effectively destroys microorganisms, particularly *Enterococcus faecalis*, a species associated with secondary, persistent infections and failed endodontic treatments. Studies by Sohrabi et al.[14], Dai et al.[16], Jambagi et al.[20], and Nagadi et al.[28] report significant reductions in *Enterococcus faecalis*, which can be linked to the deep penetration of laser energy into the dentinal tubules. Furthermore, Shirani Lapari et al.[24] and Al-Jaberi et al.[30] confirm that variations in diode laser wavelengths influence the efficacy against biofilm formation.

On the other hand, while ultrasonic irrigation provides positive results in microbial reduction, its action is largely superficial, leading primarily to mechanical disruption of the biofilm rather than deep disinfection within dentinal tubules. This was demonstrated in the study by Liu et al.[21].

Nevertheless, the systematic review by Badami et al.[22] indicates that the majority of studies support the superior antimicrobial efficacy of laser-activated irrigation over ultrasonic-activated irrigation. Overall, the current evidence in this systematic review suggests that laser-activated irrigation is more effective than ultrasonic-activated irrigation in eliminating microorganisms, dentinal debris, and smear layer from the root canal system. Laser activation generally exhibits higher antimicrobial potential, particularly when combined with chemical irrigants.

Smear Layer Removal

Variable results have been reported regarding smear layer removal for the two techniques, largely due to their differing mechanisms of action. Diode lasers function through photothermal energy, whereas ultrasonic activation promotes improved irrigant circulation within the canal. The study by Sahar-Helft et al.[13] demonstrated superior smear layer removal with laser activation, while Abaza et al.[25] reported better results using ultrasonic irrigation, particularly in the apical third. Amin et al.[15] highlighted that combining EDTA with ultrasonic activation significantly enhances smear layer removal.

Cleaning of Lateral Canals

One of the major challenges during endodontic treatment is effective disinfection and mechanical cleaning of lateral canals and anatomically inaccessible areas. In root canals with complex anatomy and lateral canals, studies indicate that ultrasonic activation achieves more effective disinfection due to the dynamic movement of irrigants. Pereira et al.[19] demonstrated that ultrasonic activation better removes biofilm from lateral canals because of its hydrodynamic effects.

Conversely, lasers contribute to microbial elimination within the root canals, but their effect is primarily antimicrobial rather than mechanical. Rajakumaran et al.[17] showed that lasers achieve deeper penetration into dentinal tubules, making them superior for deep disinfection. Liu et al.[21] concluded that combining both techniques can yield optimal results in anatomically complex root canal systems.

Postoperative Pain

Most of the analyzed studies report that patients treated with diode lasers experience lower postoperative pain following endodontic treatment, attributed to reduced microbial load and a consequently diminished inflammatory response. Gulhane et al.[29], in a systematic review, indicated that laser-assisted irrigation is associated with less postoperative pain compared to ultrasonic and conventional methods, likely due to improved microbial elimination and reduced irritation of periapical tissues.

For ultrasonic activation, postoperative pain levels are moderate and vary depending on the technique and type of irrigants used. Verma et al.[18] demonstrated that both laser and ultrasonic activation contribute to improved clinical healing compared to conventional irrigation methods.

Safety and clinical application

Operational safety is a critical factor when selecting irrigation techniques. Although diode lasers are highly effective, their use requires proper training, careful parameter selection, and adherence to correct protocols to avoid damage to periapical tissues or injury to surrounding oral structures. Ultrasonic activation, on the other hand, is generally considered safer and more broadly applicable, with a lower risk of thermal damage. Karimzadeh et al.[26] emphasize the importance of controlling laser parameters to pre-

vent thermal injury to periapical tissues. Ahmad et al.[27] also note that ultrasonic activation may lead to irrigant extrusion into periapical tissues if proper usage guidelines are not followed.

While most studies are in vitro, clinical evidence reported by Verma et al.[18] and Ahmad et al.[27] confirms that both techniques significantly enhance the effectiveness of endodontic treatment. Systematic reviews by Badami et al.[22] and Gulhane et al.[29] indicate that there is no single universally superior method. Instead, a combined approach-integrating laser, ultrasonic activation, and chemical irrigation-provides the most favorable outcomes in the overall success of endodontic therapy.

Discussion

The analysis of the available literature indicates some inconsistency in the reported results, which can largely be attributed to variations in study design. Differences in the choice and concentration of irrigants, duration of activation, and laser energy parameters significantly influence the final outcomes[13,15,21]. This is particularly evident in studies employing different diode laser wavelengths, where variations are observed in antimicrobial efficacy and depth of penetration into dentinal tubules[24,30].

It is also important to note that most of the analyzed studies were conducted under in vitro laboratory conditions[13,14,15,16,17,19,20,21,23,24,25,26,28,30]. While such an approach allows for better control of experimental parameters, it cannot fully capture the complexity of clinical situations. The absence of biological factors, such as immune response and individual anatomical variability, may lead to overestimation or underestimation of the efficacy of certain techniques[19,21].

Although lasers often demonstrate superior results under laboratory conditions[14,16,20,28,] clinical studies do not always show a significant difference in overall treatment outcomes[18,23,27]. This suggests that increased antimicrobial activity does not necessarily translate into better clinical results, highlighting the importance of a comprehensive treatment approach.

Furthermore, several authors emphasize that combining different irrigation techniques can provide better results than using each method alone[21,22,29]. Such combinations leverage the advantages of each technique: the mechanical action of ultrasound and the deeper penetration capability of lasers, which is particularly valuable in complex root canal morphologies and in the presence of lateral canals[17,19].

Recent research also shows a notable trend toward minimally invasive endodontic approaches, aiming to achieve effective disinfection while preserving healthy tissue and minimizing irritation to surrounding structures[23,26,27]. In this context, laser and ultrasonic activation play an important role as adjunctive techniques that can enhance treatment success without aggressive mechanical instrumentation. Together, these modern endodontic strategies contribute to more efficient and predictable clinical outcome.

Conclusion

Based on the analysis of the available literature, it can be concluded that both diode lasers and ultrasonic irrigation represent significant advancements over conventional irrigation methods in endodontics. Both approaches demonstrate improved efficacy in disinfecting the root canal system, particularly in eliminating microorganisms and removing organic and inorganic debris.

The diode laser stands out for its ability to penetrate deeper into dentinal tubules and for its pronounced antimicrobial effect, whereas ultrasonic activation offers advantages in mechanical cleaning, smear layer removal, and enhanced irrigant flow, especially in lateral canals and anatomically complex areas of the root canal system. However, no single technique alone can achieve complete disinfection of the root canal system.

In this regard, a combined approach-incorporating chemical irrigants alongside different activation methods-emerges as the most rational solution for achieving optimal disinfection. Additionally, careful attention must be paid to safety considerations, particularly regarding the control of laser energy and preventing irrigant extrusion into periapical tissues.

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MANAGEMENT OF COMPLICATED TRAUMA TO FRONTAL TEETH WITH ALVEOLAR PROCESS FRACTURE – A CASE REPORT

МЕНАЏИРАЊЕ НА КОМПЛИЦИРАНА ТРАУМА НА ФРОНТАЛНИ ЗАБИ СО ФРАКТУРА НА АЛВЕОЛАРЕН ПРОДОЛЖЕТОК – ПРИКАЗ НА СЛУЧАЈ

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Abstract

Traumatic injuries to the dentoalveolar complex represent a serious clinical condition that often occur as a result of direct impact, falls, or sports injuries and may lead to complex damage to both hard and soft oral tissues. One of the most challenging conditions is complicated dental trauma, in which multiple types of injuries to the teeth and supporting structures occur simultaneously, particularlyluxations such as extrusion and intrusion, accompanied by a fracture of the alveolar process. The aim of this paper is to present a case of a 14-year-old patient with complicated trauma to the anterior teeth, including intrusion of tooth 12, extrusion with fractures of enamel and dentin, and mobility of teeth 11 and 21. Additionally, there is contusion and enamel fracture of tooth 22, as well as a fracture of the alveolar process. The paper emphasizes a multidisciplinary approach and long-term prognosis. **Materials and Methods:** A case of severe dental trauma in a 14-year-old female patient is presented. According to the medical history, the injury was caused by a fall from a scooter and involved a fracture of the alveolar process, injuries to teeth 12, 11, 21, and 22, as well as trauma to the soft tissues of the upper jaw. The patient was initially admitted to the University Clinic for Maxillofacial Surgery, where diagnostic and therapeutic procedures, including 3D CBCT imaging and maxillomandibular fixation (MMF), were performed, along with other standard interventions for this type of injury. The patient was subsequently referred to the Clinic for Pediatric and Preventive Dentistry for further management. The affected teeth were immobilized using composite–wire splinting, endodontically treated, and restored with nanocomposite restorations. In such cases, long-term follow-up of at least five years is essential. Since the patient is young, continued growth and development of the jaws and teeth are expected. Regular follow-up examinations are necessary to ensure that these injuries do not interfere with normal growth and to detect possible complications such as root resorption and ankylosis. **Keywords:** trauma, extrusion, intrusion, multidisciplinary approach, prognosis.

Апстракт

Трауматските повреди на дентално-алвеоларниот комплекс претставуваат сериозна клиничка состојба која често се јавува при директен удар, пад или при спортска повреда и може да води до комплексни оштетувања на тврдите и на меките орални ткива. Една од најпредизвикувачките состојби е комплицирана траума, каде што истовремено се комбинираат повеќе типови повреди на забите и на потпорниот апарат, особено дислокации како екструзија и интрузија, придружени со фрактура на алвеоларниот гребен. Целта на овој труд е да се прикаже случај на третман на 14-годишна пациентка со комплицирана траума на забите во фронтот, интрузија на заб 12, екструзија со фрактура на емајл и дентин со присутна мобилност на заб 11 и 21, контузија и фрактура на емајл на заб 22, и фрактура на алвеоларниот продолжеток,со нагласок на мултидисциплинарен пристап и долгорочна прогноза. **Материјал и метод:** Сериозна стоматолошка траума кај пациентка, која е 14-годишна. Според описот, повредата е предизвикана од пад од тротинет и вклучува фрактура на алвеоларниот гребен , повреда на забите 12, 11, 21, 22 и меките ткива на горната вилица. Приемот најпрво е направен на Универзитетска клиника за максилофацијална хирургија каде што се применети техники, како 3D CBCT и мономаксиларна фиксација (MMF), како и други медицински интервенции што се вообичаени мерки за ваков тип повреда. Пациентката е препратена на Клиника за детска и превентивна стоматологија за понатамошен третман. Забите се имобилизирани со композитно-жичната фиксација, ендодонски третирани и реставрирани со нанокомпозитни надоградби. Во овие случаи, важно е пациентот да се следи најмалку 5 години по повредата. Бидејќи пациентката е млада (14 години), растењето и развојот на нејзините вилици и заби ќе продолжат. Потребно е редовна контрола за да се осигура дека овие фрактури и повреди не го нарушуваат природниот раст на коските и на забите и можните компликации, како што се ресорпција и анкилоза. **Клучни зборови:** траума, екструзија, интрузија, мултидисциплинарен пристап, прогноза.

Introduction

Dental trauma represents a significant health problem affecting all age groups, but it occurs most frequently in children and adolescents. It includes a wide range of injuries to the teeth and surrounding tissues resulting from physical impact, falls, sports activities, traffic accidents, or violence. Depending on the intensity and direction of the applied force, trauma may cause damage ranging from minor enamel fractures to complete avulsion of the tooth from its socket (alveolus).

Dental injuries require immediate and appropriate intervention, as timely diagnosis and proper treatment are crucial for preserving aesthetics, function, and a favorable long-term prognosis. Inadequate or delayed treatment may lead to serious complications such as pulp necrosis, root resorption, infection, malocclusion, and premature tooth loss.

Given the complexity of dental trauma and the need for modern therapeutic approaches, the development of systematic knowledge is essential for minimizing complications and achieving effective treatment[1,2].

Classification of Dental Trauma

Classification is important because it guides the choice of therapy, influences prognosis, and allows for standardized treatment protocols. Dental trauma is divided into two main categories:

1. Injuries to hard dental tissues and pulp:

- Enamel fracture
- Enamel and dentin fracture without pulp exposure
- Enamel and dentin fracture with pulp exposure (complicated fracture)
- Root fracture
- Crown-root fracture

2. Injuries to the periodontium and surrounding structures:

- Contusion
- Subluxation
- Extrusion
- Lateral luxation
- Intrusion
- Avulsion

In addition to the teeth, surrounding oral tissues may also be affected:

- Alveolar bone (alveolar process fracture)
- Gingiva and soft tissues (lacerations, contusions, abrasions)
- Lips, tongue, and oral mucosa (3–6)

Extrusion (Extrusive Luxation)

Extrusion is a luxation injury in which the tooth is partially displaced out of the alveolar socket in a coronal direction. This injury results from tearing of the periodontal ligament fibers, compromising the periodontal ligament and causing partial disruption of the neurovascular bundle at the level of the root apex. It most commonly occurs following moderate to severe trauma, where vertical forces displace the tooth from its socket. Prompt repositioning and stabilization are essential to prevent pulp necrosis and root resorption[7].

Although extrusion itself does not necessarily involve alveolar bone damage, severe trauma may cause fractures or microfractures of the alveolar process. Clinically, this injury may be characterized by mobility of the affected tooth or involved segment, swelling, and hematoma, while radiographically a disrupted cortical bone outline may be observed. Treatment requires careful repositioning of the affected tooth and flexible splinting for approximately two weeks. Close follow-up of all involved teeth is necessary due to the high risk of pulp necrosis and root resorption[8,9].

Intrusion (Intrusive Luxation)

Intrusion represents the most severe injury to the tooth-supporting structures, in which the tooth is displaced axially into the alveolar bone. This displacement causes compression and destruction of periodontal ligament fibers, as well as damage to the neurovascular complex, resulting in a high incidence of ankylosis and inflammatory root resorption[10].

Unlike extrusion, intrusion leads to severe degenerative consequences, particularly in permanent teeth[7,10].

Enamel and Dentin Fracture

This injury involves damage to the enamel and underlying dentin without pulp exposure. Since dentin is an innervated and permeable tissue, patients often experience pain in response to thermal and mechanical stimuli, along with an increased risk of bacterial invasion and pulpitis[9].

Alveolar Process Fracture

An alveolar process fracture is a serious injury affecting the alveolar bone supporting the teeth. It typically results from high-impact forces such as sports injuries or traffic accidents and is often associated with displacement of multiple teeth that move as a single bony segment[7].

Objective:

The objective is to present a case of treatment of a 14-year-old patient with complicated trauma to the anterior teeth and fracture of the alveolar process, with an emphasis on a multidisciplinary approach and long-term prognosis.

Material and methods: Case report

A fourteen-year-old female patient presented to the Public Health Institution (PHI) University Surgical Clinical Center "St. Panteleimon", Skopje, at the Clinic for Pediatric and Preventive Dentistry due to a traumatic injury in the anterior region. From the anamnestic data obtained from the parent and the patient herself, it was reported that the injury occurred two days prior to presentation, during a fall from a scooter.

On the same day of the injury, she was admitted to the Clinic for Maxillofacial Surgery. A fracture of the maxilla with dislocation of the anterior teeth into the soft tissues, as well as fractures of the hard dental tissues, was diagnosed. A 3D CBCT scan was performed.

Under local anesthesia, repositioning of teeth 12, 11, 21, and 22 was performed, followed by fixation with MMF (maxillomandibular fixation) using a flexible splint (0.5 mm wire) (Figures 1 and 2). Antibiotic, analgesic, and corticosteroid therapy was prescribed.

Figures 1. and 2. *MMF suture (monomaxillary fixation with a resilient splint 0.5)*

The patient was then referred to the Clinic for Pediatric and Preventive Dentistry for continuation of treatment with the placement of composite-wire splinting.

A multidisciplinary team was formed for treatment. During the clinical examination, blood and Betadine residues were observed, as well as orthodontic brackets on the lateral teeth from ongoing orthodontic treatment.

Figures 3. *Orthopantomographic radiograph*

A complicated trauma was diagnosed, including intrusion of tooth 12, extrusion with fracture of enamel and dentin with mobility of teeth 11 and 21, and contusion with enamel fracture of tooth 22. The patient was referred for radiographic imaging (Figure 3.).

First, soft deposits and coagulum were carefully removed with a brush and a low-speed handpiece to obtain a clearer picture of the type of injury and the status of the teeth (Figure 4.).

Figures 4. *Preparation of teeth for placement of composite-wire fixation.*

Due to the specificity of the injuries, the presence of edema, and the limited mouth opening, rubber dam isolation was not feasible; therefore, a decision was made to provide a dry working field using relative isolation with cotton rolls and suction.

The teeth were prepared by etching with 37% orthophosphoric acid for 20 seconds, followed by thorough rinsing with a water spray. Adhesive bonding was applied to the affected teeth, and teeth 15, 14, 13, 23, and 24 were additionally included in the splinting.

A flexible splint of appropriate length was selected. The splint was first fixed to teeth 15, 14, 13, 23, and 24 using

Figures 5. - 8. *Placement of composite-wire fixation.*

Figures 9. *Follow-up examination at 14 days.*

Figures 10. *Follow-up examination at 28 days.*

Figures 11. and 12. *Condition after removal of the composite-wire fixation and endodontic treatment of teeth 22, 21, and 11.*

Figures 13. and 14. *Nanocomposite restorations.*

flowable composite. Subsequently, fixation of teeth 11, 21 (which had been manually repositioned), and 22 was performed. Tooth 12 was not included in the splinting because it was intruded and in infra occlusion.

The splint was reinforced with conventional composite resin. At that stage, the primary goal was retention of the teeth rather than aesthetic outcome (Figures 5.–8.).

The patient was given instructions for maintaining oral hygiene at home and an appropriate diet. A follow-up examination was scheduled after 14 and 28 days (Figures 9 and 10). At the control examination, soft deposits were carefully removed. The situation was stable; however, it was still too early to predict the final treatment outcome.

After 4 weeks, the MMF fixation and composite–wire splint were removed. Due to limited mouth opening and the inability to perform adequate endodontic treatment of teeth 22, 21, and 11 while the splint was in place, endodontic therapy was performed after removal of the fixation.

The root canals were obturated with mineral trioxide aggregate (MTA). Pulp vitality testing had previously been performed and was negative (Figure 11. and 12.).

The following day, the teeth were restored with aesthetic nanocomposite resin materials (Figures 13. and 14.).

Follow-up examinations were performed at 3, 6, and 12 months. The condition after 1 year was highly favorable,

Figures 15. and 16. *Clinical results after 1 year.*

despite the complicated trauma. The teeth demonstrated satisfactory mobility control, function, and stability. Radiographic evaluation showed no signs of root resorption. The soft tissues exhibited satisfactory contour, color, and texture (Figures 15. and 16.).

Conclusion

Complicated multiple dentoalveolar trauma requires a complex and individualized therapeutic approach, which may include repositioning, stabilization, endodontic treatment, restoration, and, in some cases, surgical intervention. Injuries accompanied by bone fractures require urgent and long-term management, with clinical and radiographic follow-up for at least five years.

Treatment success depends on the timing of intervention, the patient's age, root development, and the extent of periodontal tissue damage. Furthermore, patient cooperation, maintenance of good oral hygiene, and timely management of secondary complications play a crucial role in successful healing.

When treatment is performed in accordance with contemporary clinical protocols and guidelines, complex dentoalveolar fractures can be managed with satisfactory functional, esthetic, and biological outcomes, allowing long-term preservation of both teeth and alveolar

bone. Due to its complexity and potential for serious complications, complicated dentoalveolar trauma remains an important area of clinical practice and research in modern dentistry.

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DMFT INDEX STRUCTURE IN CHILDREN AGED 12: COMPARISON BETWEEN URBAN AND RURAL AREAS

СТРУКТУРА НА КЕП-ИНДЕКС КАЈ ДЕЦА ОД 12-ГОДИШНА ВОЗРАСТ, СПОРЕДБА ПОМЕЃУ УРБАНА И РУРАЛНА СРЕДИНА

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Abstract

Objective: The main objectives of this professional paper were to determine the DMFT index among 12-year-old children from several primary schools in urban versus rural areas of Bitola, Republic of North Macedonia, to compare the obtained results, to assess the prevalence of dental caries, and to identify the factors contributing to its occurrence. **Materials and Methods:** The schools included in this study were selected using a simple random sampling technique. A total of 120 children participated in the research – 60 from urban areas of Bitola and 60 from rural areas. Data were collected through questionnaire surveys. **Results:** The mean DMFT index among the participants was 1.80. The DMFT index was 2.283 in the urban area and 1.33 in the rural area. **Conclusion:** The results of this study provided not only data on the oral health status of 12-year-old children from both urban and rural settings, but also a clearer insight into their socioeconomic and demographic characteristics. Appropriate oral health education programs targeting parents should be implemented as part of the prevention process. **Keywords:** dental caries, DMFT index, children, Bitola.

Апстракт

Цел: Главните цели на овој стручен труд беа да се одреди КЕП-индексот кај деца на 12-годишна возраст од неколку основни училишта од урбана во однос на рурална средина од Битола, Република Северна Македонија, да се направи споредба на добиените резултати, да се процени преваленцата на денталниот кариес и да се одредат факторите што придонесуваат за таквата појава. **Материјали и методи:** Училиштата вклучени во ова истражување беа избрани со едноставна техника на случаен избор на примерок. Во истражувањето беа вклучени вкупно 120 деца, од кои 60 деца од основни училишта во урбаната средина во Битола и 60 деца од руралната средина. Податоците беа собирани со пополнување на прашалник. **Резултати:** КЕП-индексот кај испитаниците изнесуваше 1,80. Во урбана средина КЕП-индексот изнесуваше 2,283, додека во рурална средина КЕП-индексот изнесуваше 1,33. **Заклучок:** Резултатите што ги добивме во оваа студија, освен што ни обезбедија податоци за состојбата на оралното здравје кај децата од 12-годишна возраст во две средини–урбана и рурална, ни обезбедија и појасна слика за социоекономскиот и за демографскиот статус на децата. Во рамките на превентивниот процес треба да се имплементираат соодветни програми за едукација за орално здравје на децата, наменети и за родителите. **Клучни зборови:** дентален кариес, КЕП-индекс, деца, Битола.

Introduction

Prevention, as an integral part of the healthcare system, plays a crucial role in maintaining the stomatognathic system. The occurrence of dental caries is a widespread problem for the population worldwide. Therefore, preventive dental associations continuously work on finding more effective preventive methods aimed at reducing the incidence of dental caries from an early age.

Dental caries is a the most vomon oral disease worldwide and can occur throughout the entire lifespan. Particularly concerning is the fact that dental caries is becoming increasingly prevalent in school-aged children[1–7].

According to the World Health Organization (WHO), dental caries affects 60–90% of school-aged children, and as a result, children are increasingly absent from school due to toothache, which interferes in eating, communication, sleeping, and students' concentration, thereby negatively affecting their educational development[8–13].

Dental caries is the most common chronic infectious disease in children, which can be effectively prevented through appropriate preventive measures. In the USA, dental caries is the most common chronic childhood disease, five times more common than asthma[14]. Dental caries, and consequently dental infections, may increase the risk of pneumonia, infectious arthritis, and endocarditis, or inflam-

mation of the heart lining. In individuals with diabetes, the incidence of dental caries is higher, particularly in the presence of periodontal disease and its associated complications[15].

Due to the increasing availability and frequent consumption of fast and processed foods, as well as foods high in sugar, poor oral hygiene, and inadequate or delayed visits to the dentist, the number of children diagnosed with dental caries is steadily rising. This situation leads to a greater financial burden for parents and society, especially in countries where dental insurance and treatment are expensive.

Dental caries is a disease that can be prevented if addressed promptly and can be halted with timely and appropriate treatment, depending on the stage at which it is diagnosed. Recently, in addition to advice on maintaining regular oral hygiene, recommendations for reducing sugar intake-especially refined sugars-using fluoride or casein calcium extracts, as well as recommendations for additional intake of the probiotics such as *Bifidobacterium reuteri* and *Bifidobacterium rhamnosus*, as well as *Streptococcus salivarius*, have become more common. Probiotic microorganisms can inhibit cariogenic microorganisms in the mouth by producing antimicrobial substances such as bacteriocins, bacteriocin-like peptides, lactic acid, and hydrogen peroxide, which inhibit the activity of cariogenic microorganisms. Dairy products have proven to be the fastest method for introducing these probiotic strains, except for patients allergic to milk, who should take these cultures in the form of tablets, powder, syrup, or other available pharmacological forms[16–17].

Pediatric dentists play a key role in promoting and implementing preventive programs that significantly contribute to preserving oral and, particularly, dental health. Identifying prevalence, as well as the timely detection of risk factors, helps in adapting and applying appropriate preventive programs that will reduce the number of children with dental caries.

Aim

Timely application of preventive methods and early detection of dental caries is a primary goal and direction in all developed countries worldwide. Proper implementation of preventive measures from an early age and population education, aimed at reducing the DMFT index, is one of the main goals to be achieved in children's oral health.

The main objectives of the research are to determine the DMFT index in 12-year-old children from primary schools in urban versus rural areas of Bitola and the Bitola region, to compare the obtained results, to assess the prevalence of dental caries, and to identify the factors contributing to this condition.

The set objectives will be realized through:

Determining the value of the DMFT index and its urban-rural distribution.

For achieving the established objectives, the factors relevant to the condition of oral health will also be determined. Through an appropriate questionnaire, the following parameters will be assessed:

Living environment (urban/rural); Parents' education; The influence of parents' socioeconomic and employment status on the DMFT index in children.

Material and methods

The schools included in this study were selected using a simple random sampling technique. The inclusion criteria for participants in the study were children from primary schools who attended regular classes during the data collection period. Parents/guardians of all children were informed about the examinations and provided signed consent.

A total of 120 children from the Municipality of Bitola were included in the study. Of the total number, 60 participants were from an urban area (30 females and 30 males), and 60 participants from a rural area, (also 30 females and 30 males).

Data were collected through face-to-face questionnaire interviews, conducted by the preventive team responsible for the systematic preventive examinations of the selected students. Through the questionnaire, we obtained information about parents' educational level and employment status. The purpose of this questionnaire was to help identify the most common factors and causes contributing to the development of dental caries, as well as to determine the main risk factors leading to this condition (Appendix 1).

Each child underwent a dental examination using disposable gloves, artificial light, a dental mirror, and a dental probe. The diagnosing protocol for dental caries was based on the WHO guidelines for caries diagnosis, using the DMFT index (Decayed, Missing, Filled Teeth), which is one of the most widely used methods for assessing caries prevalence.

Index Parameter

DMFT: the sum of the number of decayed (D), missing due to caries (M), and filled (F) teeth (T).

The mean DMFT value is calculated by dividing the total of all individual DMFT scores by the number of individuals examined.

The formula used to calculate the DMFT index is:

$$\text{DMFT index} = \frac{\text{Total number of DMFT}}{\text{Total number of participants}}$$

D + M + F = total number of decayed + total number of extracted + total number of filled teeth (DMFT).

The values used to assess the structure of the DMFT index are:

0.0 - 1.0 very low
1.2 - 2.6 low
2.7 - 4.4 moderate
4.4 - 6.5 high

Statistical Analysis of the Results

The analysis of the obtained data was performed using the statistical software Statistika 2.3.21, with a standard deviation of 0.05-0.07.

Results

The population included in this study consisted of 120 children, aged 12 years, from the Municipality of Bitola.

In the Municipality of Bitola, the DMFT index among the examined participants was 1.80.

In the urban area, the DMFT index was 2.283 (2.33 in male participants and 2.23 in female participants), while in the rural area, the DMFT index was 1.33 (1.033 in male participants and 1.633 in female participants).

In tables 2, 3, 4, 5, and 6, the results obtained from the data collected in the Municipality of Bitola are presented.

Table 1. Distribution of Participants

	BITOLA DMFT index
Urban area	2,283
Rural area	1,333
DMFT	1,808

Analysis of the results from the Municipality of Bitola

The analysis of the results (Table 2) for the territory of the Municipality of Bitola included primary schools from the urban area of Bitola, as well as the rural areas — Mogila, Novaci, and Orizari.

In the Municipality of Bitola, the DMFT index among the examined participants was 1.80.

In the urban area, the DMFT index was 2.283 (2.33 in males and 2.23 in females), while in the rural area, the DMFT index was 1.33 (1.033 in male participants and 1.633 in female participants).

In the subsequent analysis, several findings from the questionnaire were highlighted as potential risk factors contributing to the higher DMFT index in the urban compared to the rural environment.

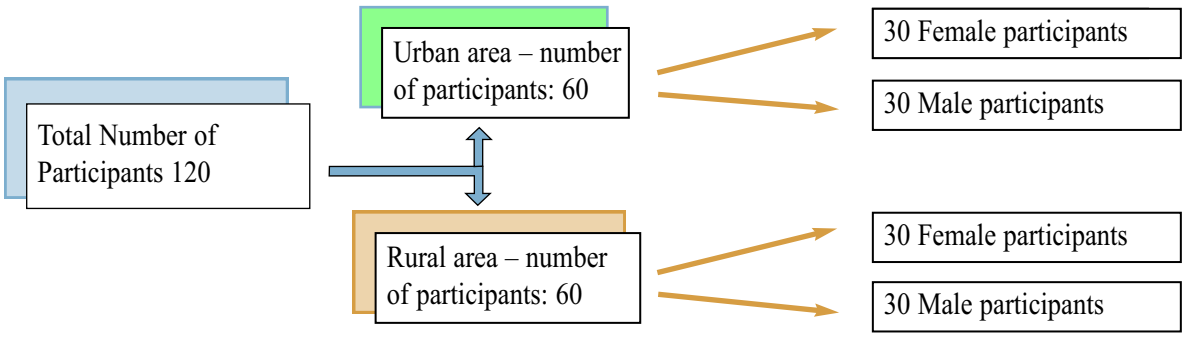

Table 2. Calculation of the DMFT Index Value – Municipality of Bitola

SEX/AREA	CARIOUS	EXTRACTED	RESTAVRATED	TOTAL
Girls/urban area	19	5	43	67
Boys/urban area	27	6	37	70
Girls/Rural area	19	3	27	49
Boys/rural area	12	2	17	31
TOTAL	77	16	124	217

Table 3. Level of Parental Education in the Urban Area of Bitola

SEX	LEVEL OF EDUCATION URBAN AREA	MOTHER	FATHER	%MOTHER	%FATHER
Female	Secondary school	12	19	20.0 %	31.7%
	Higher school	15	7	25.0 %	11.7%
	Primary school	1	3	1.7 %	5.0%
	No data	2	1	3.3 %	1.7%
Male	Secondary school	12	22	20.0 %	36.7%
	Higher school	11	2	18.3 %	3.3%
	Primary school	7	5	11.7 %	8.3%
	No data	0	1	0.0 %	1.7%

Table 4. Level of Parental Education in the Rural Area of Bitola

SEX	LEVEL OF EDUCATION RURAL AREA	MOTHER	FATHER	%MOTHER	%FATHER
Female	Secondary school	17	19	28.3 %	31.7%
	Higher school	7	3	11.7 %	5.0%
	Primary school	6	8	10.0 %	13.3%
Male	Secondary school	21	25	35.0 %	41.7%
	Higher school	5	4	8.3 %	4%
	Primary school	4	1	6.7 %	1.7%

Table 5. Employment Status of Mother/Father in the Urban Area of Bitola

SEX	Parent Employment Status	TOTAL MOTHER	TOTAL FATHER	%MOTHER	%FATHER
Female	Regular employment	25	27	41.7 %	45.0%
	Unemployed	3	2	5.0 %	3.3%
	Temporary employment	2	1	3.3 %	1.7%
Male	Regular employment	23	27	38.3 %	45.0%
	Unemployed	5	3	8.3 %	5.0%
	Temporary employment	2	0	3.3 %	0.0%

Table 6. Employment Status of Mother/Father in the Rural Area of Bitola

SEX	Parent Employment Status	TOTAL MOTHER	TOTAL FATHER	%MOTHER	%FATHER
Female	Regular employment	20	23	33.3 %	38.3%
	Unemployed	8	4	13.4 %	6.7%
	Temporary employment	2	3	3.3 %	5.0%
Male	Regular employment	15	26	25.0 %	43.4%
	Unemployed	15	3	25.0 %	1.7%
	Temporary employment	0	1	0.0 %	5.0%

From Tables 3 and 4, it can be observed that in the urban area of the Municipality of Bitola, the majority of mothers have a higher education level (25% of mothers of female participants and 18.3% of mothers of male participants), totaling 43.3%. In contrast, the percentage of mothers with higher education in rural areas is much lower, 20%, of which 11.7% are mothers of female partcicipants and 8.3% are mothers of male participants.

Regarding fathers, 15% of fathers in the urban area have a higher education level, compared to 9% in rural areas. The percentage of fathers with secondary education is higher (68.4%) compared to mothers (40%). The percentage of parents with primary education is higher in rural areas than in urban areas.

According to the results presented in Table 5, there are no significant percentage differences regarding the employment status of parents for both female and male participants in the urban area. 80% of the mothers of the participants are employed (41.7% for mothers of female participants and 38.3% for mothers of male particiapnts). The employment rate for fathers is slightly higher, at 90%, with 45.0% for fathers of female participants and 45.0% for fathers of male participants.

According to the results presented in Table 6 regarding the employment status of parents in the rural area, 58.3% of mothers of the participants are employed (33.3% for mothers of female participants and 25% for mothers of male participants), compared to 81% of fathers who are employed (38.3% for fathers of female participants and 43.4% for fathers of male participants).

Discussion

In the Municipality of Bitola, the DMFT index among the examined participants was 1.80. In the urban area, the DMFT index was 2.283 (2.33 for male participants and 2.23 for females), while in the rural area, the DMFT index was 1.33 (1.033 for males and 1.633 for female participants).

From the results obtained in the Municipality of Bitola, the overall DMFT index was 1.80, which, according to the classification of DMFT index values, falls into the low DMFT category. This suggests that the implemented preventive plans and programs have achieved their intended results. However, dentists involved in caries prevention programs should strive to achieve even better outcomes and lower DMFT index values.

According to the survey results, the only notable difference observed was in the mother's level of education and employment status. This can be considered a risk factor, as a mother's greater absence from home due to regular employment, combined with higher educational qualifications, may increase the risk of a higher DMFT index in children.

Other identified risk factors include irregular tooth brushing, which should be performed at least twice a day, and the need for using mouth rinses. Employment status can also be considered a contributing factor to a higher DMFT index among children from urban areas. A mother's absence due to work obligations and the resulting reduced parental supervision of children's dental hygiene support the DMFT index results.

The comparison of the DMFT index between urban and rural areas favors the rural areas, with the DMFT index in the urban area being 2.283, compared to 1.333 in the rural areas.

The most significant risk factor identified was the percentage of unemployed mothers in rural areas of Bitola, which is 38.4%. Regarding the educational level of the parents of the participants, a lower level of education does not appear to be a risk factor for an increased DMFT index.

Conclusion

Based on the results and their analysis, several conclusions can be drawn:

Diagnosis Limitation: Diagnosis of dental caries based solely on a dental examination, without the use of radiography, may not detect all cases of dental caries.

Questionnaire Limitations: Although the questionnaire was designed to be easily understandable, some children may not have fully comprehended the questions or may have provided inaccurate answers, which could partially influence the results.

Study Insights: The results of this study not only provided data on the oral health status of 12-year-old children in Bitola across urban and rural areas, but also offered a clearer picture of their oral hygiene and dietary habits, as well as their socioeconomic and demographic status. This information can significantly contribute to the planning and successful implementation of preventive activities.

Preventive Education: Appropriate oral health education programs targeting children and involving parents should be implemented in the preventive process.

Promotion and Awareness: Preventive activities should include oral health promotion and education, aimed at improving awareness among citizens, their children, and other family members, as well as enhancing their knowledge and attitudes regarding oral health and its impact on overall health.

Appendix 1.

Survey Questionnaire

1. **Patient's age: .....**

2. **Patient's sex** (circle):

a) Male b) Female

3. **Place of residence** (circle):

a) Urban area b) Rural area

4. **Mother's level of education** (circle):

a) Primary b) Secondary

c) Higher education d) No data

5. **Father's level of education (circle)**:

a) Primary b) Secondary

c) Higher education d) No data

6. **Parents' employment status:**

Mother - regular/occasional

Father - regular/ occasional

Assessment of Dental Condition

The assessment of the dental condition was performed by completing a table indicating the current state of dentition, based on which the DMF index (DMFT index) of the examined population was determined.

DMF Index Condition Table

17	16	15	14	13	12	11	21	22	23	24	25	26	27
47	46	45	44	43	42	41	31	32	33	34	35	36	37

D-Decayed tooth **M**-Missing (extracted) tooth **F**-Filled tooth

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PROSTHETIC REHABILITATION WITH DENTAL BRIDGE CONSTRUCTIONS IN A PATIENT WITH PROGENIA: A CASE REPORT

ПРОТЕТСКА РЕХАБИЛИТАЦИЈА СО МОСТОВНИ КОНСТРУКЦИИ КАЈ ПАЦИЕНТ СО ПРОГЕНИЈА: ПРИКАЗ НА СЛУЧАЈ

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Abstract

Dental bridges are prosthetic restorations whose primary role is not to correct jaw irregularities, but to replace missing teeth and the discontinuity in the dental arch. In case where patients don't receive timely orthodontic treatment, and prosthetic rehabilitation becomes necessary, treatment maypresent a challenge in everyday dental practice. **Aim:** To achieve prosthetic rehabilitation a patient with progenia, using two statically balanced fixed bridge constructions, and correction of the occlusion. **Materials and methods:** A 50-year-old patient, with Class III orthodontic malocclusion and a need for prosthetic rehabilitation, visited the University Dental Clinical Centre 'St. Pantelejmon'. With the provision of two statically balanced dental bridge constructions, a reduction of the interocclusal space, replacement of the missing teeth, and correction of the overbitewas performed. **Result:**Precise tooth preparation was performed,resulting inreduction of the interocclusal distance and successful replacement of the missing teeth and correction of the occlusion with two dental bridges. **Conclusion:** Accurate preparation is an important factor in dimensioning and positioning bridge constructions, especially when lower teeth overlap the upper teeth. A multidisciplinary approach to the prosthetic treatment is crucial for achieving successful results. **Keywords:** progenia, bridge, impression, preparation.

Апстракт

Денталните мостови претставуваат протетски надоместоци, чијашто примарна улога не е да ги коригираат виличните неправилности, туку да ги надоместат изгубените заби и настанатиот прекин во забниот лак. Кога пациентите не добиваат навремен ортодонски третман, а се јавува потреба од протетска рехабилитација, тие претставуваат предизвик во секојдневната стоматолошка практика. **Цел:** Протетска рехабилитација кај пациент со прогенија, преку изработка на два статички урамнотежени мостовски конструкции и корекција на загризот. Материјал и метод: На Универзитетскиот Стоматолошки Клинички Центар„Св. Пантелејмон" Скопје, се јави пациент на 50-годишна возраст, со ортодонска малоклузија од III класа и со потреба од протетска рехабилитација. Со изработка на две статички урамнотежени мостовни контрукции, постигнавме намалување на интероклузалниот простор, надоместување на изгубените заби и корекција на оклузијата. **Резултат:** Беше спроведена многу прецизна препарација на преостанатите заби, намалување на интероклузалното растојание, успешно надоместување на преостанатите заби и корекција на загризот преку изработка на две мостовни контрукции. **Заклучок:** Прецизната препарација е важен фактор во димензионирањето и во позиционирањето на мостовните конструкции, особено кога долните заби ги преклопуваат горните заби. Мултидисциплинарниот пристап во протетскиот третман е многу значаен за постигнување на успешни резултати. **Клучни зборови:** прогенија, мост, отпечаток, препарација.

Introduction

Patients who have not received timely orthodontic treatment in their lifetimepose a challenge during prosthetic rehabilitation. Orthodontics plays an essential role in maintaining oral health by treating dental irregularities, including malocclusions and misalignments of the dental arches and individual teeth. This specialty focuses on the

diagnosis, protection, and correction of dental and facial-skeletal irregularities and uses various orthodontic appliances in its practice (functional appliances, mobile orthodontic appliances, fixed therapy, positioners, etc.). On the other hand, prosthodontics plays a fundamental role in the rehabilitation of oral function and aesthetics, using prosthetic restorations (crowns, bridges, dentures, and implant-supported prosthetic solutions) to replace missing teeth and surrounding tissues[4].

The most widely used systemfor theclassification of malocclusions is that proposed by Edward H. Angle in 1899, as well as the classification by Marković from 1976.

Angle classified malocclusions into three classes based on the anteroposterior relationship of the first permanent molars and the sagittal relationship of the jaws. Class I (neutroclusion) includes irregularities of individual teeth and dental arches. Class II (distocclusion) is characterized by a distal positioning of the mandible in relation to the maxilla in the sagittal direction. Angle further subdivided Class II into Division 1 (Class II/1), where the maxillary anterior teeth are protruded, and Division 2 (Class II/2), where the maxillary anterior teeth are retroclined. Class III malocclusion is relatively less common and represents a sagittal discrepancy in which the mandible is positioned in a mesial directionwith respect to the maxilla. Depending on its severity and clinical presentation, various forms may occur, including pseudo-prognathism, true prognathism (progenia), anterior crossbite, and forced prognathic bite[5].

Mandibular prognathism is a skeletal malocclusion, most often of genetic origin, characterized by an excessively mandibular development in the sagittal and vertical direction. This malocclusion is considered the most severe form of Class III. In this condition, the maxilla may be normally developed, underdeveloped, or overdeveloped, and very often exhibits protrusion of the maxillary anterior teeth[6,7].

From a prosthodontic standpoint, dental bridges are prosthetic replacements whose primary role is not to correct dental arch irregularities, but to restore missing teeth and the continuity of the dental arch (due to extraction or trauma). These constructions with special connections are attached to the holder teeth that border the defect[8]. When the static stability of individual bridges is compromised, the connection of posterior and anterior bridge segments into a single unified framework results in a more mechanically balanced prosthetic construction. Through surface (polygonal) linking, thisdesign more effectively counteracts the detrimental transverse and sagittal forces acting within the horizontal plane[9].

Aim

The purpose of this study is to present a case of progenia and its prosthetic rehabilitation using two statically balanced bridge constructions in the maxilla and mandible, with the purpose of restoring missing teeth and correct the bite within physiological limits.

Material and methods

At the University Clinical Center “St. Pantelejmon,” specifically at the Clinic of Fixed Prosthodontics, a 50-year-old patient with a Class III orthodontic malocclusion requiring prosthetic rehabilitation (Figure 1.).

Based on the patient’s medical history, no previous orthodontic treatment had been undertaken. Intraoral examination revealed sensitivity to vertical percussionof the first premolar in the upper left quadrant , absence of both maxillary central incisors, andabsence of premolars and molars in the upper right quadrant. Additionally, a metal post restoration was observed on the canine in the upper left quadrant.Intraoral examination of the mandible

Figure 1. *Overbite of mandibular teeth towards the maxillary teeth*

Figure 2. *Intraoral examination findings*

revealed extraction of the second premolar in the lower right third quadrant and absence of the molars in the lower left fourth quadrant. The incisal edges of the lower anterior teeth were slightly abraded (Figure 2.).

Clinical examination of the gingiva revealed inflammatory changes, including slight bleeding, erythema, and edema. Furthermore, dental calculus was observed in the region of the lower anterior teeth. Before initiating prosthetic treatment, the patient was referred to the Clinic of Oral and Periodontal Diseases for periodontal therapy and to the Clinic of Dental and Endodontic Diseases for the management of a periapical lesion identified on panoramic radiography.

In the first phase of the prosthetic therapy, simultaneous preparation of the maxillary teeth was performed (Figure 3.). Tooth preparation was carried out with a tangential finish line located in the subgingival region. After completion of the final stage of tooth preparation, attention was directed towards the preparation of the gingival sulcus and the oral cavity for impression taking. For retraction of the gingival sulcus, chemical-medication agents and a gingival retraction cord were used.

Figure 3. *Preparation of the maxillary teeth*

Figure 4. *Two-step corrective dental impression*

A perforated custom tray was used to take an impression of the processus alveolaris and the maxillary teeth. In this patient, a two-step corrective impression technique was performed, using a heavy-body impression material followed by a light-body material (Figure 4.). The use of a two-step impression technique in designing metal-ceramic bridges provides better dimensional stability compared to other impression methods, which is crucial for obtaining accurate models and precise fixed prosthetic restorations[10,11,12].

Using a tangential finish line, with circular margin design, provides optimal marginal closure of crowns on the abutment teeth. This technique is also easy to perform and is characterized by minimal removal of dental substance. In teeth with reduced periodontal support, the finish line may have a para-gingival position[13,14].

In the second phase of the prosthetic therapy, we tested the metal sub-construction of the maxillary bridge in occlusion, its relationship with the adjacent teeth, as well as the vestibular and palatal surfaces, along with assemsment of the retention, marginal fit, and overall adaptation (Figure 5.).

Figure 5. *Testing the metal skeleton of the dental bridge*

To test the fit of the metal skeleton, the following method was implemented: underlaying the bridge with a flowable silicone material (xanthoprene - blue). The interior walls of the crowns and the bridge framework were filled with silicone, and the restoration was then seated in the oral cavity under gentle pressure. Areas where the material was displaced were appropriately adjusted.

In the third phase of prosthetic therapy, evaluation was made onthe gingival fit of the metal-ceramic bridge, its relationship with the antagonistic and agonistic (supporting) teeth, the tooth color, shape, size, and overall esthetic appearance (Figure 6.). To test the gingival fit of the faceted dental bridge, the same fit-check method was used as in the second phase, underlaying the bridge with a flowable sili-

Figure 6. *Testing the gingival seating of the maxillary metal-ceramic bridge*

Figure 7. *Final testing of the occlusion, before definitive cementation*

Figure 8. *Definitive cementation of both prosthetic restorations*

cone material (xanthoprene - blue). The interior walls of the crowns and the body of the bridge were filled with silicone, and the restoration was then seated in the oral cavity under gentle pressure.

Areas where the material was displaced were appropriately adjusted. After recording the occlusal relationship between the maxillary and mandibular teeth,with the preparation of the mandibular teeth was initiated.

The maxillary bridge was temporarily cemented by applying a thin layer of temporary cement to the gingival third of the carrier teeth, aiming to seal the communication of the dentin exposure with the external environment, prevent potential infection, and allow patient adaptation[15].

During this phase, any potential clinical manifestations that could indicate theneed for re-occlusion or re-articulation were monitored.

While the maxillary dental bridge was temporarily cemented, the previously described procedural steps were applied toprepare the mandibular dental bridge.

In the final phase of prosthetic therapy, we evaluated the occlusal relation between the maxillary and mandibular dental bridges (Figure 7). Once both bridges achieved a satisfactory interocclusal relationship, acceptable esthetic appearance, and functional integrity, definitive cementation of the two prosthetic restorations was performed simultaneously (Figure 8). For cementation of the patient's bridge constructions, a glass-ionomer cement was used, which allows fluoride release and promotes remineralization of the dental structures[16,17].

Results

The prosthetic therapy of this case resulted withtwo balanced fixed prosthetic constructions that restore the lost teeth and are designedto more successfully oppose the transversal and sagittal forces in the horizontal direction. With our prosthetic therapy, we achieved satisfactory reconstruction of the esthetics in the facial lower third, reduction of the interocclusal space by performing a precise preparation, improved occlusion, and bridging of the interalveolar space caused by tooth extraction. The patient expressed improved phonetic and masticatory performances, no clinical manifestations or symptoms of TMJ dysfunction, better social well-being, and quality of life.

Discussion

In everyday dental practice, a clinical dilemma may arise regarding the treatment of choice for unilateral terminal edentulism: whether to fabricate a visil partial denture with a Bonwill clasp on the natural teeth, a conventional dental bridge, or a bridge-supported implant restoration[16]. However, the choice of prosthetic therapy in many cases also depends on the patient's financial circumstances. Some literature sources recommend treating unilateral terminal edentulism with a remobable (visil) partial denture incorporating Bonwill clasps on the natural teeth. This clasp also requires preparation of the natural teeth to create space for an occlusal rest or the fabri-

cation of custom crowns. However, the use of removable partial dentures in the management of unilateral shortened dental arches, or in cases requiring replacement of both lateral and anterior teeth in extended or fixed saddle areas, has demonstrated limited clinical and phonetic performance, while implant-supported prosthetic solutions remain costly. The fabrication of dental bridges, i.e., fixed prosthetic restorations, whenever clinical conditions allow, should be prioritized in the management of such cases. Fixed restorations enhance the perception of naturalness and comfort, provide improved structural stability of the bridge, and protect the remaining natural teeth from the forces exerted by clasps, which are directed into the infra- and supra-occlusal zones. The degree of mandibular prognathism further determines whether management should be limited to orthodontic therapy alone or require a multidisciplinary approach involving maxillofacial surgical intervention, prosthetic restorations, dental implants, and orthodontic treatment[17].

Conclusion

Precise tooth preparation is a critical factor in fabricating, dimensioning, and positioning of bridge constructions in patients with mandibular teeth overlapping maxillary teeth. In this case, during preparation of the maxillary teeth, greater reshaping was performed on the palatal surfaces toward the buccal direction. In contrast, during the preparation of the mandibular teeth, greater reshaping was carried out on the labial surfaces toward the lingual direction. Such tooth preparation approach allows a reduction of the interocclusal space in the anterior segment. Furthermore, it is essential to continuously monitor patients' feedback on newly made prosthetic restorations to facilitate faster adaptation and achieve an integrated esthetic, functional, and high-quality outcome. Furthermore, the sequential provision of the maxillary and mandibular dental bridges, followed by their simultaneous definitive cementation, allows reconstruction of the vertical dimension and correction of the occlusal relationship, as in complete dentures.

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RETENTION IN ORTHODONTIC PRACTICE
РЕТЕНЦИЈА ВО ОРТОДОНТСКАТА ПРАКТИКА

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Abstract

Introduction: Retention in orthodontics is an obligatory phase in orthodontic treatment designed to prevent relapse after the completion of orthodontic therapy. Relapses occur as a result of forces exerted by the periodontal fibers, which tend to return the teeth to their original position, thereby moving the teeth back to the position they were in before orthodontic treatment. Growth and changes in the surrounding soft tissues also affect the outcome of orthodontic treatment; therefore, retention after the completion of fixed appliance treatment is imperative in orthodontic practice. **Aim:** The aim of this article is to present and review different types of retention appliances, both removable and fixed, used in everyday orthodontic practice after treatment with fixed orthodontic appliances. **Material and methods:** To realize the set goals, we conducted a literature search of the PubMed/MEDLINE, Academia.edu, and Google Scholar databases covering the past twenty years and reviewed articles and books containing the following keywords: retention in orthodontics, removable and fixed retention appliances. **Results:** The results of our study and the analysis of the literature showed that both removable and fixed retention appliances are equally used and appropriate, with similar effects and reliability in maintaining the results achieved through orthodontic therapy. The combined type of retention is usually used after dental arch expansion, while fixed retention is used when tooth extraction has been performed. **Conclusion:** Retention is certainly one of the most important phases of orthodontic treatment. The most common type of retention is the combined type, using a fixed retainer and a removable appliance for the maxillary dental arch and a fixed retainer for the mandibular dental arch. The importance of cooperation between the patient and the orthodontist is enormous for achieving the most satisfactory long-term aesthetic and functional results. **Keywords:** retention in orthodontics, removable and fixed retention appliances.

Апстракт

Вовед: Ретенцијата во ортодонцијата е неопходна фаза по ортодонтскиот третман за да се спречи појавата на рецидив по завршувањето на ортодонтскиот третман. Рецидивите се јавуваат како резултат на силите од пародонталните влакна, кои имаат тенденција да се вратат во првобитната положба, а со тоа да ги поместат и забите во положбата во која биле пред ортодонтскиот третман. Самиот раст и промените во околните меки ткива, исто така, влијаат на резултатот од ортодонтскиот третман, оттаму ретенцијата, по завршениот третман со фиксни апарати, е императив во ортодонтската практика. **Цел:** Целата на овој труд е да се направи приказ и преглед на различни типови на подвижни и фиксни ретенциони апарати што се користат во секојдневната ортодонтска практика по третманот со фиксни ортодонтски апарати. **Материјал и метод:** За реализација на поставените цели, спроведовме истражување на базите на податоци на Pubmed/Medline, Academia Edu и Google Scholar, во изминатите дваесет години, како и анлиза на статии и книги што ги содржат следниве клучни зборови: ретенција во ортодонцијата, подвижни и фиксни ретенциони апарати. **Резултати:** Резултатите на нашите испитувања и анализата на литературните податоци покажаа дека подеднакво се применуваат и мобилните и фиксните ретенциони апарати, со слични ефекти и сигурност во однос на ретенцијата на резултатите добиени со ортодонтска терапија.Комбинираниот тип ретенција обично се користи по експанзија на денталниот лак, додека фиксните ретејнери обично се применуваат по спроведени екстракции. **Заклучок:** Ретенцијата е сигурно една од најважните фази во ортодонтскиот третман. Најчест е комбинираниот тип ретенција, со примена на фиксен ретејнер и подвижен апарат за максиларниот дентален лак и фиксен ретејнер во мандибуларниот дентален лак. Огромно е значењето на соработката помеѓу пациентот и терапевтот со цел да се добијат максимално задоволителни долготрајни естетски и функционални резултати.
Клучни зборови: ретенција во ортодонцијата, подвижни и фиксни ретенциони апарати.

Introduction

Retention is the final step of orthodontic treatment, the main purpose of which is to keep the teeth in the position achieved after orthodontic treatment, where they are properly aligned within the dental arch and proper occlusion has been achieved. While active orthodontic treatment is focused on correcting malocclusion and straightening the teeth, retention has the task of opposing the forces that tend to return the teeth to their initial position. Primarily, teeth move due to the elasticity of the gingival fibers, but also because of the forces produced by the muscles of the lips

and tongue, the pressure of the surrounding soft tissues, and the changes are influenced by the patient's age as well.

Unwanted tooth movement after orthodontic treatment can be directly proportional to the patient's age. Changes in the pressure of the soft tissue and skeletal structures around the teeth in combination with ongoing growth are part of the normal aging process and can be unpredictable. Therefore, retainers are not only indicated to prevent the force from returning the teeth to their original position before orthodontic treatment, but they also counteract the undesirable factors of aging[1].

In addition to the orthodontist's success, the desire and persistence of the patient are also important during the retention phase. Inchingolo et al.[2] reported relapse and re-crowding of the lower incisors when the retainers were worn for less than 9 hours per day. This emphasizes the need for longer retention, especially during the first months of post-orthodontic treatment.

Retention treatment includes different types of retainers, including fixed or removable appliances, depending on the specific condition and needs of the patient.

The large-scale production of materials, the study of biomechanics, and technological innovations have increased the need to improve existing designs and overcome their limitations, leading to the development of new retainers. Despite these advances, retention remains a subject of discussion among clinicians.Treatment time, different types of retainers, and protocols are topics that are most often discussed among orthodontists[3].

Aim

The purpose of this paper is to provide an overview of the different types of retention appliances used in everyday orthodontic practice, their basic characteristics, their application, the possibility of combining removable and fixed retention appliances, and the justification and significance of their application, all with the aim of improving the long-term outcome of post-orthodontic treatment.

Material and methods

The main tool in our study was a literature search of databases covering the last twenty years, including PubMed/MEDLINE, Academia.edu, Google Scholar, and relevant literature in the field of retention in orthodontic practice, focusing on evidence indicating the importance of retention, as well as the justification for the choice of specific retention appliances.

Results and Discussion:

Our analysis of the literature on the protocols and trends in orthodontic retention revealed that more than 40% of orthodontists combined fixed and removable retainers in different clinical situations. The first-choice option after expansion of the maxillary dental arch was the removable retainer (54.3%); meanwhile, a fixed retainer was used after correction of rotations in the mandibular anterior teeth (49.4%).[4]

For orthodontic retention in the upper dental arch, clinical preferences vary: fixed retainers were more often chosen in Switzerland[5] and the Netherlands[6], Hawley retainers in the USA[7] and Saudi Arabia[8], and vacuum-formed retainers in the UK[9], Ireland[10], and Malaysia[11]. A combination of a fixed and removable retainer in the form of a vacuum-formed retainer (VFR) was the most commonly used in Norway[12]; however, orthodontists in Lithuania gave priority to Hawley retainers (Table 1).

Table 1. Preferredtypes of retention in maxillary dental arch

	Authors	Country	VFR	Hawley retainer	Fixed retainer
Maxilla	Renkema at al.	Netherlands			x
	Meade at al.	Ireland	X		
	Singh at al.	UK	X		
	Vandevska-Radunovic at al.	Norway	X		x
	Lai CS at al.	Switzerland			x
	Pratt MC at al.	USA		x	
	Ab Rahman at al.	Malaysia	X		
	Al -Jewair TS at al.	Saudi Arabia		x	
	Padmos J. at al.	Denmark	X		x
	Abid MF at al.	Iraq		x	x
	Andriekute Aat al.	Lithuania		x	x

Table 2. Type of retention in different regions in mandibular dental arch

	Authors	Country	VFR	Hawley retainer	Fixed retainer
Mandibula	Renkema at al.	Netherlands			x
	Meade at al.	Ireland	X		
	Singh at al.	UK	X		x
	Vandevska-Radunovic at al.	Norway			x
	Lai CS at al.	Switzerland			x
	Pratt MC at al.	USA			x
	Ab Rahman at al.	Malaysia	x		
	Jans AD at al.	Denmark			x
	Abid MF at al.	Iraq		x	x
	Andriekute Aat al.	Lithuania		x	x

Lithuanian orthodontists[4] preferred a combination of a fixed and removable retainer in the upper and lower arches, except after expansion of the maxillary dental arch or correction of rotations of the mandibular anterior teeth. The reason for combined retention might be that orthodontists are concerned about the tendency for relapse and about patients who are not compliant with wearing their removable retainer as prescribed. Additionally, the findings of the study by Atack et al.[13] showed similar results for fixed and removable retainers and confirmed that relapse of the lower anterior teeth can occur with both types of retainers.

Studies performed in other European countries[5,6,9,12], the USA[7], Saudi Arabia[8], and Australia and New Zealand[13] showed that fixed retainers in the mandibular dental arch were dominant, except in Ireland[10] and Malaysia[11], where vacuum-formed retainers were the most popular choice (Table 2).

According to the literature, fixed retainers are among the most commonly used appliances during the orthodontic retention phase. Since they cannot be detached for cleaning, the accumulation of plaque and tartar is increased, so maintaining excellent oral hygiene is crucial. Since the bonding and attachment of the retainer to the tooth are critical factors, they must be regularly checked, and care must be taken to ensure that they do not come loose at any point. Various types of occasional, unwanted tooth movements have been observed in cases of incorrectly placed retainers or debonding of the retainer from a tooth.

Inchingolo et al.[2] (2023) compared the benefits of fixed and removable retainers and showed that both types reduce the possibility of relapse, but there are situations in which 24-hour retention is required, and a fixed retainer is preferred in cases where there is a higher risk of relapse, such as: after diastema closure in cases with spacing (including median diastema); after space creation before prosthetic treatment; in patients with reduced periodontal support; or after correction of large rotations.

A combination of fixed and removable retainers is often chosen in a process called double retention. In the Netherlands,[6] most orthodontists are using a bonded retainer in the upper and lower arch, except when the upper arch was expanded during treatment or when extractions were performed in the upper arch, in which case they placed a removable retainer or used double retention.

A recent Cochrane review by Littlewood et al.[15] on retention methods showed that there is insufficient evidence to support the best retention protocol. As a result, each practitioner should develop their own protocol based on clinical experience and market availability, but also taking into account the patient's needs, expectations, and conditions.

From the group of fixed retainers, palatal retainers are less commonly used than lingual retainers due to the possibility of detachment due to contact with antagonists or during biting. However, they are necessary for retention at the end of treatment, especially in adults, since many patients develop diastemas or other movements of the incisors in the absence of a retainer. The patient's overjet and overbite must be considered, and the retainer should be placed further away from the contact surface with the antagonist teeth.

As for the lingual retainers, certain authors such as McLaughlin, Bennett, and Trevisi[16] concluded that a mandibular fixed canine-to-canine retainer is the best option for retention in all patients at the end of treatment. In cases where first premolars have been extracted, this retainer is placed on the mesial fossae of the second premolars.

Fixed retainers are usually used in situations where instability in the occlusal relationship is expected and long-

term retention is planned. There are four main indications for their use: the first is to maintain the position of the lower incisors during late growth. The main reason for the occurrence of crowding of the mandibular incisors in late adolescence in those who have had and those who have not had previous orthodontic treatment is the physiological growth of the mandible. Especially if there was crowding in the region of the mandibular incisors before treatment, even a small mandibular growth between the ages of 16 and 20 can cause a reappearance of incisor crowding.[17] Recurrence is usually accompanied by lingual inclination of the central and lateral incisors. In these cases, in order to avoid distortion of the material, a wire of appropriate thickness should be placed; therefore, a 28–30 mil steel wire is placed from canine to canine. Booth et al.[18] (2008) in their study concluded that, with regular controls, patients who wore this type of retainer for more than 10 years showed no relapse or signs of periodontal problems.

The second indication for the use of these retainers is the retention of closed diastemas. In cases of median diastema, although frenectomy has been performed, there is still a tendency for recurrence in certain cases. The retainer should be contoured so that it fits close to the cingulum so that it is out of occlusal contact. A flexible wire should be used in order to allow functional movement of the teeth and at the same time to hold them together.

The third indication for a fixed retainer is to maintain a space that was created for a bridge pontic or implant. A fixed retainer reduces the mobility of the teeth on which a bridge is planned to be made and provides stability before definitive prosthetic restoration. The preferred way to maintain space in the posterior region is a strong intracoronary wire bonded to the adjacent teeth (with shallow preparations where the future bridge abutments will be). For maintaining spaces in the anterior region, in cases of trauma or hypodontia, it is necessary to place a replacement tooth connected to a mobile retainer. It is satisfactory for short periods and until adolescent vertical growth is complete; therefore, it is preferable to place a fixed retainer in the form of a bridge.

The other indications for fixed retainers are the maintenance of closed extraction spaces in adults. According to Axelsson and Zachrisson[17], a fixed retainer can be placed on the labial surface of the posterior teeth in adults, when the spaces have been closed, especially when skeletal anchorage was used to bring the posterior teeth forward over a greater distance.

In the group of different types of retention appliances, removable orthodontic appliances have a special place in everyday orthodontic practice. Among the most used removable retainers is Hawley retainer named by the author[19]. It is an acrylic retainer with a labial bow, which whose main purpose is to act on the teeth, keeping them straight in the desired position after orthodontic treatment.

The acrylic base lies on the palate or envelops the lingual surfaces of the lower teeth. Ramazanzadeh et al.[20] emphasize the effectiveness of the labial bow in controlling the torque of the frontal teeth. According to Lyros et al.[21], the passive Hawley retainer is the most well-known and used removable retainer for many years. Their variations include the use of teardrop or equatorial clasps instead of Adams clasps, which are easy to make and do not irritate the gingiva, but are contraindicated in patients with short clinical crowns[22].

Although used in many cases, over time, different Hawley modifications have also appeared, such as: the Wrap-around retainer, with an extended labial arch to the premolars; the Aesthetic (Astycs) retainer, which is an aesthetic variant of the traditional Hawley retainer; and the Reinforced Removable Retainer (RRR), where the acrylic base is reinforced with a metal mesh, and small balls are added to the retention hooks at the end parts[20].

Chagas et al.[22] highlighted the following advantages of mobile Hawley retainers: easy fabrication; affordable price for patients; easy maintenance of hygiene; comfort during wear; and good patient acceptability. They compared 70 subjects who were in the retention phase. Patients wore a Hawley retainer and a thermoplastic retainer for 1 month. Their conclusion was that the Hawley retainer was better in maintaining hygiene and was more resistant to damage than the thermoplastic retainer, while the thermoplastic retainer was more acceptable to patients in terms of swallowing liquids and saliva[21].

Regarding the maintenance of hygiene of acrylate retainers, Topaloglu et al.[23] stated that in patients who wore removable retainers for 6 months, bacteria of the type Streptococcus mutans and Lactobacillus spp. were present.

Wan et al.[24] concluded that removable retainers could affect speech as well. Their study was conducted on 20 volunteers from the Chinese-speaking area and a comparison was made between speech with a Hawley retainer and with a thermoplastic vacuum-formed retainer. Their conclusion was that the Hawley retainer had a greater impact on speech changes than the thermoplastic retainer. Regarding relapse, in cases of rotated teeth before orthodontic treatment, Littlewood et al.[25] concluded that the Hawley retainer showed weaker effectiveness and a higher relapse rate of rotated teeth compared to other removable retainers[15].

The more recent retention devices are vacuum-formed retainers (VFRs), which are also referred to in the literature. The first to use these appliances was Pontick, who introduced Essix retainers, removable thermoplastic retainers, invisible retainers, or overlay retainers (VFR), and later Sheridan[26] further developed them. VFRs are the most commonly used retention devices in Ireland, Australia, and

the United Kingdom.

There are two types of VFR designs that have been described. The original Essix retainer is a canine-to-canine design initially[29,30,31,32], while the other type—VFRs—cover the entire occlusal surface[33,34,35,36] or are extended to the most distal molar present[37,38]. The margins of the VFR extend 1–2 mm buccally and 3–4 mm lingually to the gingival margin[39]. Advantages of these types of retainers are aesthetics, patient acceptability, quick and easy fabrication, and affordable price[39,40,41,42], and disadvantages are compromised retention in areas with gingival hyperplasia, possibility of breakage, potential demineralization, caries, and gingival problems if drinks are consumed while wearing the retainer.

When it comes to stability after orthodontic treatment connected with the type of retention, most studies have focused on the position of the lower incisors, as this represents the most noticeable relapse and the most common patient complaint. The Little Irregularity Index (LLI)[41] is most often used to determine this irregularity. Additional measurements in retention studies include intercanine width, intermolar width, overjet, overbite, and arch length. These retainers have no adverse effects on dental and periodontal health compared with bonded retainers, are more acceptable to wear, and cause less difficulty in speaking compared to acrylic retainers. They break more easily than acrylic retainers, especially the lower ones and along the midline. If they are not worn, relapse is inevitable[43,44].

The studies confirmed that VFR is as effective as an acrylic retainer in terms of post-treatment stability, but less effective than a bonded retainer when it comes to incisal alignment[45,46,47,48].

For enhancement of retention in orthodontics, supplementary methods such as pericision and interproximal reduction (IPR) are suggested. These are additional procedures that affect the hard and soft tissues in order to reduce the possibility of relapse and to help maintain the alignment of the teeth and jaws achieved at the end of the active phase of treatment. Interproximal reduction (IPR), as an additional measure to aid retention, was proposed by Peck and Peck[49] to increase post-treatment stability of the position of the lower incisors.

With pericision, an incision of the periodontal fibers around the necks of the teeth is performed in order to prevent relapse of the previous tooth position due to the pressure of the periodontal fibers during therapy. Sometimes it is referred to as a supracrestal circumferential fiberectomy[50]. Certain authors such as Anjali Koul et al.[48] (2022) consider that pericision has limited effectiveness when it comes to retention, especially in the maxilla, and its role in long-term stability is debatable. They emphasized that it should be performed only in cases with a good gingival biotype, sufficient cortical bone, minimal or no recession, and excellent oral hygiene. Since it is still a surgical procedure, it should be reserved for cases with significant tooth rotation.

Study conducted by L.R. Boese[51] examined the stability of mandibular incisors four to nine years after treatment using circumferential supracrestal fibrotomy and IPR. They concluded that these procedures could increase stability in the mandibular anterior region without the use of retainers. IPR is included in all three phases of treatment: the first phase is during early treatment, when the lower incisors are aligned; the second, soon after the removal of the fixed appliance; and the third, when the contact points are too close and it is observed that the teeth are no longer properly aligned.

Maintaining the intercanine width at the same dimension is crucial in order to increase the chances of successful retention, and if IPR is used instead of expansion in the lower anterior region, the chances of maintaining the desired width are greater.

Conclusion

There are various factors which influence the final stability of teeth after treatment. Appropriate orthodontic diagnosis, treatment planning, and the achievement of appropriate occlusal and soft tissue treatment outcomes are the key factors for reducing orthodontic relapse.

Orthodontic retention and relapse continue to be one of the biggest challenges in orthodontics, and the role of patient compliance is important, as well. The type of retention depends on the movements and corrections that have been achieved and it is maintained with a combination of fixed and removable retainers. For the maxillary dental arch, retention usually is combined with the use of a removable and a fixed retainer, especially when there was an expansion in the maxilla, and for the mandibular dental arch, usually a fixed retainer is placed or a vacuum-formed retainer is used.

In order to prevent unwanted post-treatment changes and to avoid an unpredictable amount of post-treatment tooth movement, it is important to emphasize at the beginning of orthodontic treatment the importance of the passive phase of orthodontic treatment and the role and significance of proper wear of retention appliances.

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ASSESMENT OF THE DIMENSIONS, FORM AND SIZE OF THE MAXILAR AND MANDIBULAR DENTAL ARCH IN INDIVIDUALS WITH MALLOCLUSION II CLASS 1 BY ANGLE

ПРОЦЕНА НА ДИМЕНЗИИТЕ, ФОРМАТА И НА ГОЛЕМИНАТА НА МАКСИЛАРНИОТ И МАНДИБУЛАРНИОТ ДЕНТАЛЕН ЛАК КАЈ ИСПИТАНИЦИ СО МАЛОКЛУЗИЈА II КЛАСА 1 ОДДЕЛЕНИЕ СПОРЕД ANGLE

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Abstract

Malocclusion represents a morphological and functional change in the orofacial region, including the teeth in both jaws. It is both a skeletal and developmental change, which is mostly genetically determined. Compared to normal occlusion, it is a deviation, and compared to ideal occlusion, it represents an extreme variation. Irregularities in the mutual relationships of the teeth and in their position, as well as the mutual relationship of the jaws are its most striking components. Orthodontic diagnostics places great emphasis on the dimensions of the dental arches. Their dimension, shape and size are mostly genetically determined, but it is often under external influences during craniofacial growth and development. According to the obtained values for each parameter separately, the orthodontist will decide whether to proceed with the extraction of individual teeth or to proceed with the expansion of the dental arches, for each patient individually. **Aim of the study:** is to compare the dental arches of patients with Class II/1 malocclusion according to Angle, with the dental arches of patients with Class I malocclusion according to Angle, by measuring the following parameters: intercanine width of maxillary and mandibular dental arch, interpremolar and intermolar maxillary and mandibular dental arch width, dental arch height, dental arch length, palatal depth, and rotation of the first molars. **Methods and materials:** In order to achieve the set goals, gnatomethric analyzises were performed on 80 subjects from 12 to 18 years old, of which 40 have malocclusion class II/1 according to Angle and the remaining 40 subjects represent the control group of the same age, with malocclusion class I according to Angle, defenses by the method of random selection. Gnathometric analysis was performed with a two-pronged caliper and an orthometer with millimeter division according to Korkhaus. **Results:** The statistical processing of the obtained values for the given parameters indicate that subjects with malocclusion II class 1 grade according to Angle have lower values for intercanine, interpremolar and intermolar width compared to subjects from the control group. Regarding the height of the dental arches and the height of the palate, the values are significantly higher in contrast to the subjects with malocclusion class I according to Angle. Our research observed smaller parameters of the dental arches in the studied group, and the rotation of the first maxillary molars is of a higher degree compared to the subjects in the control group. Our results are similar to the results obtained by numerous authors of papers in the field of orthodontics in the past decades. **Conclusion:** Patients with Angle class II Division 1 malocclusion have narrower dental arches in the transverse plane, have a deep palate, and the maxillary first molars are rotated, thus occupying more space in the maxillary dental arch. Early diagnosis of this malocclusion and its timely treatment will lead to correct orofacial functions, but also emphasizing aesthetics, as a priority of patients and their requirements. At the time, it will enable the proper growth and development of the orofacial region. **Key words:** malocclusion, dental arches, maxillary width, mandibular width.

Апстракт

Малоклузијата претставува морфолошка и функционална промена во орофацијалната регија, вклучувајќи ги забите во двете вилици. Таа е скелетна и развојна промена, која најчесто е генетски условена. Во однос на нормалната оклузија, таа е девијација, а споредено со идеалната оклузија, претставува екстремна варијација. Неправилностите во заемните односи на забите, а и во нивната положба, како и меѓусебниот однос на вилиците се најзините најпечатливи компоненти. Ортодонтската дијагностика става голем акцент на димензиите на денталните лакови. Нивната димензија, форма и големина се најчесто генетски условени, но често се и под надворешни влијанија за време на краниофацијалниот раст и развој. Според добиените вредности за секој параметар посебно,

ортодонтот ќе одлучи дали ќе пристапи кон екстракција на одредени заби или, пак, ќе пристапи кон експанзија на денталните лакови, за секој пациент индивидуално. **Цел на трудот:** Основна цел на оваа студија е да се споредат денталните лакови кај пациенти со малоклузија II класа 1-во одделение според Angle, со денталните лакови кај пациенти со малоклузија I класа според Angle, преку мерење на следниве параметри: интеркаинска ширина на максиларен и мандибуларен дентален лак, интерпремоларна и интермоларна ширина на максиларен и мандибуларен дентален лак, висина на денталните лакови, должина на денталните лакови, длабочина на непце и ротација на први молари. **Метод и материјали:** За реализација на поставените цели, извршени се испитувања кај 80 испитаници од 12 до 18 години, од кои 40 се со малоклузија II класа 1-во одделение според Angle, а другите 40 испитаници ја претставуваат контролната група на иста годишна возраст, со малоклузија I класа според Angle, одбрани според методот на случаен избор. Гнатометриската анализа беше извршена со двокрак шестар и ортометар со милиметарска поделба според Коркхаус (Korkhaus). **Резултати:** Статистичката обработка на добиените резултати за дадените параметри укажува на фактот дека испитаниците со малоклузија II класа, 1-во одделение, според Angle, имаат помали вредности за интеркаинината, за интерпремоларната и за интермоларната ширина во однос на испитаниците од контролната група. Во однос на висината на денталните лакови и висината на непцето, вредностите се значајно поголеми за разлика од испитаниците со малоклузија од 1 класа според Angle. Нашето истражување забележа помали параметри на денталните лакови кај испитуваната група, а ротацијата на првите максиларни молари е со повисок степен во однос на испитаниците во контролната група. Нашите резултати се слични со резултатите добиени од многубројни автори на трудови во областа на ортодонцијата во изминатите децении. **Заклучок:** Пациентите со малоклузија II класа, 1-во одделение според Angle имаат потесни дентални лакови во трансверзална рамнина, имаат длабоко непце и првите максиларни молари се ротирани, со што заземаат поголем простор во максиларниот дентален лак. Раното дијагностицирање на оваа малоклузија и нејзино навремено третирање ќе доведе до правилни орофацијални функции, но нагласувајќи ја и естетиката, како приоритет на пациентите и нивните барања. Воедно, ќе овозможи непречен правилен раст и развој на орофацијалната регија. **Клучни зборови:** малоклузија, дентални лакови, максиларна ширина, мандибуларна ширина.

Introduction

Orthodontics, as a branch of dentistry, primarily aims to achieve proper alignment of the teeth within the dental arches, thereby improving the function of the entire orofacial system. In addition, through orthodontic therapy and correction of orthodontic anomalies, orthodontics plays a significant role in enhancing facial aesthetics and creating a smile that meets patients' aesthetic expectations.

For this purpose, prior to initiating therapy, the orthodontist must assess growth and development individually for each patient, calculate dental, skeletal, and soft-tissue parameters, and identify changes resulting from the orthodontic anomaly. These evaluations serve as a guideline for establishing an accurate diagnosis and implementing appropriate orthodontic treatment.

Normal occlusion and articulation between the teeth of both jaws are prerequisites for proper function of the entire dentoalveolar complex. Any deviation from normal occlusion affects intercuspation and may manifest not only in dentoalveolar structures but also in soft tissues.

According to Moyers, human dentition and dental arch dimensions continuously change until maturity. During craniofacial growth, changes in facial dimensions and proportions occur in the vertical and sagittal planes, while the shape and size of dental arches are significantly influenced by changes in various cranial components[1].

Kanurkova states that postnatal growth of the orofacial complex is a multifunctional and complex phenomenon strongly influenced by genetic factors. In addition to genetics, orofacial functions significantly impact facial morphology. Increasing evidence suggests that impaired orofacial functions can alter the growth, shape, and width of dental arches in both jaws[2].

Orofacial functions are broadly divided into two groups: digestive functions, including sucking, mastication, and swallowing, and non-digestive functions, including respiration, speech, and facial expression.

Early childhood is a critical period for palatal development and represents an ideal time to initiate orthodontic treatment if indicated. If a narrow palate develops during this period and remains untreated, it will persist throughout life. In such cases, the maxillary dental arch is also narrow, resulting in insufficient space for tooth alignment. Consequently, teeth are positioned closer to the median palatine raphe, leading to posterior crossbite formation[2].

Malocclusion represents a morphological and functional alteration of the orofacial region involving teeth in both jaws. It is both a skeletal and developmental anomaly, most commonly genetically determined. Relative to normal occlusion, it represents a deviation, while compared to ideal occlusion, it constitutes an extreme variation. Irregularities in tooth position, interarch relationships, and jaw relationships are its most prominent features.

In 1899, Angle introduced his classification of malocclusions, which remains widely used today. It represents a diagnostic systematization of orofacial anomalies and is the primary classification used in orthodontics[3].

Angle Class II Division 1 malocclusion is characterized by an anteroposterior discrepancy between maxillary and mandibular dental arches, with the mandibular teeth positioned distally relative to the maxillary teeth and labial inclination of the maxillary incisors[3].

However, Angle Class II Division 1 malocclusion is not a simple clinical entity but rather a combination of multiple morphological forms resulting from genetic

determinants, muscular activity patterns, and local dentoalveolar factors[4].

This malocclusion occurs in deciduous, mixed, and permanent dentitions. Although genetic factors play a crucial etiological role, impaired orofacial functions and deleterious habits significantly contribute to increased sagittal severity.

Transverse dimensions of dental arches in both jaws are essential for dentoalveolar development. Some authors report a higher prevalence of malocclusions today compared to earlier periods. Comparisons of ancient skulls with modern populations indicate that intermaxillary transverse discrepancies are relatively recent anomalies[5].

Changes in dietary habits over recent centuries have been implicated. Increased consumption of processed foods reduces physiological loading of masticatory muscles, leading to insufficient stimulation of craniofacial growth and resulting in transverse compression of dental arches[5].

Transverse growth of the stomatognathic system is most intense around six years of age, with another growth phase occurring before and during puberty. This growth is most pronounced in the auricular, zygomatic, and gonial regions. Intraorally, transverse growth is most evident in the canine region[3].

In addition to arch width, palatal depth has also changed. Studies of ancient skulls reveal shorter dental arches and shallower palates compared to modern standards[6].

Orthodontic diagnostics place significant emphasis on dental arch dimensions. While arch size, shape, and dimensions are genetically determined, they are also influenced by environmental factors during craniofacial growth[7]. Based on these parameters, orthodontists decide between tooth extraction and dental arch expansion[8].

Key criteria for diagnosing malocclusions include dental arch width and palatal depth. Numerous studies demonstrate correlations between arch form, intercanine and intermolar width, and orthodontic anomalies[9-11].

Transverse parameters of maxillary and mandibular dental arches play a crucial role in smile aesthetics. In transverse discrepancies, maxillary first molars often compensate buccally to prevent crossbite, resulting in palatal cusps positioned below the Wilson curve[9].

Material and methods

This study was performed on study casts of80 individuals aged 12–16 years. Forty subjects presented with Angle Class II Division 1 malocclusion, while 40 subjects with Angle Class I normal occlusion formed the control group, selected randomly.

Gnathometric analyses were performed on plaster models using the methods of Schwartz[4], Korkhaus[4], Howe[12], Lamons and Holmes[13], and Pont[14]. Models were obtained from anatomical impressions of both jaws using elastic impression material (Alligat, Heraeus Kulzer) and articulated with an individual wax bite.

Measurements were conducted using orthodontic instruments including a three-dimensional Korkhaus compass, digital caliper, two-point compass with millimeter scale, agglomerate, and orthocross ruler.

The following parameters were measured:

1. **Maxillary and mandibular intercanine width** – distance between canine cusp tips (Pont method[14]).
2. **Interpremolar width (anterior width) of the maxillary dental arch** – represents the distance between the distal points of the deepest part of the central fissures of the first maxillary molars. It is measured according to the Schwartz method[14].
3. **Interpremolar (anterior width) of the mandibular dental arch** – represents the distance between the points located at the apex of the angle between the mesial and distal sides of the second premolar. It is measured according to the Schwartz method[14].
4. **Maxillary intermolar width** – distance between deepest points of the central fissures of first molars (Schwartz method1[4]).
5. **Mandibular intermolar width** – distance between buccal cusp tips of first mandibular molars (Schwartz method1[4]).
6. **Dental arch height** – the distance from the most labially placed central incisor to the line joining the anterior widths of the dental arches is measured. It is measured in the upper and lower jaw. It is measured according to the Schwartz method[4].
7. **Palatal depth** – measured with a three-dimensional Korkhaus compass (Korkhaus method1[4]).

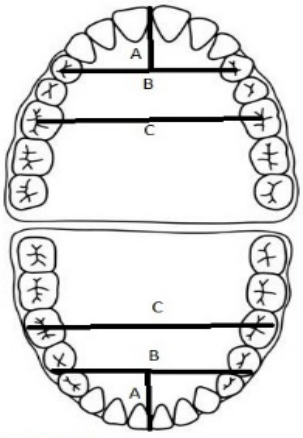

Figure 1. *Illustration of measurement points for anterior and posterior width, and height of dental arch according to Schwatz.*

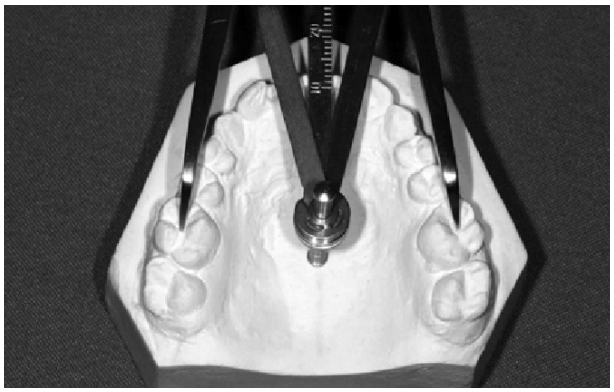

Figure 2. Illustration of measuring palatal depth with a three-dimensional compass according to Korkhaus.

Figure 3. Illustration of a method for measuring the perimeter of a dental arch with a flexible wire.

8. **Dental arch perimeter**-according to the Howe method, it represents the sum of the mesiodistal diameters of the maxillary and mandibular teeth, including the incisors, canines, premolars, and first molar[14].

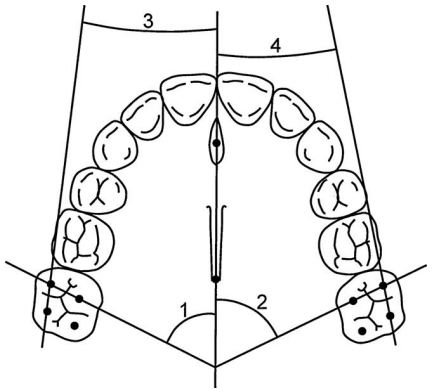

Figure 4. Illustration of the method of measuring the rotation of the maxillary first molars according to the Lamos FF method and Holmes CW.

9. **Rotation of maxillary first molars**-angle formed between the median palatine raphe and a line connecting mesial cusps (Lamons and Holmes method[13]).

The study included anamnesis, clinical examination, impression taking, model casting, and parameter analysis. Written informed consent was obtained from patients and parents.

Results

The study was conducted on study models of 80 subjects, i.e., children aged 12 to 16 years, with permanent dentition, of which 40 had Class II Division 1 malocclusion according to Angle and the remaining 40 had Class I malocclusion according to Angle representing the control group,The following parameters were analyzed: interca-

Table 1. The difference between the study group and the control group for intercanine maxillary and mandibular width and intermolar maxillary and mandibular width.

Parameter	Rank Sum class II/1 by Angle	Rank Sum class I by Angle	U	Z adjusted	P level	N	N
Maxillary intercanine width	1167.5	2072.5	347.5	-4.4	0	40	40
Mandibular intercanine width	1627.5	1612.5	792.5	0.07	0.94	40	40
Maxillary interpremolar width	947	2293	127	-6.52	0	40	40
Mandibular interpremolar width	1445	1795	625	-1.71	0.09	40	40
Maxillary intermolar width	933.5	2306.5	113.5	-6.65	0	40	40
Mandibular intermolar width	1987.5	1252.5	432.5	3.57	0	40	40

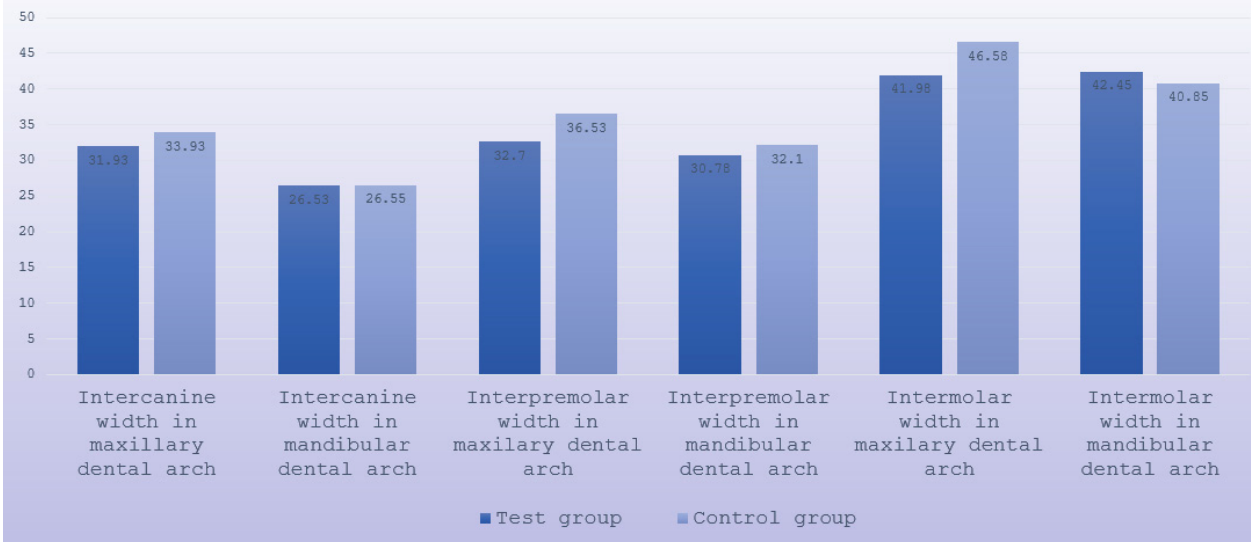

Chart 1. *Graphical representation of the difference between the mean values for intercanine, interpremolar and intermolar width in the maxillary and mandibular dental arches in test and control group.*

nine width, interpremolar width, intermolar width, palatal depth, arch height, arch perimeter, and rotation of the first maxillary molars.

Statistical analysis of the measurements obtained from the study models of both the experimental and control groups highlights the characteristic features of Angle Class II Division 1 malocclusion. The present studyidentified the morphological characteristics of the dental arches associated with this malocclusion, including the dimensions, shape, and size of the maxillary and mandibular dental arches.

Differences between the experimental and control groups in maxillary and mandibular intercanine width, as well as maxillary and mandibular interpremolar and intermolar width, are presented in Table 1.

Statistical analysis showed the following results: the height of the maxillary dental arch in the study group for

Table 2. The difference between the values for the test group and the control group of subjects for height of dental arches

Parameter	Rank Sum class II/1 by Angle	Rank Sum class I by Angle	U	Z adjusted	P level	N	N
Height of maxillary dental arch	1864.5	1375.5	556	2.39	0.02	40	40
Height of mandibular dental arch	1537	1703	717	-0.81	0.42	40	40

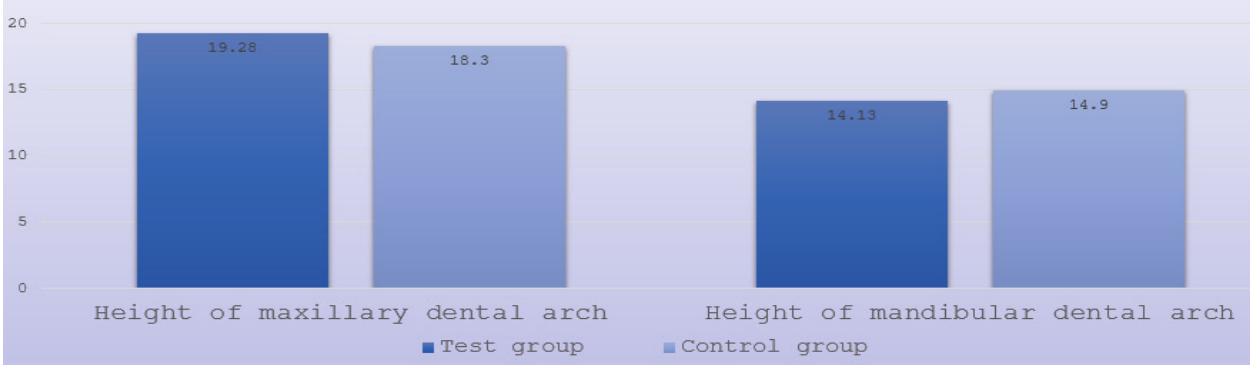

Chart 2. *Graphical representation of the difference between the mean values for the height of dental arches in test and control group.*

Table 3. The difference between the values for the test group and the control group of subjects for palate depth.

Parameter	Rank Sum class II/1 by Angle	Rank Sum class I by Angle	U	Z adjusted	P level	N	N
Palatal depth	1304	1936	484	-3.1	**0.002**	40	40

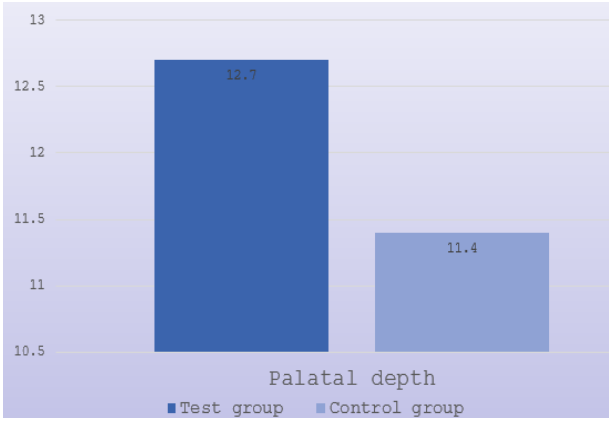

Chart 3. *Graphical representation of the difference between the mean values for the palatal depth in test and control group.*

Z=2.39 and p<0.05(p=0.02) is significantly higher than the height of the maxillary dental arch in the control group.

While the height of the mandibular dental arch in the control group for Z=- 0.81 and p>0.05(p=0.42) is insignificantly higher than the height of the mandibular dental arch in the study group.Differences between the experimental and control groups in the height of the dental arches are presented in Table 2.

Palatal depth was analyzed in individuals with Angle Class II Division 1 malocclusion and in individuals with Angle Class I malocclusion. Based on the obtained results, the difference in palatal depth between the experimental and control groups is presented in Table 3.

The results of the present study indicate that palatal depth in the experimental group was significantly smaller compared to that in the control group ($Z = -3.10$; $p < 0.01$).

Table 4. The difference between the values for the test group and the control group of subjects for height of dental arches

Parameter	Rank Sum class II/1 by Angle	Rank Sum class I by Angle	U	Z adjusted	P level	N	N
Perimeter of maxillary dental arch	1722.5	1517.5	697.5	1	0.32	40	40
Perimeter of mandibular dental arch	1262.5	1977.5	442.5	-3.49	0	40	40

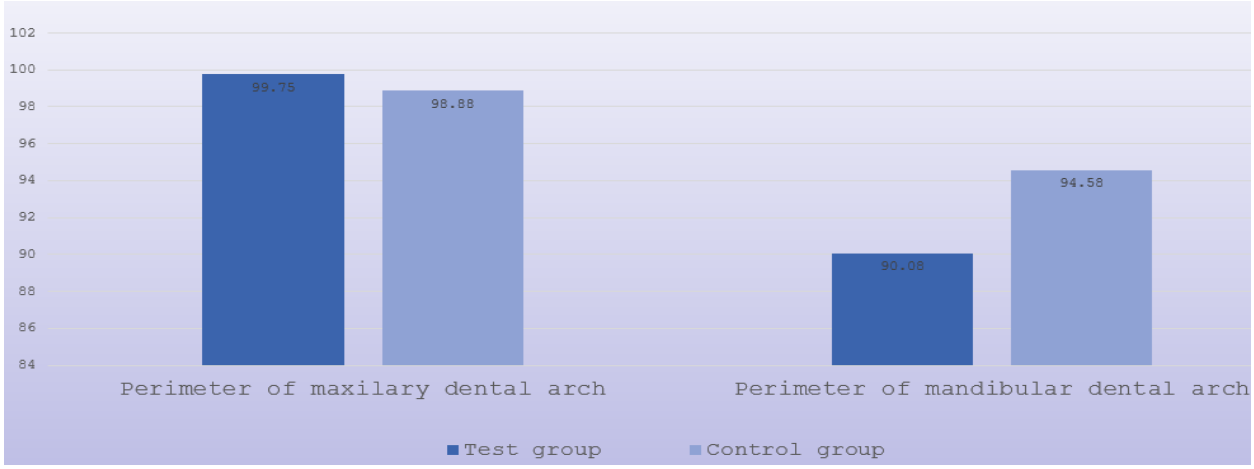

Chart 4. *Graphical representation of the difference between subjects from the study group and the control group for the perimeter of the maxillary and mandibular dental arch in the study and control groups of subjects.*

Table 5. The difference between the rotation values of left and right maxillary molars in the study and control groups of

Parameter	Rank Sum class II/1 by Angle	Rank Sum class I by Angle	U	Z adjusted	P level	N	N
Rotation of left maxilary molars	1361.5	1878.5	541.5	-2.51	0.01	40	40
Rotation of right maxilary molars	1477.5	1762.5	657.5	-1.38	0.17	40	40

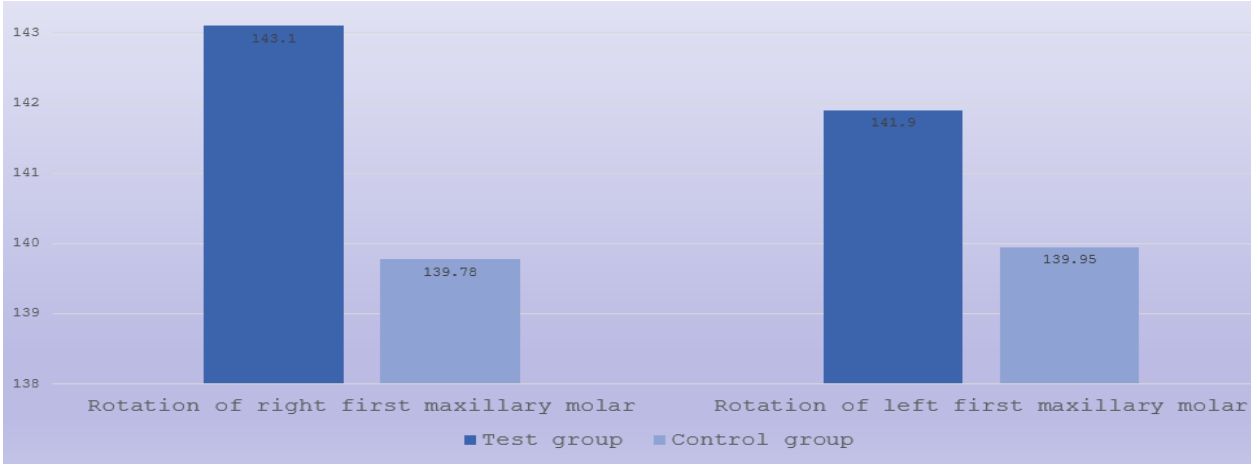

Chart 5. *Graphical representation of the difference between the mean values for rotation of the first maxillary molars in the study and control groups of subjects.*

According to our research, the maxillary dental arch perimeter in the study group for Z=1.00 and p>0.05(p=0.32) is insignificantly lower than the perimeter of the maxillary dental arch perimeter in the control group.

While, the perimeter of the mandibular dental arch in the control group for Z = - 3.49 and p<0.001(p=0.000) is significantly higher than the mandibular dental arch perimeter in the study group.

Differences between the experimental and control groups in the rotation of left and right maxillary molars are presented in Table 5.

According to the statistical analysis, rotation of the left maxillary molars in the experimental group was significantly greater than that observed in the control group ($Z = -2.51$; $p < 0.05$).

With regard to the rotation of the right maxillary molars, the experimental group showed slightly greater rotation compared to the control group; however, this difference was not statistically significant ($Z = -1.38$; $p > 0.05$).

Discussion

The most important goal of orthodontic treatment is to establish and maintain normal occlusion. Therefore, it is necessary to have a greater understanding of changes ocurring in the dental arches and in the entire orofacial region, particulary in patients during growth and development. Regarding early orthodontic treatment, knowledge of the dental arch parameters and their deviations from normal in the sagittal, vertical, and transverse planes is crucial for orthodontists and their treatment planning. Due to the high prevalence of dental arches crowding, knowledge of the morphological characteristics of this malocclusion is key for treatment planning. Motivated by this, in addition to anamnesis and clinical examination, we performed an analysis of gypsum models of patients with Class II Division 1 malocclusion according to Angle and compared them with a control group consisting of subjects with Angle Class I malocclusion.

To determine the morphological features of the dentofacial system in individuals with Class II Division 1 malocclusion according to Angle, we analyzed gypsum models. The aim of our study was to determine the size, shape, and dimensions of the dental arches, transverse relationships, and displacement of the teeth and bony structures in the orofacial region using gnatometric analysis, which reflects the degree of malocclusion.

Starting from the hypothesis question of whether Class II Division 1 malocclusion according to Angle

affects the shape and size of the maxillary and mandibular dental arches, and considering the numerous studies addressing this issue in the scientific literature, we examined the dimensions, shape, and size of the dental arches in patients with this malocclusion.

Analysis and statistical processing of the obtained results indicate differences in the dimensions, shape, and size of the dental arches between the examined and control groups.

The subject of our study was intercanine width in the maxillary and mandibular dental arches. The mean value for intercanine width of the maxillary dental arch in the study group was 31.93 mm, while 33.93 mm in the control group. Thus, it was shown that the maxillary intercanine width in the control group is significantly greater compared to the maxillary intercanine width in the study group. This difference in intercanine width values showed high statistical significance with a coefficient of $p<0.001$ ($p=0.000$).

On the other hand, the mandibular intercanine width in the study group was 26.53 mm, which is insignificantly smaller compared to the mandibular intercanine width in the control group, which was 26.55 mm. This indicates that there is no significant difference in the values for this parameter, with a coefficient of $p>0.05$ ($p=0.94$).

These findings are consistent with the results of Rajiv Yadav15, who found that intercanine width in the maxillary dental arches has higher values in patients with Class II Division 1 malocclusion according to Angle, compared to patients with Angle Class I malocclusion. In contrast, intercanine width in the mandibular dental arches does not show a significant difference between subjects of the two groups.

Intermolar width of the dental arch is a parameter that plays an important role in the transverse dimensions of the dental arches and in occlusion in each individual. During crossbite therapy, the most important parameter for correction is intermolar width, i.e., it is most important to achieve expansion of the dental arch in the transverse plane. However, increasing intermolar width can also be for aesthetic reasons, i.e., filling the buccal corridors to achieve a "broad smile," which is of great importance to patients. The results of our study on the intermolar width of the maxillary dental arch show that its value is significantly greater in the control group, where the mean value for this parameter is 46.58 mm, compared to the study group, where the mean value is 41.98 mm. This indicates high statistical significance with a coefficient of $p<0.001$ ($p=0.000$).

In the analysis of intermolar width in the mandibular dental arch, we concluded that there is a significant difference in the values for this parameter between subjects from the control and study groups, with a coefficient of $p<0.001$ ($p=0.000$). The mean value for intermolar width in subjects with Class II Division 1 malocclusion according to Angle is 42.45 mm, while in subjects with Class I malocclusion according to Angle it is 40.85 mm.

Intermolar width was also examined in the study by Mustafa Raja Abalgadir[16]. He reports that individuals with Class II Division 1 malocclusion according to Angle have narrower maxillary intercanine and intermolar widths. He emphasizes the necessity of therapy to expand the maxillary dental arches in the transverse plane in the treatment of patients with Class II malocclusion according to Angle.

To better and fully explain the morphological characteristics of Class II Division 1 malocclusion according to Angle, we also analyzed palatal depth. Numerous authors[15-17] indicate that a compressed maxillary dental arch together with a "gothic" palate is characteristic of individuals with Class II Division 1 malocclusion according to Angle. However, Aznar T.[17] states that a high V-shaped palate is a genetic characteristic. In the examination of monozygotic twins, it was found that they have the same palatal height. This suggests that palatal height is under genetic control. The morphology of the palate plays an important role in defining the facial pattern of an individual. A symmetrical face is characterized by proper occlusion and good relationships between the bony elements of the entire stomatognathic system. Therefore, analysis of dental arch dimensions is fundamental in orthodontic treatment planning.

In the analysis of the palatal depth parameter, it was shown that this value is significantly greater in the study group, where the mean value is 12.70 mm, compared to the control group, where the mean value is 12.70 mm. This statistical difference showed high significance, with a coefficient of $p<0.01$ ($p=0.02$).

In our study, we analyzed the degree of rotation of the maxillary first molars according to Lamons and Holmes[13]. From the results obtained regarding maxillary molar rotation, it was shown that there is rotation with a higher degree on the left and right sides in patients from the control group compared to the study group. The mean value for the rotation of the first maxillary molar on the left side in subjects with Class II Division 1 malocclusion according to Angle is 139.79°, while in subjects with Class I malocclusion according to Angle it is 143.10°. This statistical difference showed high significance with a coefficient of $p<0.05$ ($p=0.01$). The mean value for the same parameter on the right side in the study group is 139.95°, and in the control group it is 141.90°. Here, the statistical difference indicates no significant difference, with a coefficient of $p>0.05$ ($p=0.17$). Our results are similar to those of Cristiane de Oliveira Viganóand Betânia Pessoa Lima[19]. Cristiane de Oliveira Viganó[20], with her colleagues, analyzed the position of the maxillary first molars and their degree of rotation.

The U-test showed a significant difference in molar rotation between the two groups of subjects, with a greater degree of rotation present in the study group compared to the control group.

The results we obtained from the presented examinations emphasize the need for early diagnosis of Class II Division 1 malocclusion according to Angle. In addition to early diagnosis, there is a need to simplify the approach in studying this malocclusion. For this purpose, multiple diagnostic methods are applied. In addition to anamnesis and clinical examination, gnatometric analysis and cephalometric analysis are necessary. Only in this way, as orthodontists, can we establish a good treatment plan and use adequate orthodontic therapeutic means for this malocclusion.

Conclusion

The position of the teeth within the dental arches, their mutual relationships, as well as the interrelationship of the jaws and their position relative to the remaining cranial and facial bones, play a crucial role in the overall configuration and appearance of the individual. Therefore, analysis of the facial structures and dental arches in both jaws is essential for establishing an accurate orthodontic diagnosis.

Based on the obtained results from studying the dimension, shape, and size of the maxillary and mandibular dental arches in Class II Division 1 malocclusion according to Angle, using analysis of gypsum study models and their statistical processing, the following results were obtained:

1. Class II Division 1 malocclusion most often has a hereditary etiology. Following heredity are bad habits, oral respiration, and adenoid problems.
2. The obtained values for intercanine width in the maxillary dental arch and their statistical processing using the Mann-Whitney U-test indicate that patients with Class II Division 1 malocclusion according to Angle have smaller values for this parameter, with a mean value of 31 mm, while in the control group the mean value is 34 mm.
3. There is no significant difference between the study and control groups regarding intercanine width in the mandibular dental arch and their mean values.
4. There is a significant difference in the values for the interpremolar width in the maxillary dental arch in both groups of subjects (32 mm mean value in subjects with malocclusion II class 1 grade according to Angle and 36 mm mean value in subjects with malocclusion I class), and the difference for the same parameter in the mandibular dental arch is not significant (31 mm mean value in the studied group and 32 mm mean value in the control group).
5. There is a significant difference in the values for intermolar width between the study and control groups, in both dental arches. There is a significant difference in palatal depth values between the study and control groups. Subjects in the study group have much higher values for this parameter.
6. The height of the maxillary dental arch in the study group is significantly higher than in the control group. In the mandibular dental arch, the difference is not significant.
7. The length of the mandibular dental arch is significantly higher in the control group than in the study group. In the maxillary dental arch, the difference is not significant.
8. Rotation of the maxillary molars in the study group has a significantly higher degree compared to the maxillary molars in the control group.
9. From all this, we can conclude that Class II Division 1 malocclusion according to Angle has characteristic deviations from normal values of the parameters in the dental arches.

Considering these changes, we want to emphasize that our study and the results we obtained will contribute to the early diagnosis of this malocclusion, timely and appropriate treatment, aiming to establish proper functions in the orofacial system, such as breathing, chewing, swallowing, and phonation, while also emphasizing aesthetics. The choice of orthodontic therapy will depend on the degree of malocclusion, the age of the patient, and the etiological factor. Early diagnosis and timely treatment of the malocclusion will enable the achievement of functional and aesthetic optimum, which will preserve the characteristics of the individual and allow uninterrupted proper growth and development of the orofacial region.

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DYNAMICS, CHANGES AND FACTORS INFLUENCING THE DMFT INDEX IN CHILDREN FROM URBAN AND RURAL AREAS IN THE REPUBLIC OF NORTH MACEDONIA

ДИНАМИКА, ПРОМЕНИ И ФАКТОРИ ШТО ВЛИЈААТ ВРЗ КЕП ИНДЕКСОТ КАЈ ДЕЦА ОД УРБАНИ И РУРАЛНИ СРЕДИНИ ВО РЕПУБЛИКА СЕВЕРНА МАКЕДОНИЈА

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Abstract

Introduction: Oral health in children is an important indicator of their growth, development, and access to health care. The DMFT index allows for an objective assessment of the prevalence and severity of caries, especially when the same group of children is followed over a longer period of time. **Objective:** This study aimed to assess the dynamics of the DMFT index and to determine the factors that influence oral health in children living in urban and rural areas in the Republic of North Macedonia, specifically in the Municipality of Resen. In addition, the impact of the COVID-19 pandemic on access to dental care and the general condition of children's oral health was examined. **Material and method:** The research was conducted as a longitudinal study with a duration of nine years, which included 60 children born in 2009, divided into two subgroups: children from urban areas (30) and children from rural areas (30), followed up at the ages of 7, 10, and 15 years (2016, 2019, and 2025). The examinations were carried out according to the diagnostic criteria for dental caries of the World Health Organization (WHO) from 2013, and the data were statistically processed with the SPSS program, using the t-test and ANOVA tests. **Results:** The average values of the DMFT index showed a continuous increase with age, with children from rural areas having significantly higher values (DMFT = 6.6) compared to children from urban areas (DMFT = 3.9). The analysis showed that the education and employment of parents, especially mothers, have a significant impact on the values of the index. The COVID-19 pandemic has further worsened access to dental services, which has resulted in an increase in untreated caries. **Conclusion:** The results indicate the need for long-term public health measures and targeted prevention programs, with a particular emphasis on rural areas, emphasizing the need to establish sustainable systems for dental prevention even in conditions of health crises. **Keywords:** oral health, DMFT index, dental caries, urban and rural environment, COVID-19.

Апстракт

Вовед: Оралното здравје кај децата е важен индикатор за нивниот раст, развој и пристап до здравствена заштита. КЕП-индексот овозможува објективна проценка на преваленцата и на сериозноста на кариесот, особено кога истата група деца се следи подолг временски период. **Цел:** Целта на ова истражување беше да се процени динамиката на КЕП-индексот и да се утврдат факторите што влијаат врз оралното здравје кај децата што живеат во урбани и во рурални средини во Република Северна Македонија- Општина Ресен. Дополнително, беше испитано влијанието на пандемијата COVID-19 врз пристапот до стоматолошка заштита и врз општата состојба на забите кај децата. **Материјал и метод:** Истражувањето е спроведено како лонгитудинална студија со времетраење од девет години, во која се вклучени 60 деца родени во 2009 година, поделени во две подгрупи: деца од урбани средини (30) и деца од рурални средини (30), следени на возраст од 7, 10 и 15 години (2016, 2019 и 2025 година). Прегледите се спроведени според дијагностичките критериуми за кариес на Светската здравствена организација (СЗО) од 2013 година, а податоците се статистички обработени со програмата SPSS, користејќи го t-тестот и ANOVA анализата. **Резултати:** Просечните вредности на КЕП-индексот покажаа континуирано зголемување со возраста, при што децата од руралните средини имаат значително повисоки вредности (КЕП-6,6) во споредба со децата од урбаните средини (КЕП-3,9). Анализата покажа дека образованието и вработувањето на родителите, особено мајките, имаат значително влијание врз вредностите на индексот. Пандемијата COVID-19 дополнително го влоши пристапот до стоматолошки услуги, што резултираше со зголемување на нетретираниот кариес. **Заклучок:** Резултатите укажуваат на потребата од долгорочни мерки за јавно здравје и насочени превентивни програми, со посебен акцент на руралните средини, нагласувајќи ја потребата од воспоставување одржливи системи за стоматолошка превенција дури и во услови наздравствени кризи. **Клучни зборови:** орално здравје, DMFT-индекс, дентален кариес, урбана рурална средина, COVID-19.

Introduction

Oral health is an important part of every child's physical, psychological, and social well-being. According to the World Health Organization (WHO), oral health is not only the absence of disease of the teeth and soft tissues in the mouth, but also the ability to chew, speak, and socially interact without pain or discomfort[1]. The condition of teeth in early childhood has a long-term impact on nutrition, speech, and quality of life. At the same time, oral health in childhood sets the foundation for oral health in adulthood[2]. Dental caries, as one of the most common chronic diseases, is a significant public health problem in both developed and developing countries. According to the latest global data, over 2.5 billion people have untreated caries. The number of children with untreated caries expressed in percentages ranges between 60–90%, i.e.,almost every child before the age of 12 has at least one decayed tooth[1,3]. The DMFT index, which summarizes the number of carious, extracted, and filled teeth, is a standard epidemiological measure for assessing the state of oral health. Its analysis allows for monitoring trends in the development of caries, as well as the impact of economic, educational, and health factors on caries prevalence. According to GBD (Global Burden of Disease) data, untreated caries in permanent teeth is the most common disease globally, and in children aged 6–12 years, caries in primary teeth affects over 500 million children[3]. Within Europe, a review of data from the European Platform for Better Oral Health indicates significant differences between countries[4]. In Sweden and the Netherlands, the average DMFT index in 12-year-old children is below 1.0, while in Eastern and Southern Europe it ranges between 4–6. These differences are explained primarily by health policies, socio-economic conditions, population education and the implementation of preventive programs. In the Republic of North Macedonia, the latest national survey shows an average DMFT index of 4.7 in 12-year-old children, which places the country in the high-risk zone according to WHO criteria[5]. Research shows that the largest jump in the DMFT index occurs in the period from 11–15 years of age, especially in populations where dental intervention is limited or irregular[6]. In this regard, monitoring the DMFT index over a certain, longer period of time in the same group of children enables an understanding of the dynamics of the occurrence, progression, and treatment of caries, as well as the impact of education, urbanization, and public health policies. According to the study by Skeie et al.[7], the mother's education is the strongest indicator of the dental condition of children aged 5 to 10 years. In addition, unstable employment, low income, and rural location are associated with irregular and insufficient dental services, irregular check-ups, and low rates of dental treatment[8]. The differences between urban and rural areas in terms of dental care are particularly pronounced in countries with uneven health infrastructure. Children in rural areas often face limited access to dental services and a lower level of education among parents. With the emergence of the COVID-19 pandemic, access to dental care has further deteriorated. Fear of infection, limited appointments, and closure of health facilities, as well as the interruption of regular systematic examinations and preventive activities, have led to reduced dental care. The analysis of these factors is necessary to develop targeted interventions and overcome health inequalities. This longitudinal study aimed to show the movement of the incidence of dental caries by determining oral health indicators depending on the environment, socioeconomic status, and parental education, as well as the impact of the COVID-19 pandemic on access to dental services and oral health, especially during the critical period of development of the permanent dentition.

Material and methods

The study was conducted as longitudinal descriptive-analytical research, following the same group of children in three time intervals – at 7, 10, and 15 years of age. The research included a total of 60 children born in 2009, divided into two equal groups according to their place of residence: 30 from urban and 30 from rural areas in the Municipality of Resen. Data for 2016 and 2019 were collected retrospectively from the children's dental records, with the approval of the Health Center – Resen, while in 2025, a clinical examination was performed by two calibrated dentists. For each respondent, carious (K), extracted due to caries (E), and restored (filled/repaired)teeth (P) were recorded, based on which the DMFT index for 2025 was calculated. and DMFT and DMFT indices for 2019 and 2016.

The examinations were performed with a dental mirror and probe, without radiographic examinations, according to WHO standards. In addition, a questionnaire was applied regarding the hygiene habits of the respondents, as well as sociodemographic data on the use of dental services during the COVID-19 pandemic.

The data were statistically processed with the SPSS 25.0 program, using the t-test for comparison of mean values and ANOVA for analysis of variation between groups. The level of statistical significance was set at p=0.05.

Results

Values of the DMFT index by year and environment.

The analysis of data from three time periods (2016, 2019 and 2025) shows that there is a clear trend of a decrease in the value of the DMFT index at an early age (from 7 to 10 years), but at the same time a dramatic increase in DMFT values up to the age of 15 years, especially among children from rural areas.

Among rural children, the DMFT index decreased from 6.1 to 3.6 between 2016 and 2019, which indicates partial success of dental interventions at an early age. However, at the age of 15, the value of the DMFT index increases to 6.6 – the highest in the entire analysis. This indicates that children did not receive adequate continuous dental care during the critical period of eruption of permanent teeth.

In urban areas, the trend is more subtle. The value of the DMFT index decreases from 5.26 (in 2016) to 1.9 (in 2019), while the value of the DMFT index in 2025 reaches 3.9, which is significantly lower than that among children from rural areas. These data confirm that children from urban areas have better access to dental services and better oral health.

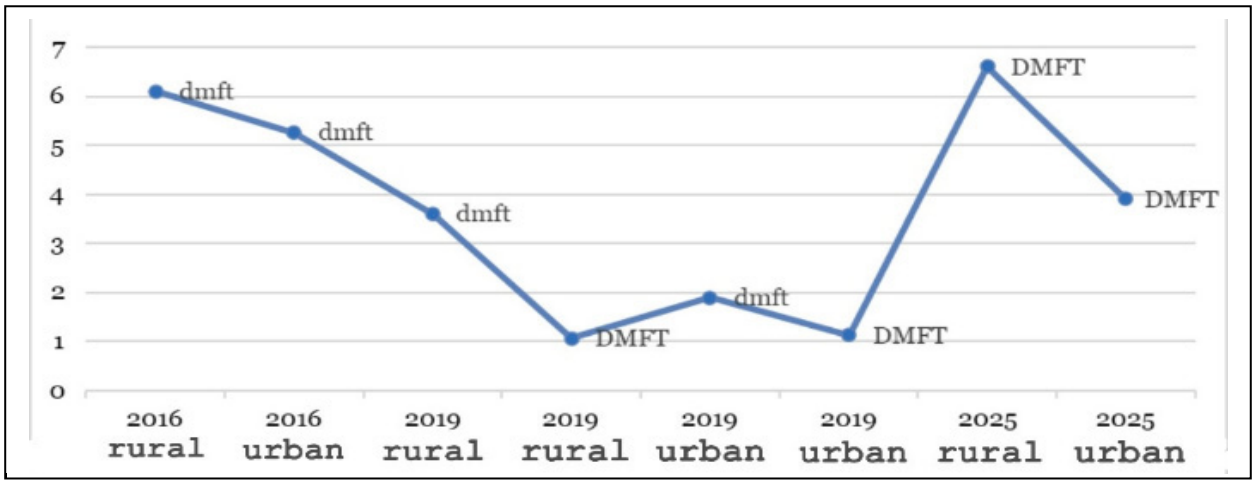
These data confirm that children from urban areas have better access to dental services and better oral health. These differences are graphically displayed in Line Chart 1, which visualizes the progression or regression of the indices in the two subgroups.

The development line for children from rural areas shows a V-shaped pattern – initial improvement, followed by drastic deterioration, while for urban children, the line is more gradual, with a slight increase until 2025.

Table 1. Average values of the DMFT index by age andtype of environment

Year	Environment	Index	Value
2016	rural	dmft	6.1
2016	urban	dmft	5.26
2019	rural	dmft	3.6
2019	rural	DMFT	1.07
2019	urban	dmft	1.9
2019	urban	DMFT	1.13
2025	rural	DMFT	6.6
2525	urban	DMFT	3.9

The results showed a gradual increase in the DMFT index with increasing age in all respondents. The difference between urban and rural children is consistent and statistically significant in all three time intervals.



Graph 1. *Average values of DMFT and DMFT indices in the two analyzed living environments*

Table 2. Percentage of K/k(%), E/e(%), P/p(%) components by age and environment

age	environment	K (%) к (%)	E (%) e (%)	P (%) p (%)
7 (2016)	urban	55.0	5.0	40.0
7 (2016)	rural	70.0	10.0	20.0
10 (2019) DMFT;dmft	urban	45.0	5.0	50.0
10 (2019) DMFT;dmft	rural	65.0	8.0	27.0
15 (2025)	urban	22.0	2.1	75.9
15 (2025)	rural	40.7	8.8	50.5

Table 3. Comparison of the average number of restored teeth (P-component)

environment	total DMFT - index	P-component representation (%)	average number of restored teeth (P)*	statistical significance (p)
urban	3.9	75.9%	2.96	p < 0.05
rural	6.6	50.5%	3.33	

In rural areas, the K-component (untreated caries) dominates with 40.7%, while in urban children, the P-component (fillings) dominates with 75.9%.

Relationship with parents' educational level:

The analysis of the values of the DMFT index depending on the education of the mother and father is shown in Table 4.

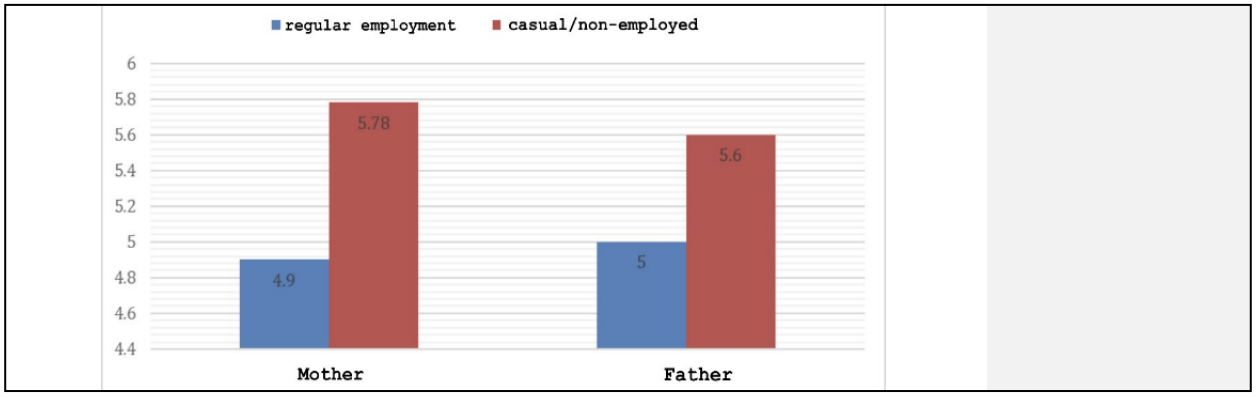
Children whose mothers have secondary education have the lowest average value of the index (4.71), while those whose mothers have higher education have a higher index value (6.46), with a predominance of the P-component. At the same time, among parents with primary education, the index is also high (5.63), but in this case, most of the value comes from the K and E components. This indicates that, although the average value may be similar, the nature of the problem is different – untreated caries in some, and more restorative treatments in others.

Relationship with parents' employment

The results showed that children whose mothers are in regular employment have a lower value of the DMFT index (4.9) compared to those whose mothers are in part-time employment or unemployed (5.78).

Table 4. Average value of the DMFT index by level of education

education of parents	mother (DMFT)	father (DMFT)
primary	5.63	4.5
secondary	4.71	4.84
higher	6.46	5.72
no data	5.5	6.33



Graph 2. Index according to the employment relationship of the mother and father

Table 5. Influence of mother's education on the value and structure of the DMFT - index

mother's education	average DMFT - index	dominant component in the structure	statistical significance (p)
primary	5.63	C (Caries) and E (Extractions))	p < 0.001
secondary	4.71	Mixed (lowest index)	
high	6.46	F (Fills/Repaired)	

The situation is similar regarding fathers' employment status, where the values are 5.0 for regular employees and 5.6 for part-time employees. This relationship is expected and supports numerous data from the literature: economic stability and access to health services directly affect the quality and frequency of dental interventions. A visual comparison of these values is presented in Graph 2.

The ANOVA analysis showed that maternal education was a significant predictor of the DMFT index values ($p<0.001$). Children whose mothers had secondary education had the lowest DMFT index values, while the highest DMFT index values were recorded in children whose mothers had only primary education.

Survey data – hygiene habits

Table 5. Influence of mother's education on the value and structure of the DMFT - index

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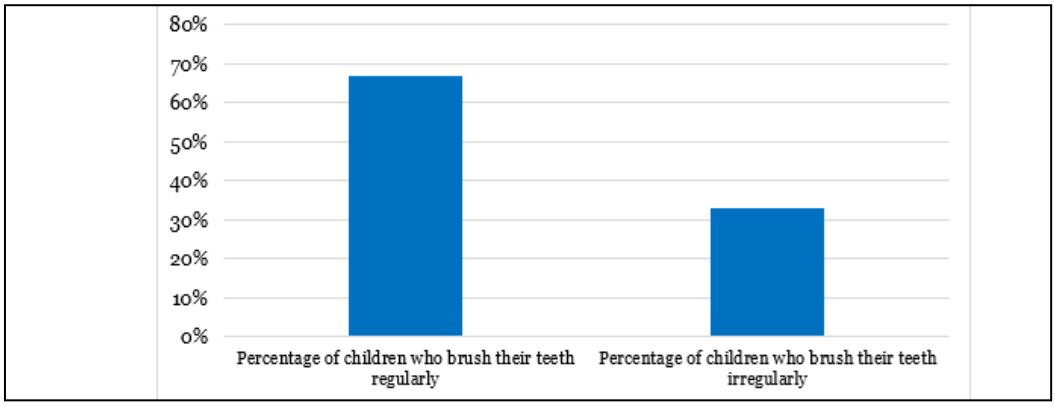
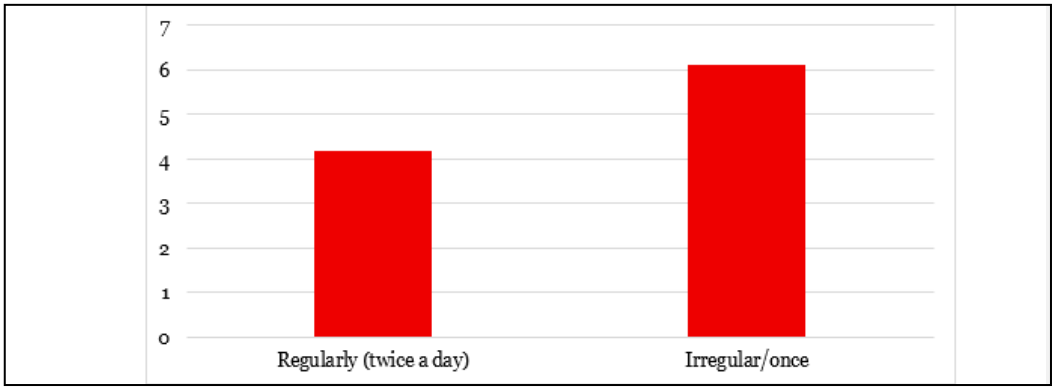
high	6.46	F (Fills/Repaired)	

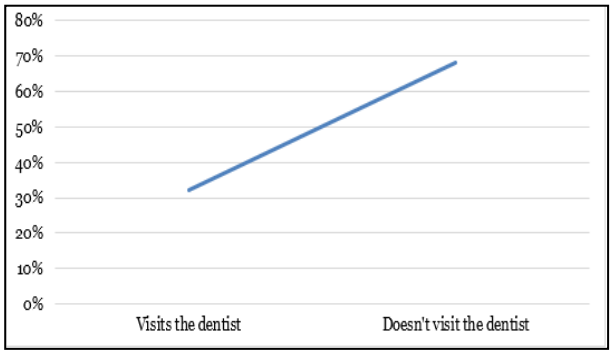


Graph 3. *Percentage of children who brush their teeth*



Graph 4. *Average DMFT index depending on tooth brushing frequency*

The survey questionnaire showed that 67% of children have regular tooth brushing habits (twice a day), while the remaining 33% brush once a day or irregularly. The average DMFT index in the first group is 4.2, while in the second group it is 6.1. This difference is statistically significant ($p<0.05$), which confirms the importance of personal hygiene in the prevention of caries. In addition, children who use fluoride toothpaste and visit the dentist at least once a year have a significantly better composition of the index (more P, less K). Impact of the COVID-19 pandemic.



Graph 5. *Access to a dentist during COVID-19 (2020 - 2022)*

In the period from 2020 to 2022, limited access to dental services was observed due to restrictions and priority of emergencies. According to the survey, 68% of parents stated that they did not visit a dentist during the pandemic, and in rural areas this percentage reached 80%. The values of the DMFT index showed higher values of the K and E components and a lower value of the P component, indicating an increased need for therapeutic interventions that were not implemented due to the situation. These results are particularly pronounced among respondents from rural areas, where access to a dentist, even under normal conditions, is limited.

Discussion

The analysis of the results of this longitudinal study allowed observation of the dynamics of changes in the DMFT index, i.e., the state of oral health, within the same group of children monitored at 7, 10, and 15 years of age. The study revealed not only changes in the values of the DMFT index with increasing age, but also significant differences according to socioeconomic and demographic factors, as well as the impact of the COVID-19 pandemic. These results confirm that oral health is significantly dependent on social and economic factors, as well as on the availability of dental services. A clear trend of increasing DMFT index values up to 15 years of age was observed, consistent with Pitts et al.[6], who reported that the most intensive appearance and progression of caries occur during puberty. The most drastic increase in the DMFT index is noted among respondents from rural areas, reaching an average value of 6.6, while among children from urban areas, it was 3.9. Children from rural areas have a higher DMFT index due to limited health infrastructure, but also due to certain financial barriers. These findings are consistent with the results of other studies in the South-Eastern European region[9].

The fact that the P-component is dominant among children from urban areas indicates a greater culture of maintaining oral hygiene and easier access to a dentist. On the contrary, untreated cases dominate in rural areas, which emphasizes the need for mobile dental teams and educational programs. Of particular concern is the fact that more than 40% of teeth of children from rural areas in 2025 had active, untreated caries, which indicates insufficient treatment and poor dental supervision. At the same time, children from urban areas showed a higher percentage of treated (restored) teeth (75.9%), which indicates better access to therapeutic services and regular dental check-ups. This is supported by the results of the survey, which showed that a

majority of children from urban areas have regular tooth brushing habits and regular dental care.

The COVID-19 pandemic has created an additional gap between the two groups. The reduced number of dental check-ups, closed practices, and interrupted preventive programs have contributed to the deterioration of the situation. Limited access to dental services in the period 2020–2022 led to a significant increase in the K and E components, especially among children from rural areas[10]. Over 68% of parents reported that they did not take their children to the dentist during the pandemic, which is directly reflected in the increased number of untreated caries. In summary, the results obtained confirm the hypothesis that the value of the DMFTindex increases with age, and that these dynamics is strongly influenced by socio-economic factors, health habits, and global circumstances. Such knowledge has important implications for planning preventive programs, especially aimed at the rural population and children with limited access to dental care. These data confirm that access to dental care must be sustainable even in times of crisis.

Conclusion

Oral health deteriorates with age if not supported by continuous dental care. The differences between urban and rural areas are significant and persistent. The studied group of children, at 15 years of age, has a moderate DMFT index in urban areas and a very high DMFT index in rural areas. In rural areas, regular preventive dental check-ups need to be intensified. The interruption of the work of preventive teams during the COVID-19 pandemic contributed to higher caries activity. The findings of this study emphasize the importance of continuous preventive dental services even in emergency conditions.

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PERI-IMPLANT DISEASE AND RISK FACTORS: A NARRATIVE REVIEW

ПЕРИИМПЛАНТНА БОЛЕСТ И РИЗИК ФАКТОРИ: НАРАТИВНА РЕВИЈА

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Abstract

Peri-implant disease is a consequence of the interaction of multiple factors, some of which are known, while others remain unknown. This systematic literature review discusses the various factors associated with peri-implant disease, highlighting their role in its etiopathogenesis. Peri-implant tissue is strongly influenced by various local and systemic factors. Local factors, such as poor oral hygiene, directly and immediately negatively affect peri-implant tissues, while various biomaterials, occlusal loading, and the presence or absence of keratinized mucosa also influence the condition of implants placed in the jaws. The effect of these factors depends on the individual's genotype, epigenetic factors, systemic health, nutrition, and many other contributing factors. Risk factors are numerous, but their impact is not yet fully defined. The advancement of medicine necessitates their continuous research, updating, and improved management strategies. Plaque accumulation and biofilm formation play a significant role in the development of peri-implant disease; however, the influence of other local factors should not be neglected and requires further clarification. Within the peri-implant microenvironment, systemic factors create favorable conditions for the harmful effects of local risk factors. Timely detection of risk factors and their elimination will reduce the risk of peri-implant diseases, and will ensure reliability for precise planning, successful implantation, and a long, stable survival period for the implants. **Keywords:** peri-implantitis, peri-mucositis, risk factors, implant.

Апстракт

Периимплантната болест е последица на заемно дејство на многу фактори, дел од кои се познати, а дел сè уште остануваат непознати.Во овој систематски литературен преглед се дискутира за различните фактори кои се поврзуваат со периимплантната болест, истакнувајќи ја нивната улога во нејзината етиопатогенеза. Периимплантното ткиво е под силно влијание на различни фактори како од локална така и од системска природа. Локалните фактори, како што е лошата орална хигиена,директно и непосредно негативно влијаатврз периимплантните ткива, но различните биоматеријали, оклузалното оптоварување, кератинизираната гингива,истотака,имаат влијание врз состојбата на имплантите поставени во вилиците. Каков ќе биде ефектот од овие влијанија зависи од генотипот на индивидуата од епигенетските фактори, системското здравје, исхраната и многу други дополнителни и помошни фактори. Факторите на ризик се многубројни, но нивното влијание сè уште не е дефинирано во целост. Напредокот на медицината условува нивно постојано истражување, дополнување и надрагдување на нивниот третман. Акумулацијата на плакот и формирањето на биофилмотимаат значајна улога воразвојот на периимплантната болест, но секако дека не треба да се занемари влијанието надругителокални фактори, па дури итреба попрецизно да се разјасни. Во услови на микроимплантна средина, системските фактори создаваат олеснителни услови за штетно влијание на локалните ризик-причинители. Навремена детекција на ризик-факторите и нивна елиминацијаќе го намали ризикот од појава на периимплантни заболувања, а ќе обезбеди сигурност за прецизно планирање, успешно имплантирање и за долг и стабилен период на опстанок на имплантите. **Клучни зборови:** периимплантитис, перимукозитис, ризик-фактори, имплант.

Introduction

Tooth loss is a condition that adversely affects the quality of life of an individual. The loss of teeth primarily impacts self-confidence, significantly impairs the masticatory process and the function of the temporomandibular joint, and may also be associated with systemic conditions, primarily by disrupting the function of the gastrointestinal system.

For completely edentulous patients, available therapeutic solutions include the placement of removable dentures, with or without implants, and fixed implant-supported prostheses[1,2].

However, fixed full-arch implant-supported prostheses attached to implants represent the gold standard for improv-

ing oral health and providing a solution for total edentulism. This procedure achieves the correction of impaired aesthetics and function.

Dental implants are a common choice for addressing partial or total edentulism. Although the use of dental implants is a good choice from an aesthetic and functional perspective, implantation can sometimes result in failure. Therefore, special attention should be paid to possible complications and anatomical limitations, which must always be considered when planning and performing the placement of dental implants[3] (Figure 1.).

Figure 1. *Implant placement - model (drawing) - (taken from a free online source)*[4]

Millions of dental implants are placed each year, but a large number of them develop biological complications such as peri-implant mucositis or peri-implantitis. Adverse effects are generally classified as early and late, where early ones occur before, and late ones occur after the functional loading of the implant[5].

Some of the causes are known, while others still need to be investigated.6 However, the onset and progression of peri-implant disease are the result of the interaction of many factors (known and unknown) in each individual, which can combine in different ways[7].

Peri-implant diseases are pathological inflammatory processes resulting from a disrupted microbiome that affects the integrity of soft and hard structures[8]. Peri-implant mucositis precedes peri-implantitis, in which the primary inflammatory process of the soft tissues is followed by destructive processes affecting the alveolar bone. Peri-implantitis can progress rapidly and negatively impact osseointegration[9]. Scientific evidence confirms that certain systemic factors, such as diabetes mellitus, cardiovascular diseases, obesity, and alcohol consumption, among others, play an important role in modulating bone physiology and wound healing[10].

Therefore, these conditions may be significant risk indicators or factors for the prevalence and incidence of peri-implant diseases[11]. Local factors should by no means be overlooked as possible etiological factors. These include the material from which implants are made, typically titanium[12], oral hygiene[13], and the influence of the peri-implant microbiome on the implant surface[14].

Based on these data, the aim of this paper was to identify the risk factors and explain their influence on the occurrence of peri-implant diseases.

Method

This systematic literature review discusses the various factors associated with peri-implant disease, highlighting their role in its etiopathogenesis. The relevant articles cited in this study were retrieved from the MEDLINE/PubMed database, published in English, with no time frame restrictions.

This article discusses various factors associated with peri-implant disease, highlighting their role by presenting their respective advantages and disadvantages. The search strategy for relevant articles included studies retrieved from the MEDLINE/PubMed database, published in English, with no time restrictions. This narrative review encompasses and cites original research, narrative reviews, and systematic literature reviews. The keywords used to conduct the research were “peri-implantitis” and “risk factors.” A total of 484 works, including abstracts and full-text articles, were identified in the PubMed database using these keywords.

The first selection, i.e., potentially suitable articles, was made based on the criterion of being fully published in the database (full text), with a title corresponding to the stated objective, which included a total of 151 articles and excluded 333 abstracts. After the initial selection, articles presenting case reports, short communications, or articles with predominantly preventive content were excluded from this selection. According to this criterion, 84 studies were discarded. All articles that met these specified criteria were characterized as potentially relevant studies and suitable for further analysis.

Full texts were retrieved without contacting or obtaining approval from the study authors.

For greater precision in the selection, inclusion and exclusion criteria were established to guide the process.

Inclusion criteria:

- Study design: original research, narrative reviews, systematic reviews
- Population: patients with peri-implantitis and peri-mucositis
- Factors: systemic and local risk factors
- Language: English

Exclusion criteria:

- Study design: case reports, short communications, and brief reports
- Abstracts
- Articles in languages other than English

Within the limitations of this narrative review, the findings are based on the literature available according to the criteria and are discussed narratively without conducting a systematic analysis.

Etiology and Risk Factors in Peri-Implant Diseases

Peri-implant tissue is strongly influenced by various factors of both local and systemic nature. Local factors, primarily poor oral hygiene, directly and immediately negatively affect peri-implant tissues, while genetic and epigenetic factors, systemic health, and nutrition influence the health of each individual and their susceptibility to various diseases, including peri-implant diseases.

Systemic Factors

The factors influencing the success of implant therapy are numerous and heterogeneous. The most common systemic diseases considered to affect the survival of implants in the jaws are diabetes mellitus, cardiovascular diseases, Crohn's disease, hypothyroidism, osteoporosis, chemotherapy, and radiotherapy in the treatment of head and neck malignancies. All of these listed risk factors belong to the group of factors representing a relative contraindication for implantation. Although many of them have been studied for a long time, there is still no consensus or definitive guidelines on this issue. For clinicians whose field of practice is implantology, the rule of an individual approach to each patient applies. Specifically, the therapist is obligated to adapt the decision for implant placement, as well as the treatment plan, according to the assessment made regarding the risk factor. It is considered that in most situations, the degree of control of the systemic disease is more important than the disease itself.

However, in implantology, there are also absolute contraindications for implant therapy. These include intravenous bisphosphonate therapy, myocardial infarction, cerebrovascular insult (stroke), placement of artificial heart valves or transplants, active malignancy treatment, acute high-grade malignancy condition, risk of hemorrhage, immunosuppression, psychiatric conditions, and substance abuse.

Diabetes mellitus

Diabetes is typically preceded by a prediabetic condition, which is defined as moderate hyperglycemia that does not reach the threshold for a diabetic state[15]. However, diabetes and prediabetes are very common metabolic disorders that cause hyperglycemia, leading to microangiopathies and macroangiopathies[16]. It has been confirmed that they are associated with periodontal disease[17]. delayed wound healing[18], and disorders of bone metabolism[19] Diabetes mellitus, as well as prediabetic conditions, represent a common and growing health problem with extensive harmful effects on the entire organism. In the oral cavity of patients with diabetes, periodontal disease is more advanced, and the destructive processes are more pronounced[20].

Under such circumstances, osteoblast activity is reduced, while osteoclasts progressively multiply and enhance resorption processes. Collagen production is also decreased[21].

Unlike uncontrolled diabetes, in moderately controlled diabetes, there is an insignificant difference in implant failure rates. The duration of diabetes can influence the failure of implant therapy. This status is explained by the likely existence of microvascular complications that affect the wound healing process. The literature confirms that the success rate of implant therapy in patients ranges from 85.5% to 100%[22,23].

Diabetes is often a disease present in the population over 65 years of age[24]. where the need for implants is also most common[24]. For a long time, it was considered that this disease is a relative contraindication[25,26]. However, the general consensus in professional circles is that implant placement is permissible in patients with well-regulated blood glucose levels. If glycemia is not regulated, implantation should be avoided[27].

It has been proven that implant integration can be achieved independently of glucose levels, but an important benchmark to strive for is an HbA1c value below 8%. Clinical experiences confirm that an additional factor influencing implant failure is the combination of two risk factors: diabetes and bone loss, with approximately 1 mm more bone loss observed in diabetic patients[26].

The greatest risk of implant loss in diabetics exists within the first 5 years after implantation; failure in the subsequent five-year period is less common.

Cardiovascular Diseases

It is known that cardiovascular diseases (CVD) have an impact on the development of peri-implantitis. They compromise blood flow, reducing the supply of oxygen and nutrients to the tissues. These processes negatively affect the healing process[26], osseointegration, and alveolar bone resorption processes[28].

The resulting tissue hypoxia leads to reduced fibroblast activity, decreased collagen synthesis, impaired

macrophage function, and increased capillary pressure, creating conditions conducive to the development of infection.

Some studies[29,30] have shown that patients with CVD and previously diagnosed periodontal disease have a significantly increased risk of mortality, while the association of CVD with peri-implantitis has been confirmed by a correlation between CVD risk markers. Specifically, high levels of triglycerides and uric acid are not only biochemical markers of these diseases but have also been proven to be risk parameters for peri-implantitis[31]. Further investigation of the correlation between CVD and peri-implant inflammation could encourage clinicians to take relevant measures before the intervention to improve implant success rates and alleviate patient discomfort. Moreover, this correlation could further support the link between local inflammation and systemic diseases and promote research in this direction.

A definitive recommendation is that implant therapy in patients with cardiovascular diseases should be carefully assessed and monitored, because evidence suggests that cardiovascular diseases can affect the level of marginal bone around implants, and an unfavorable status in this regard is a possible risk factor for peri-implant diseases.

Crohn's Disease

Crohn's disease is an autoimmune disorder of an idiopathic nature, characterized by granulomatous changes affecting the mucosa of the large intestine. The changes, which manifest in the form of erosions or ulcerations, are present on the intestinal wall and are the cause of gastrointestinal discomfort[32].

In the oral cavity, this disease manifests with lesions similar to those in the lower digestive tract, resembling recurrent aphthous ulcers (smaller and more numerous). The mucosa is cobblestoned and folded, while the gingiva is of a hyperplastic type.

The stance of clinicians regarding diagnosed Morbus Crohn is to perform only urgent interventions during the active phase of the disease. Since treatment is carried out using immunosuppressants or corticosteroids, healing time is impaired, and the predisposition to infection is increased[33]. Based on its course and mechanism of action, it is believed that Crohn's disease has a negative impact on successful implant osseointegration[34].

Thyroid Gland Disorders

Disorders of thyroid gland function affect bone metabolism. Thyroxine (T4) and, to a lesser extent, triiodothyronine (T3) regulate the healing process. In hypothyroidism, the maturation and activity of bone cells are reduced, therefore bone formation is diminished, which can be a reason for implant failure.

A retrospective study was conducted on 27 patients with hypothyroidism. The results obtained were compared with 29 patients as a control group. The overall success rate after more than 1 year was 95% and 97%, respectively[35] These findings are consistent with results obtained in other studies[35], leading to the main conclusion that well-controlled hypothyroidism does not affect the final success rate of implants.

Osteoporosis

Osteoporosis is a systemic disease manifested by bone degradation and reduced bone density. Bone loss in men and women is 0.5% annually. Postmenopausal women have an increased risk of developing the disease, as a negative calcium balance is registered, which is twice as low during menopause. Most clinicians agree that osteoporosis is not a contraindication for implant placement, unless the implant candidates are on parenteral bisphosphonate therapy.

There is a consensus that dental implant placement is safe for patients who have been receiving oral bisphosphonate therapy for less than three years without other systemic diseases. However, if the therapy is shorter than three years but the patient is also on corticosteroids, or the oral bisphosphonate therapy is longer than three years, the therapy should be discontinued three months prior to the procedure. Therapy can be resumed three months after implant placement, i.e., once bone healing has been achieved[36].

In a study by Cho[37] involving postmenopausal women with osteoporosis, a cumulative success rate of 100% was registered. Resonance frequency analysis at 12 months showed a mean implant stability test value of 71.4±5.52, indicating excellent osseointegration. The average bone loss around the implant was 0.54±0.35mm. During the study, no implant defects were registered, and satisfactory results were recorded for bleeding on probing and peri-implant pocket depth. Changes in bone mineral density (BMD) and bone turnover markers (BTMs) were minimal.

Radiotherapy and Chemotherapy

In the treatment of oncological cases, radiotherapy, as well as chemotherapy, besides destroying malignant cells, non-selectively damages healthy cellular structures as well. All of this therapy results in numerous oral complications, among which osteoradionecrosis is worth mentioning. It occurs in 8.2% of treated patients[32]. If surgical intervention is necessary, maximum selectivity of the procedure is required, with a recommendation to avoid interventions. If they need to be performed for justified or necessary reasons, they should be carried out atraumatically and under antibiotic protection[38].

Studies on humans and animals show a 12 times greater risk of implant failure in patients undergoing oncology therapy.

Radiotherapy destroys malignant tumor masses through ionizing radiation. These processes release free radicals that damage cellular DNA, disrupt replication, and cause the death of mitotic cells. Radiotherapy primarily destroys cells that are integral parts of tissues with high mitotic activity. Bone structures are most sensitive; under the influence of radiation therapy, osteoblasts lose their function, thereby disrupting bone remodeling. In contrast to strong osteoblastic sensitivity, osteoclasts survive more safely, intensify their activity, and lead to resorptive, destructive, and osteolytic processes[32].

The outcome of radiotherapy is strongly influenced by the interval (time) between radiation treatment and implant placement, as well as the total radiation dose administered. All patients who received a high radiation dose (65 Gy or more) have a low rate of implant rehabilitation success. Furthermore, osseointegration is exceptionally poor in cases of reduced healing capacity of the implant bed[39].

On one hand, most implantologists agree that implant placement in this category of patients is best performed 12-18 months after the completion of therapy. On the other hand, it is true that as the time since radiation increases, due to progressive endarteritis processes, hypovascularization occurs, making the bone increasingly less suitable for dental implant placement.

There is limited data on the effect of chemotherapy on implant success. Retrospective studies have shown a negative impact of chemotherapy on implant success, but a higher survival rate was registered if chemotherapy was administered immediately before or one month after implant placement[40].

The length of the implant placed is also responsible for unsuccessful implant therapy. Thus, if the implant is short, the incidence of failure is more frequent, especially in irradiated bone. Therefore, it is advisable to use implants with greater length, a rougher surface, and a screw-shaped implant design.

Genetic Predisposition

Starting from the fact that not all people with the same risk factors develop peri-implant disease, it is believed that genetic predisposition may explain the development of this condition[41]. Biomarkers in peri-implantology of a biochemical and genetic nature are sophisticated tools capable of precisely identifying factors involved in the pathology of peri-implant disease, having the ability to compensate for the limitations of other routine diagnostic methods. Genetic biomarkers, which are constant, are suitable for risk assessment and can be measured before the onset of the disease; on the other hand, biochemical markers are the biomarkers of choice for monitoring the onset, intensity, and activity of the disease[42]. The most widespread genetic polymorphisms are single nucleotide polymorphisms (SNPs), which are variations in the DNA sequence affecting more than 1% of the population.

SNPs that have been the subject of multiple studies in the context of peri-implantitis are related to inflammatory interleukin genes and proteins involved in bone metabolism. These genes, when mutated, can cause an abnormal inflammatory response and/or reduced peri-implant osseointegration, resulting in the development of this disease. In patients who are at higher genetic risk for peri-implantitis, these inflammatory molecules may serve as potential biomarkers[43].

An association with implant loss, present peri-implantitis, or peri-implant marginal bone loss has been demonstrated for certain genetic polymorphisms. No association has been proven for IL-2, IL-6, TNF-α, or TGF-β1 genetic polymorphisms, while an association has been registered for IL-1A and IL-1B genetic polymorphisms. An association exists in the Iranian population with OPG, RANKL, IL-17, but there is no clear association regarding biological complications.

Literature based on clinically followed cases emphasizes that functional polymorphisms of IL-1α (C-889T), IL-1β (C+3954T, C-511T), and the composite IL-1 genotype can be used as predictive markers for peri-implant disease, while the TNFα G-308A polymorphism is not associated with peri-implant disease[43], table 1.

Table 1 shows the systemic and local risk factors in patients with peri-implantitis and peri-mucositis cited in this article.

Local Factors

Oral hygiene

Oral hygiene has a strong influence on both the periodontal tissue of a healthy tooth (periodontium) and the surrounding peri-implant tissue. It has been proven that increased levels of dental plaque promote inflammatory and destructive processes around the implant[44].

In lesions with peri-implantitis and periodontopathy, gram-negative anaerobic bacteria have been identified compared to healthy periodontal and peri-implant tissues. However, greater microbial diversity has been found in peri-implant tissues[45]. Furthermore, in peri-implantitis, there is predominantly an infiltrate rich in inflammatory cells, B-lymphocytes, and plasma cells. Unlike the periodontal tissues of a healthy tooth, the implant lacks cementum and the periodontium (the protective and func-

Table 1. Systemic and local risk factors in patients with peri-implant mucositis and peri-implantitis

	Peri-implant lesions	Authors
Systemic risk factors		
Diabetes mellitus	✓	Oates TW[23]
Cardiovascular disorders	✓	Ustaoğlu G[30]
Crohn's disease	✓	Alsaadi G[33]
Bisphosphonate therapy	✓	Rotim Ž[35]
Osteoporosis	✓	Cho JM[37]
Radiotherapy	✓	Cekić-Arambašin[31]
Chemotherapy	✓	Gabrić Pandurić D[39]
Genetic predisposition	✓	Chang Z[42]
Local factors		
Oral Hygiene	✓	Matsuda S[44]
Dysbiosis	✓	Cui Z[46], Roccuzzo A[47], Chen T[48], Gasimi B[49], Goncalves LF[50], Belibasakis GN[51], Sumida S[52], Lindhe J[53]
Periodontosis	✓	Matsuda S[44], Cui Z[46], Chen T[48], Gasimi B[49]
Smoking	✓	Maló PS[57],Reis INRD[58]
Keratinized mucosa	✓	Shaya F[59]
Occlusal loading		Vigolo P[60], Rossi F[61] Blanes RJ[62], Lindquist LW63, Heitz-Mayfield LJ[64]
Titanium (Ti)		Franchi M[67], Schwarz F[68], Berglundh T[69]

Figure 2. *Plaque accumulation on the implant surfaces (Taken from Roccuzzo et al.47)*

tional tissue layer) overlying the bone, which makes the peri-implant tissue less resistant to the action of dental plaque. This characteristic histological and morphological structural composition represents an easily surmountable barrier to the altered oral microbiome, i.e., dental plaque. There are arguments confirming that, histologically, peri-implant lesions are twice as large and have more blood vessels and inflammatory infiltrate in the connective tissue compared to periodontal tissues[46] (Figure 2.).

Given all these specific characteristics around the implant, it is quite logical that poor oral hygiene has a detrimental effect on implant survival. If plaque deposits are not removed through maintaining oral hygiene, they easily cause gingival inflammation, rapidly infiltrate the deeper structures, i.e., the bone, and cause destruction and

resorption, which affects implant stability, with the possibility of complete loss.

Dysbiosis

When the microbial homeostasis in the periodontium is disrupted for any reason, pathogens within the biofilm trigger a series of immune reactions in the host organism that can cause periodontopathy in natural teeth. This disruption of microbial homeostasis is also characteristic of peri-implant disease. Elucidating the complex role of the microbial community, as well as the immune mechanisms in oral health and disease, is crucial for the development of improved preventive, diagnostic, and therapeutic strategies[46].

Although many mechanisms are known, many questions remain about how changes in bacterial populations contribute to the development and progression of these conditions.

Microbiological similarity between periodontal and peri-implant tissues has been demonstrated; however, differences have been registered, with a richer and more diverse microbiological finding in tissues diagnosed with peri-implantitis and peri-implant mucositis[47].

In the oral cavity, a microbiological equilibrium exists, where microorganisms are in a symbiotic relationship with the host, maintaining optimal oral health. When the physiological oral microecological balance is disrupted, pathogenic microbes proliferate freely, causing inflammation and tissue damage[48,49]. In periodontal pockets, bacteria such as Treponema, Porphyromonas gingivalis, Fusobacterium, and Prevotella are numerous, and the count of bacteria such as Fusobacterium and Selenomonas increases with the deepening of periodontal pockets[50] (Figure 3.).

In the same individual, identical genotypes of P. gingivalis have been demonstrated in both periodontopathic and peri-implantitis sites. The possibility of bacterial transmission is supported by research that identified the presence of P. gingivalis, T. forsythia, Aggregatibacter actinomycetemcomitans, and Prevotella intermedia in saliva and on the tongue[52,53].

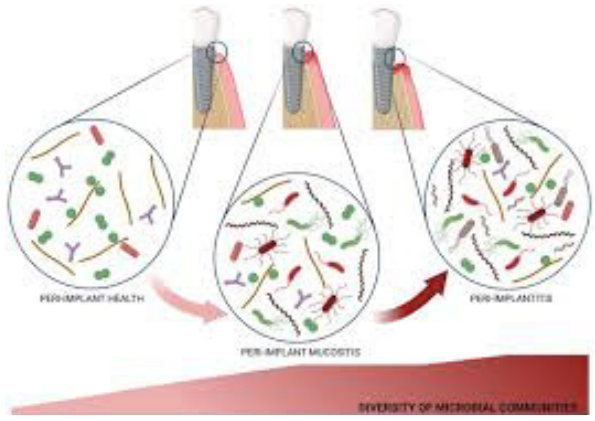

Figure 3. *Differences in the bacterial microbiome around peri-implant tissue: healthy, peri-implant mucositis, peri-implantitis (taken from Belibasakis et al.[51])*

Smoking

Smoking is one of the significant risk factors, belonging partially to the group of systemic factors due to its harmful effects on all organs and tissues, but also partially as a local factor due to its direct effect on all tissues and organs in the oral cavity. Numerous studies confirm that smoking is associated with the onset and progression of periodontal tissue inflammation[54-58]. Cigarette smoking impairs neutrophil and phagocyte chemotaxis, disrupts humoral immunity, alters serum immunoglobulin levels (IgG and IgE), increases the production of reactive oxygen species (ROS), and promotes the release of proteolytic enzymes, collagenases, and elastases, which directly contribute to the destruction of periodontal tissues.54 Research has shown that smoking-induced subgingival dysbiosis occurs before the clinical symptoms of periodontal disease[55], meaning these preclinical findings are precursors to periodontitis.

Constituents in tobacco, such as nicotine and benzo[a]pyrene, exhibit direct antimicrobial effects upon contact with oral microbial communities, leading to non-specific bactericidal effects that reduce the physiological microbiome and immune cell populations, creating opportunities for pathogenic bacteria to proliferate[56].

Knowing the biological proximity of these two tissues, and referring to the easy bacterial transmission, the impact of smoking on peri-implant tissues is justified.

Nicotine causes vasoconstriction and impaired epithelialization of lesions, which is why it has long been considered a potential risk factor for implant longevity. Nicotine affects osseointegration, increases soft tissue inflammation, and influences bone loss around the implant. Its impact on marginal bone loss around implants is well documented[57,58]. It has been proven that heavy smokers have twice the risk of implant failure compared to non-smokers or moderate smokers.

Keratinized Mucosa

The lack of keratinized mucosa may be associated with poor soft tissue condition, presence of peri-implant mucositis and peri-implantitis. It is believed that an adequate width of keratinized mucosa is related to plaque accumulation, inflammation, recession, and attachment loss, but bone loss has not been confirmed.

It has been demonstrated that a wider band of keratinized gingiva may be beneficial for patients in the treat-

ment of peri-implantitis compared to situations with a reduced width of keratinized mucosa. With wider keratinized gingiva, reduced probing depth, absence of inflammation, and improved bone stability have been registered. Combined correction of hard and soft tissue defects around lesions caused by peri-implantitis may facilitate treatment success and help maintain peri-implant stability[59].

However, it is considered that the ultimate outcome for implant survival depends on the need to meet certain criteria concerning the keratinized mucosa for the implant to be successfully placed and to achieve stable osseointegration without risk.

Occlusal loading

Under physiological circumstances, no association has been found between occlusal loading, malpositioned implants, as causes of bone resorption around the implant[60,61]. However, some experiences suggest that poorly fabricated superstructures and improperly positioned implants may cause peri-implant tissue resorption[62]. But if the tissue is affected by peri-implantitis and occlusal loading exists, bone resorption is considered very likely[63].

On the other hand, implants with very rough surfaces, i.e., surfaces coated with sprayed titanium plasma or hydroxyapatite, carry a certain risk. Manipulation during implant placement has a serious effect on bone resorption, especially if the implant is placed deeply into the bone and cemented with cement whose excess cannot be removed. Cement remnants can cause infection around the implant[64]. However, this risk is avoided by screw-retaining the abutment to the intraosseous part of the implant, a common practice in modern implantology.

Titanium as a Risk Factor

As an implant material, titanium began to be used just under 100 years ago in America, and the first titanium-based implant-supported prostheses were reported in 197765. Due to their long lifespan, corrosion resistance, good biocompatibility, and low Young's modulus, titanium and its alloys have been widely used for dental implants[66].

Currently, titanium implants are the most widely used commercial dental implants. However, factors such as friction between the implant and bone surface, wear caused by biomechanical loading, and the biological effect of fretting corrosion inevitably lead to the release of titanium particles into the surrounding tissues[67].

There is evidence of an association between titanium particles and peri-implant disease, but its role as a risk indicator for peri-implantitis remains to be further clarified and determined[68,69]. The role of titanium particles in the progression of peri-implantitis may be explained by delving deeper into the analysis of risk factors affecting the release of titanium particles around the implant and the dispersion of these particles, as well as their potential role in the initiation and progression of peri-implant disease.

The findings from which the conclusions in this article were drawn, relating to the influence of risk factors on peri-implant disease, are based on the analysis of the results obtained from the reviewed literature.

Conclusion

Risk factors are numerous, but their exact impact has not yet been definitively proven. They are still being studied, refined, and further elaborated. The development of technological and research methodologies will undoubtedly lead to new insights regarding these factors and new approaches to therapy and prevention.

Plaque accumulation and biofilm formation have been demonstrated to play a significant role in the onset and progression of peri-implant disease, while the role of prosthetic factors such as occlusal loading is a very likely cause requiring further investigation. All other systemic factors create a favorable environment for the easier expansion of local risk factors.

Undoubtedly, risk reduction is of great importance for precise planning, successful implantation, and long-term stability of implant survival in the jaws.

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SECOND GENERATION PLATELET-RICH FIBRIN

ВТОРА ГЕНЕРАЦИЈА ТРОМБОЦИТНО ЗБОГАТЕН ФИБРИН

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Abstract

Platelet-rich fibrin (PRF) is a second-generation autologous platelet concentrate that has found widespread use in modern oral surgery, primarily due to its regenerative potential and biological safety. It consists of a fibrin matrix enriched with platelets, leukocytes, cytokines, and growth factors, which promote angiogenesis, tissue regeneration, and accelerated wound healing. This literature review aims to assess the current scientific evidence regarding the use of PRF in oral surgical procedures, with an emphasis on its effects on soft and hard tissue healing and the reduction of postoperative complications. In order to meet the set objectives, a comprehensive literature search was conducted using the PubMed and Medline databases, focusing on studies published between 2001 and 2021. The findings indicate that PRF has a variety of clinical applications, including third molar surgery, socket preservation, maxillary sinus lift, implant placement, treatment of oroantral communications, use as biological dressings, and periodontal regenerative procedures. Based on the available literature, it can be noted that PRF contributes to improved clinical outcomes by reducing postoperative pain, swelling, and infection rates, while also improving bone regeneration and soft tissue healing. PRF is considered a safe, cost effective, and minimally invasive adjunct in oral surgery. However, further standardized clinical trials are requiredto optimize its use and confirm long-term outcomes. **Keywords:** PRF, third molar surgery, socket preservation,sinus floor elevation,guided bone regeneration.

Апстракт

Фибринот богат со тромбоцити (PRF) е автологен концентрат на тромбоцити од втора генерација кој наоѓа широка употреба во модерната орална хирургија, првенствено поради неговиот регенеративен потенцијал и биолошка безбедност. Се состои од фибрински матрикс збогатен со тромбоцити, леукоцити, цитокини и фактори на раст, кои ја промовираат ангиогенезата, регенерацијата на ткивата и забрзаното заздравување на раните. Овој преглед на литературата има за цел да ги процени моменталните научни докази во врска со употребата на PRF во оралнохируршките процедури, со акцент на неговите ефекти врз заздравувањето на меките и тврдите ткива иврз намалувањето на постоперативните компликации. За да се исполнат поставените цели, спроведено е сеопфатно истражување на литературата со користење на базите на податоци PubMed и Medline, фокусирајќи се на студии објавени меѓу 2001 и 2021 година. Наодите покажуваат дека PRF има различни клинички апликации, вклучувајќи хирургија на трети молари, зачувување на алвеолата, подигање на максиларниот синус, поставување на импланти, третман на ороантрални комуникации, употреба како биолошки преврски и пародонтални регенеративни процедури. Од литературните податоци, може да се забележи дека PRF придонесува за подобрени клинички исходи со намалување на постоперативната болка, оток и стапки на инфекција, а истовремено ја подобрува регенерацијата на коските и заздравувањето на меките ткива. PRF се смета за безбеден, економичен и минимално инвазивен додаток во оралната хирургија. Сепак, потребни се понатамошни стандардизирани клинички испитувања за да се оптимизира неговата употреба и да се потврдат долгорочните исходи. Клучни зборови: PRF,хирургија на трет молар,презервација на алвеола,подигање на под на синус,водена коскена регенерација.

Introduction

PPRF is a second-generation platelet concentrate. This material has a structure built of a fibrin network that contains a various growth factors and cytokines, which under normal conditions are gradually released during the tissue remodeling and healing process. The biological effects of PRF are predominantly observed in the acceleration of the wound healing process and tissue regeneration, which contributes to its diverse applications in oral surgery[1].

Modern oral surgery is focused on minimally invasive surgical methods and biological strategies that aim to improve the healing process, while minimizing the quantity and quality of postoperative complications, and therefore

the application of PRF is of crucial importance. Unlike PRP, PRF is not obtained in a complex procedure and does not require the use of anticoagulants and biochemical additives, which makes it a biologically safer and more natural substance[2].

PRF is created from whole blood samples without the use of any additional components. Therefore, there is a low risk of side effects. Another advantage is the simplicity of the obtaining process and the ease of the preparation process, which means that the intervention does not involve high costs. PRF in modern dental practice can be used both as a liquid and as a solid matrix[3].

Evidence from contemporary scientific research shows that PRF contributes to better alveolar bone preservation after tooth extraction and after dental implant placement. Qualitative analyses show that PRF has a significantly increased capacity for bone regeneration, particularlyin alveolar cleft repair cases. Additionally, meta-analytic literature findings from third molar surgical procedures report a lower rate of alveolar osteitis, a common complication in oral surgery[4].

Complications that may occur following oral surgery have catalyzed the development of innovative approaches, such as PRF. In recent years, the topic of PRF has gained significant interest in the field of clinical research.

The main aim of this literature review is to evaluate and present the current scientific evidence regarding the use of platelet-rich fibrin (PRF) in oral surgery, with a particular emphasis on its effects on tissue healing, bone regeneration, and reduction of postoperative complications. This literature review also aims to analyze the clinical efficacy of PRF in various oral surgical procedures, including tooth extraction, implant placement, sinus augmentation, and guided bone regeneration, as well as to present the relevant limitations and disadvantages in the use of this material in the available scientific and professional literature.

To fulfill the objectives of this study, a comprehensive literature search was conducted through the most widelyused medical scientific databases - PubMed and Medline. The following keyword combinations were used in the search: “PRF” AND “third molar surgery” OR “socket preservation” OR “sinus floor elevation” OR “guided bone regeneration” OR “alveolar ridge preservation”. Literature data related to the previously listed keywords, published in the last two decades (2001-2021), were analyzed. Only papers written in English were included in the study.

PRF in Oral Surgery

PRF as a material has a significant role in oral surgery. In the contemporary scientific literature about the use of PRF in oral surgery, the data are predominantly focused on its use in dentoalveolar procedures. It is inevitable to note that research related to the use of PRF in oral surgical procedures has shown mixed results, which will contribute to the hesitation of oral and maxillofacial surgeons to adopt PRF widely.

Contemporary oral surgical practice encompasses a wide range of procedures in which PRF can be used, such as:

- mandibular third molar surgery,
- socket preservation after tooth extraction,
- maxillary sinus augmentation,
- application of biological dressings,
- placement of dental implants,
- treatment of osteonecrosis of the jaw,
- closure of oroantral communications, and
- various periodontal surgical procedures.

Third molar extraction

Third molar tooth extraction is a frequently performed oral surgical procedure that can result in numerous complications leading to patient discomfort. The most common potential postoperative complications include: trismus, pain and severe swelling, which are usually more common in relation to the occurrence of infections, alveolar osteitis and sensory disturbances[5,6].

PRF can be applied after the extraction of third molars in order to improve the wound healing process, reduce postoperative pain and swelling and reduce the risk of alveolar osteitis[7]. For this purpose, especially to reduce adverse postoperative outcomes in patients related to the occurrence of swelling, trismus and pain, the literature describes the positive effect of using PRF clot to fill the defect after third molar extraction[8]. It must also be noted that some systematic literature reviews have indicated that patients treated with PRF have a reduced incidence of alveolar osteitis and lower levels of postoperative pain after third molar surgery[4,9-11].

Perhaps the most significant conclusion is the one that was drawn by Ribeiro et al.[12] who reported that the use of PRF is crucial in minimizing postoperative discomfort, edema, alveolar osteitis rate, and infections after surgical removal of third molars, compared with patients who did not use PRF.

Socket preservation

In contemporary literature, Platelet-rich fibrin (PRF) has been widely investigated as a biological adjunct for socket preservation after tooth extraction. PRF is widely known to serve as a fibrin-based scaffold that allows for the continuous release of vital growth factors, including platelet-derived growth factor (PDGF), transforming growth factor-beta (TGF-β), and vascular endothelial growth factor (VEGF), thereby facilitating angiogenesis

and osteogenic activity during the early stages of wound healing[13].

This material has been used to promote the soft tissue healing process, reduce post-extraction alveolar bone loss, and improve the quality of the regenerative ridge in preparation for future implant placement[14].

Systematic reviews suggest that PRF may help reduce post-extraction alveolar bone resorption, although its clinical efficacy may vary based on defect morphology, surgical technique, and patient-related factors[15-17]. It must also be noted that there is considerable heterogeneity in the literature, predominantly due to variations in study design, preparation protocols, and centrifugation methods, making direct comparisons of results difficult.

Numerous clinical studies have shown that the application of PRF in extraction sockets leads to better and faster soft tissue closure and more effective preservation of alveolar ridge dimensions compared to natural healing alone. In addition, its use is associated with less postoperative pain and discomfort, as well as faster maturation of the healing socket[18,19].

In conclusion, it can be noted that PRF can be considered a cost-effective, autologous biomaterial that enhances biological healing processes in socket preservation procedures.

Maxillary Sinus Augmentation

Platelet-rich fibrin (PRF) is a significant biologically active adjunct in maxillary sinus augmentation procedures, particularly with the goal of enhancing bone regeneration and improving clinical outcomes[20]. In sinus lift surgery, PRF can be applied either alone or in combination with bone graft materials to promote faster healing, enhance graft stability, and improve bone formation within the elevated sinus cavity[21].

Clinical studies and systematic reviews have shown that the addition of PRF to sinus augmentation procedures can enhance new bone formation and reduce healing time compared to traditional grafting techniques alone[4,18,22,23].

As previously noted, PRF acts as an autologous fibrin matrix that releases growth factors such as PDGF, TGF-β, and VEGF, thereby stimulating angiogenesis and osteogenesis in the grafted sinus area. This biological activity is particularly vital in the maxillary sinus, where bone regeneration is often limited due to poor vascularity and inadequate underlying bone volume[24,25].

Finally, it must be noted that PRF is associated with increased graft stability, fewer postoperative complications, and improved soft tissue healing at the site of the intervention.

Application of biological dressings

Platelet-rich fibrin (PRF) can be used as biological dressings predominantly due to its autologous origin, ease of preparation and regenerative potential. This potential is since PRF forms a dense fibrin matrix enriched with platelets, leukocytes and a wide range of growth factors, including transforming growth factor-beta (TGF-β), vascular endothelial growth factor (VEGF) and platelet-derived growth factor (PDGF). This matrix acts as a natural substrate that supports cell migration, proliferation and differentiation, while providing a continuous release of bioactive molecules over time[26,27].

Its fibrin architecture not only stabilizes the wound site, but also improves angiogenesis and soft tissue healing by facilitating neovascularization[28]. In addition, the presence of leukocytes in PRF contributes to its antimicrobial and immunomodulatory effects, further supporting tissue regeneration[24].

When applied as a biological dressing, PRF creates a protective barrier over surgical or traumatic wounds, promoting hemostasis and reducing the risk of infection. These properties make PRF particularly valuable in oral and maxillofacial surgery, including extraction sockets, periodontal defects, soft tissue grafting, and maxillary sinus augmentation procedures[3].

Clinical studies have shown that the application of PRF results in reduced postoperative pain, accelerated epithelialization, and improved wound healing outcomes[29,30]. Compared to conventional dressings, PRF offers the advantage of being completely biocompatible and additive-free, thus minimizing the risk of adverse reactions[31].

Based on the literature data, it can be concluded that PRF is increasingly considered a safe and effective biological dressing in regenerative dentistry and implantology.

Placement of dental implants

Platelet-rich fibrin (PRF) has emerged as a significant advance in dental implantology. The success of dental implants largely depends on the osseointegration process. PRFcontributes to osseointegration by enhancing the initial healing events at the implant site[32]. The fibrin matrix acts as a scaffold that supports the migration and proliferation of surrounding cells, while the sustained release of growth factors stimulates osteoblast activity and angiogenesis[24].

In addition to cell migration and proliferation, PRF enhances neovascularization, leading to an improved supply of oxygen and nutrients to the regenerating tissues. Such increased vascularization not only accelerates bone regeneration, but also reduces the risk of implant failure[33].

PRF can be applied immediately after implant placement, with PRF being placed in extraction sockets to promote faster healing and preserve the alveolar bone dimensions. PRF can also be used in socket preservation techniques, helping to minimize bone resorption after extraction[34].

PRF can be used alone, but it can also be used in combination with bone graft materials to improve graft stability and integration. Its fibrin network facilitates the incorporation of graft particles and supports the formation of new bone[22].

PRF also has beneficial effects on the soft tissues around implants. The presence of leukocytes and cytokines leads to a reduction in inflammation and an improved immune response, promoting adequate conditions for wound healing. Improved soft tissue healing is particularly important in aesthetic areas, where the quality and stability of the peri-implant mucosa significantly affect the final outcome[35].

Importantly, PRF can reduce postoperative complications. Clinical studies have shown that the use of PRF is associated with reduced postoperative pain, risk of infection, and swelling. The presence of leukocytes significantly influences the healing process predominantly due to antimicrobial and immunomodulatory effects. Along with rapid wound closure and tissue regeneration, the likelihood of complications such as delayed healing or implant exposure is reduced[18,36,37].

However, it must be stated that, although many studies report positive results, there is still variability in clinical outcomes and standardized protocols are needed to optimize its use. In the future, the integration of PRF with new technologies, such as biomaterials and growth factor delivery systems, may open up new possibilities in implant dentistry.

Closure of oroantral communications

Oroantral communications most often occur during extraction of maxillary posterior teeth due to the close anatomical contact of the roots of these teeth and the floor of the maxillary sinuses. Untreated oroantral communications can transform into oroantral fistulas. Oroantral communications and fistulas inevitably lead to chronic maxillary sinusitis, as a significant complication[38].

The treatment of oroantral communications depends on numerous factors such asthe presence of infection, the size of the defect and the duration of the communication[39]. Treatment in everyday dental practice is predominantly through conventional techniques, although in recent years, PRF has been increasingly used for this purpose. This is primarily due to the fact that PRF represents a minimally invasive and biologically active alternative for the therapy of oroantral communications.

In the treatment of oroantral communications with PRF, this material acts as a biological membrane and filler, while simultaneously having a positive effect on the healing of both soft tissues and bones. The fibrin matrix provided by this material also acts on blood clotting, which closes the communication, and the matrix acts as a basis in which the regeneration of epithelial and connective tissues occurs[40].

A modern clinical study comparing the effects of PRF with a buccal flap showed comparable closure success rates (approximately 90%), with the use of PRF also significantly improving and accelerating wound healing, minimal displacement of the mucogingival layer, and of course reduced postoperative pain[41].

Finally, it must be noted that most studies confirm that PRF in the treatment of oroantral communications is often used as an adjunct, and notas a soletreatment method.

Regenerative periodontal procedures

Regenerative periodontal techniques using PRF are becoming increasingly common among clinicians. As previously mentioned, the slow polymerization process of PRF leads to the formation of a strong fibrin network that allows release of growth factors over time; enhanced angiogenesis; increased fibroblast proliferation; and adequate modulation of the inflammatory response[42]. These fundamental advantages allow for effective healing and periodontal regeneration. Adequate regeneration is still a challenge, especially in complex periodontal cases such as those with infrabony defects, gingival recession, and furcation involvement[43].

The fibrin matrix deposited in periodontal defects allows for the migration and proliferation of cellular structures. In turn, the presence of growth factors stimulates the proliferation and differentiation of fibroblasts, osteoblasts, periodontal ligament cells and pluripotent cells[44]. These methods also affect the formation of the extracellular matrix by initiating collagen synthesis. It also leads to the formation of new blood vessels, which increases the supply of oxygen and nutrients and thus reduces the concentration of cytokines that stimulate the immune response of the host cells[45].

In periodontal surgery, PRF has been successfully used in the treatment of intrabony defects, furcation defects, gingival recession defects, socket preservation, and guided tissue regeneration procedures[14,46]. Clinical studies and systematic reviews have demonstrated that the adjunctive use of PRF may lead to significantly greater probing pocket depth reduction, clinical attachment level gain, and radiographic bone fill compared with conventional surgical therapy alone[47,48]. Furthermore, PRF has been associated with improved soft tissue healing, reduced postoperative discomfort, and enhanced patient-reported outcomes[47,49].

Recent systematic reviews and meta-analyses have confirmed the positive effects of PRF on periodontal regeneration, particularly in the treatment of infrabony and furcation defects, either alone or in combination with bone graft materials[47-49]. Nevertheless, differences in centrifugation protocols, preparation methods, and study designs con-

tinue to contribute to variability in clinical outcomes. Therefore, additional well-designed randomized controlled trials with long-term follow-up are necessary to establish standardized clinical protocols and optimize the use of PRF in periodontal surgery.

Finally, we can conclude that PRF with its ability to improve the healing of both soft and hard tissues, as well as reduced postoperative morbidity, can easily improve therapeutic outcomes. Hence, PRF can be a significant addition to periodontal surgical interventions due to its regenerative potential and biological compatibility.

Conclusion

Platelet-rich fibrin (PRF) is an autologous, safe, and cost-effective biomaterial that significantly improves the healing process of both soft and hard tissues in oral surgical procedures. Its application has been shown to achieve improved clinical outcomes, including accelerated wound healing, improved bone regeneration, and reduced postoperative complications such as pain, swelling, and infection. However, variability in clinical protocols and outcomes highlights the need for further standardized, high-quality studies to optimize its use and confirm long-term efficacy.

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COMPARATIVE EVALUATION OF SECOND-GENERATION PLATELET-RICH FIBRIN (PRF) AND CONNECTIVE TISSUE GRAFT (CTG) IN THE MANAGEMENT OF LOCALIZED MILLER CLASS I AND II GINGIVAL RECESSIONS: A CASE SERIES

ЕФЕКТИВНОСТА НА ВТОРАТА ГЕНЕРАЦИЈА ТРОМБОЦИТНО-ЗБОГАТЕН ФИБРИН PRF ВО ТРЕТМАНОТ НА ЛОКАЛИЗИРАНИТЕ ПОЕДИНЕЧНИ ГИНГИВАЛНИ РЕЦЕСИИ MILLERIИ II ВО ОДНОС НА СУБЕПИТЕЛИЈАЛЕН СВРЗНОТКИВЕН ГРАФТ SCTG (АНАЛИЗА НА СЛУЧАИ)

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Abstract

The mucogingival surgical modality SCTG + CAF (subepithelial connective tissue graft (SCTG) + coronally advanced flap (CAF)) in the treatment of Miller Class I and II gingival recessions is considered the “gold standard” technique for predictable and complete root coverage of gingival defects, with long-term clinical stability of the achieved results. The aim of this study is to evaluate the clinical efficacy of the CAF + PRF combined technique in the treatment of localized single Miller Class I and II gingival recessions in 10 patients, by comparing periodontal clinical parameters measured preoperatively and one month postoperatively, versus results obtained with the CAF + CTG (SCTG) modality in another 10 patients with the same type of recession, over the same time period. **Material and method:** Ten patients were admitted to the Clinic “St. Panteleimon” – Skopje, Department of Oral Surgery, for surgical treatment of localized single Miller Class I and II gingival recessions. Half of the patients were treated with the CAF + PRF technique, while the other half were treated with the CAF + CTG (SCTG) modality. One day preoperatively, periodontal clinical parameters were measured, including vertical gingival recession (RD/VGR), probing pocket depth (PPD/PD), clinical attachment level (CAL), keratinized gingival width (KTW/KMW), and gingival thickness (GT), all measured in millimeters, as well as gingival biotype in all 10 patients. Following mucogingival surgical procedures (CAF + PRF in five patients and CAF + CTG/SCTG in five patients), the same periodontal clinical parameters were recorded one month postoperatively in all patients. These values were then compared with the preoperative measurements both between the groups and within each group over time. **Results:** An insignificant reduction in PPD and CAL, as well as a slight, clinically minor increase in KTW, was observed when comparing measurements taken one day preoperatively and one month postoperatively between the two groups. Similarly, no statistically significant changes in these parameters were observed within the same group over the same time periods. A statistically significant increase in the RD/VR parameter ($Z = 1.984$; $p = 0.0472$) was observed in the SCTG + CAF group one month postoperatively compared with the PRF + CAF group, while other comparisons of this parameter between and within groups were not statistically significant. Regarding the GT parameter, a statistically significant change ($Z = 2.507$; $p = 0.0122$) was observed in the PRF + CAF group when comparing baseline and one-month postoperative values within the same group. However, no statistically significant differences in GT were observed between the two groups at either time point. Changes in gingival biotype from thin to thick were observed only in the PRF + CAF group one month postoperatively in 2 patients (40%). **Conclusion:** Therefore, PRF as a second generation of autologous concentrate is not only an adjuvant and/or replacement of the SCTG- "gold standard" in the treatment of Miller I and II, but is also a superior alternative in the surgical treatment of this type of superficial mucogingival defects.

Keywords: PRF, platelet concentrates, CAF, Miller I and II, gingival recessions, mucogingival surgery.

Апстракт

Мукогингивалниот хируршки модалитет SCTG + CAF (субепителијален сврзно-ткивен графт (SCTG) + коронарно позициониран флап (CAF)) во третманот на Miller Class I и II гингивални рецесии се смета за „златен стандард", односно техника за предвидливо и за комплетно коренско покривање на гингивалните дефекти, со долгорочна клиничка стабилност на постигнатите резултати. Целта на овој труд е евалуација и компарација на клиничката ефикасност на комбинираната техника CAF + PRF во однос на техниката SCTG + CAF, во третманот на локализирани поединечни Miller Class I и II гингивални рецесии, преку споредба на вредностите на пародонталните клинички параметри мерени предоперативно и 1 месец постоперативно. **Материјал и метод:** Во оваа кохортна студија се вклучени 10 испитаници од двата пола, поделени во 2 групи. Првата, контролна група од 5 испитаници беше третирана со хируршкиот модалитет SCTG + CAF, додека кај втората, тест/експериментална група од 5 испитаници беше изведен PRF + CAF оперативниот модус при третман на Miller Class I и II рецесии. Студијата е изведена на Клиниката за орална хирургија при ЈЗУ-УСКЦ "Св. Пантелејмон" – Скопје. Предоперативно беа извршени мерења на следниве пародонтални клинички параметри: вертикална димензија на гингивална рецесија (RD/VGR), длабочина на пародонтален џеб (PPD/PD), клиничко ниво на припоена гингива (CAL), ширина на кератинизирана гингива (KTW/KMW) и дебелина на гингива (GT), сите мерени во mm, како и определување на гингивалниот биотип. Како хируршки пристап беше применет терапискиот модалитет CAF (coronally advanced flap) за третман на гингивалниот дефект. Еден месец постоперативно повторно беа измерени истите клинички пародонтални параметри, и нивните вредности беа споредени со предоперативните мерења. **Резултати:** При мерењата изведени еден ден предоперативно и еден месец постоперативно беа забележани несигнификантна редукција на вредностите на PPD и CAL, како и незначајна промена на вредностите на KTW, како помеѓу двете групи, така и при интрагрупна споредба во истите временски интервали. Еден месец по интервенцијата, групата SCTG + CAF имаше статистички сигнификантно повисока вредност на RD/VR (Z = 1,984; p = 0,0472) споредено со групата PRF + CAF, додека другите резултати добиени од овој параметар, компарирани интра- и интергрупно, беа статистички несигнификантни. Што се однесува до параметарот GT, статистички значајна промена на вредноста (Z = 2,507; p = 0,0122) беше забележана кај пациентите третирани со модалитетот PRF + CAF, при интрагрупна споредба помеѓу еден ден предоперативно и еден месец постоперативно, што укажува на значајно зголемување на дебелината на гингивата кај PRF-оперативниот модус. При компарацијата помеѓу двете групи во истите временски интервали, не беа пронајдени статистички сигнификантни промени на вредностите на GT-параметарот. Промена на гингивалниот биотип од тенок во дебел беше забележана само во групата PRF + CAF, еден месец постоперативно, кај 2 пациенти (40%). **Заклучок:** PRF, како втора генерација на автологни тромбоцитни концентрати, не само што претставува адјувант и/или алтернатива на SCTG – „златниот стандард" во третманот на MillerClassI и II рецесии, туку претставува и потенцијално супериорна алтернатива во хируршкиот третман на овој тип плитки мукогингивални дефекти. **Клучни зборови:** PRF, тромбоцитни концентрати, CAF, MillerClassI и II, гингивални рецесии, мукогингивална хирургија.

Introduction

Approximately 90% of the world population up to 60 years of age hasat least one tooth with recession up to 1mm. The distribution of recessions greater than 3mm is about 40% of the entire population[1].Gingival recession is defined as theapical dislocation of the marginal gingiva towards the cemento-enamel junction-CEJ[2,3] associated with subsequent exposure of the root surfaces, root caries, hypersensitivity, plaque accumulation, and aesthetic compromise[4]. The etiology is complex; it includes traumatic occlusion, deficient or improper oral hygiene (e.g., grough tooth brushing), older prosthetic constructions or dental fillings (with inadequate marginal closure), as well as a high-inserted upper or lower labial frenulum, or a shallow vestibule, caused by muscle attachments andstrong muscle traction[5]. Malocclusions and malpositioned teeth, as orthodontic anomalies, and the peiod following treatment with fixed appliances, are conditions that presentanatomical challenge to the mucogingival complex as part of the periodontal apparatus, and these, combined with the thin biotype of the gingiva, are also etiological causes contributing to gingival recession[6]. The most common clinical manifestation of recession is the loss of vestibular/palatal "attachment loss"[7,8,9].The principles of modern aesthetic mucogingival surgery using autologous grafts (SCTG or PRF) are based on complete and predictable coverage of exposed root surfaces[10], the establishment of homeostasis of the mucogingival complex, regeneration of the lost attachment, including the formation of new cementum through the insertion of connective tissue fibers, and regeneration of the alveolar bone[11]. The most widely used and most commonly used surgical technique is the coronally advanced flap (CAF). The CAF is a simple "pedicle" flap that provides excellent root coverage in the treatment of Miller Class I and Class II gingival recessions[12, 13, 14]. The current "gold standard" or technique of choice is the use of CAF and SCTG, with a predictability of root coverage of 73-96% and graft stability for up to 20 years[15,16,17,18].The reported percentage of predictable root coverage achieved with CAF and PRF ranges from 75 to 91%[19].

In modern regenerative mucogingival surgery, the focus on the application of the second generation of autologous platelet concentrates is increasingly being emphasized. These autologous blood derivatives are divided into fourcategories/classes (according to the content of leukocytes and fibrin): P-PRP (Pure Platelet Rich Plasma); L-PRP (Leukocyte Platelet Pure Plasma), P-PRF(Pure Platelet-Rich Fibrin) and L-PRF (Leukocyte Platelet-Rich Fibrin)[20]. On the other hand, these fourclasses are divided into threegenerations of platelet concentrates[21].

PRF(platelet-rich fibrin; thrombocyte-enriched fibrin) represents the second generation of autologous platelet concentrates (APCs) embeddedinto a fibrin matrix. The

founder of the second generation ATCs, PRF, is Dr. Choukroun, who introcused it in 2001, and for the first time they were described by Dohan et al.[22]. In addition to the conventional Choukroun protocol, modifications have been developed overthe last two decades, conditioned by the aforementioned protocol variations. These new modalities are as follows:

A-PRF (Choukroun, 2004) - the protocol is characterized by a lower centrifugation speed and a longer centrifugation time (1300rpm/8min) in sterile, ordinary glass-coated vacuum collectiontubes (A-PRF).

I-PRF (Choukroun, 2004) (injectible platelet-rich fibrin) is prepared by centrifugation at 700 rpm for 3min-plastic tubes without any coating[23,24].

Microscopically, PRF consists of a three-dimensional (3D) fibrin network compoesed of thin, elastic, mature, and densely polymerized fibrin fibers, in which a multitude of cells, predominantly platelets, as well as concentrates of growth factors and cytokines are trapped. The physiological (natural) polymerization of PRF allows for enhanced trapping of circulating cytokines, which are released only when the 3D fibrin matrix is remodeled, due to the slow, prolonged, and controlled release of growth factors for a period of up to 28 days[25]. This 3D fibrin network, in addition to stimulating the activity of the trapped regulatory cytokines, also enables the adhesion of new blood vessels. Therefore, PRF can be considered as an ideal biomaterial for tissue engineering: it contains a network that behaves like a three-dimensional matrix, viable cells for tissue population as well as molecules that stimulate repair[26]. In addition to the fact that platelet-rich fibrin concentrate (PRF) contains platelets, leukocytes, and circulating stem cells, it is also a reservoir of a large number of slow-releasing growth factors (released over 7, 10, 21 to 28 days), cytokines, and matrix glycoproteins (thrombospondin-1) that influence the regeneration process of soft and hard tissues, stimulating neoangiogenesis and fibroblast/osteoblast migration.

Material and Methods

This prospective cohort study was performed at the Clinic of Oral Surgery and Implantology, University Surgical Clinic "St. Panteleimon", Skopje, the Laboratory of the Faculty of Dentistry, Ss. Cyril and Methodius University in Skopje (UKIM), as well as the Institute of Pathological Anatomy, Faculty of Medicine, Skopje.

Material

This study included 20 subjects (10 men and 10 women) indicated for mucogingival surgical correction of isolated gingival recession: 10 subjects in the test group (CAF+PRF) and 10 subjects in the control group (CAF+SCTG).

Group I: CAF + second-generation platelet-rich fibrin (A-PRF and I-PRF) (Choukroun et al., 2004)

Group II: CAF + subepithelial connective tissue graft (SCTG)

The inclusion criteria for the study group were: age 18–60 years, absence of acute diseases, systemically healthy patients (ASA I and II, American Society of Anesthesiologists), patients with localized, single, unilateral or bilateral Miller Class I and Class II gingival recessions on any teeth in both jaws, patients with an identifiable cemento-enamel junction, and subjects who understood the nature of the intervention and were able to attend subsequent follow-up examinations.

The general (systemic) exclusion criteria for members of the study group were as follows: patients receiving anticoagulant therapy, smokers, individuals with substance use disorders, patients with coagulopathies, cardiovascular diseases, hepatic disorders, malignancies, those undergoing chemotherapy, immunodeficiency conditions, and pregnant or lactating women.

The local exclusion criteria were as follows: patients with bad habits and unsatisfactory oral hygiene, mobile teeth, non-vital teeth, local signs of infection (bleeding, redness, pain, swelling), presence of restorative materials in the area to be treated, gingival thickness (GT) $\leq$ 0.8 mm, keratinized gingival width (KTW) $\leq$ 2 mm, and insufficient palatal tissue thickness $\leq$ 2.5 mm (for participants in the control group).

All patients signed an Informed Consent Form and completed a questionnaire, in accordance with the Declaration of Helsinki (1998/2008, revised). Preoperative preparation (initial therapy) included mechanical decontamination/debridement, scaling and root planing, elimination of premature contacts (traumatic occlusion) and other bad habits etiologically associated with recession. The teeth were cleaned with an abrasive paste and then polished. Patients were instructed on proper oral hygiene maintenance.

Before the surgical intervention, patients rinsed their mouths with 10 mL of 0.05% cetylpyridinium chloride. The antibiotic protocol included the administration of metronidazole 400 mg tablets (1 tablet three times daily), initiated 3 days before the intervention and continued for an additional 7 days. Instructions were given regarding postoperative oral hygiene, including a liquid and soft diet during the first week and rinsing with 0.05% cetylpyridinium chloride (3 times daily for 1 minute) for 14 days. The teeth in the surgical field were cleaned with cotton pellets, gently removing soft dental plaque while avoiding brushing until the sutures were removed after 3 weeks. Brushing with an ultra-soft toothbrush was recommended after the

first month. Non-steroidal anti-inflammatory drugs (NSAIDs) were prescribed for pain control, as well as vitamin C (1000 mg/day) and vitamin D3 (1000 IU/day, once daily) for 4–6 months.

Method

Surgical protocol:

The design of the CAF (coronally advanced flap) consists of sulcular incisions that merge with horizontal incisions in the area of the adjacent interdental papillae. The mesial and distal horizontal incisions start from the bases of the anatomical papillae of the adjacent teeth up to the CEJ of the tooth with recession, and their positioning from the tip of the papillae to the marginal gingiva of the affected tooth is equal to the sum of RD + 1 mm, without violating the integrity of the marginal edge of the adjacent teeth (method of de Sanctis & Zucchelli[27,28]). These horizontal incisions are connected with two oblique vertical incisions that start at the corners of the adjacent teeth and continue slightly divergently towards the alveolar mucosa of the vestibular fornix, crossing the mucogingival junction, resulting in a coronal-apical trapezoidal partial-thickness flap (Figures 1 and 2).

Figure 1

Figure 2

Figure 3

Figure 4

The exposed root surface is mechanically debrided using Gracey curettes, and then refined with a diamond bur. The root surface is conditioned with 24% EDTA for 2 minutes, and subsequently treated with a concentrated solution of doxycycline for 2 minutes (Figures 3 and 4).

The SCTG autograft is harvested after application of anesthesia (3% mepivacaine [Scandonest]) from the palatal side of the patient using a No. 15 scalpel blade. SCTG can be harvested with 1, 2, or 3 incisions or as a FGG with 4 incisions, which must then be de-epithelialized (Figures

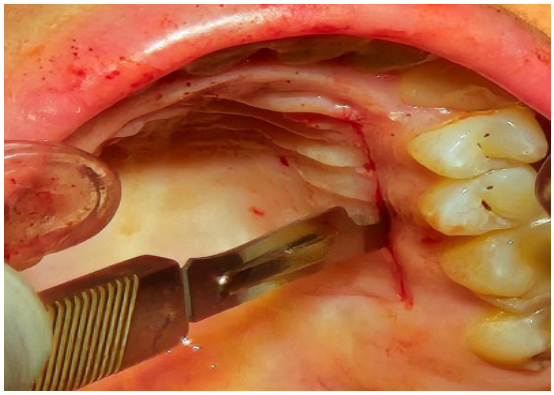

Figure 5

Figure 6

Figure 7

5,6,7). "W"-sutures are placed at the donor site using a locking technique (Figure 8). The autograft is fixed with absorbable Vicryl 5-0 sutures using a horizontal mattress suture technique for the adjacent soft tissue in the apical direction, and vertical mattress sutures for the de-epithelialized surgical papillae.

The surgical manipulation of the A-PRF membrane involves several stages. By venipuncture, 20 mL of venous blood is collected from the antecubital vein using a Vacutainer system into two sterile, glass-coated vacuum

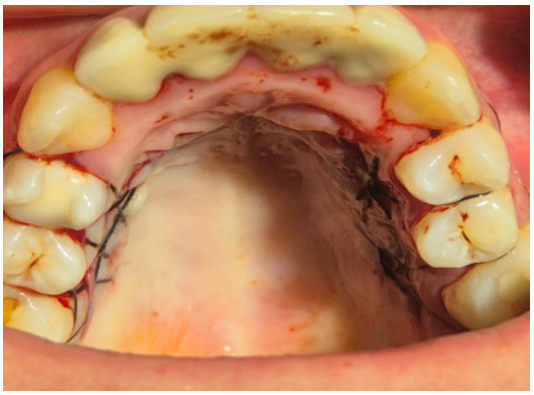

Figure 8

Figure 9

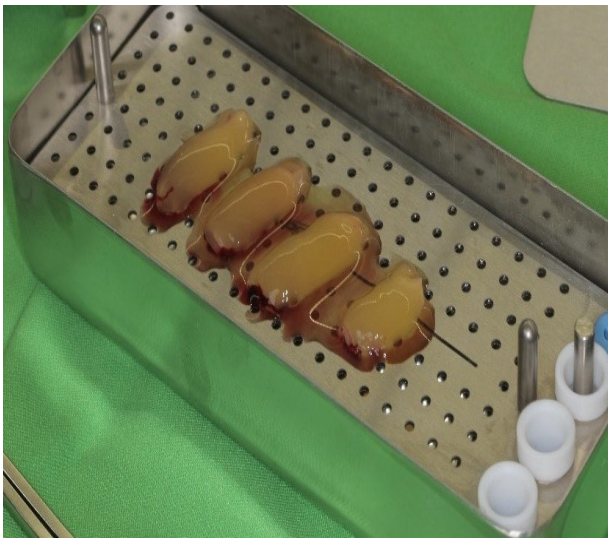

Figure 10

tubes (A-PRF), without anticoagulants or citrate. The entire manipulation should be rapid, and immediately after blood collection, the tubes are centrifuged according to the protocol of Dr. Choukroun from 2004, which is characterized by a lower centrifugation speed but a longer centrifugation time (1300 rpm for 8 minutes), in a specially designed centrifuge (BIOBASE LC-H4K, Biobase, Jinan, Shandong, China). After centrifugation, the tubes are placed on a laboratory rack and then left to stand for 5 minutes, covered with sterile gauze. With anatomical tweezers, the two fibrin clots are removed from the tubes and then placed in the PRF box for membrane preparation. The membranes can be placed coronally up to 1 mm coronal to the CEJ and, due

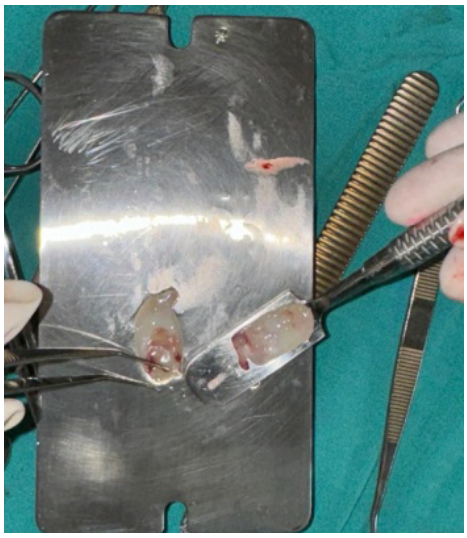

Figure 11

Figure 12

Figure 13

Figure 12

Figure 14

Figure 15

to their adhesive properties, they are not sutured but gently adapted under the mesiodistal borders of the recipient site (Figure 12).

The repositioning and suturing of the flap over both autologous graft variants is identical. The flap is positioned coronally and its marginal edge should end at the enamel, i.e. approximately 1 mm coronal to the cementoenamel junction (CEJ). The flap is sutured with non-absorbable polypropylene (5-0) suture using a horizontal sling suture technique as well as individual interrupted sutures for the adjacent soft tissue and previously de-epithelialized interdental papillae (Figure 13). Gentle pressure is applied for 3 minutes to minimize the thickness of the blood clot.

Injectable platelet-rich fibrin (I-PRF) is obtained by centrifuging 20 mL of venous blood according to the protocol of Dr. Choukroun (2004) at 700 rpm for 3 minutes in specially designed plastic tubes without any coating (I-PRF tubes). After centrifugation of both I-PRF tubes, a light yellow supernatant is observed in the upper part, which is aspirated and used as an injectable form of platelet concentrate. The remaining I-PRF is gently used to rinse the entire surgical area (flap and sutures) (Figure 14). After the intervention, an extraoral compression bandage is placed, to reduce postoperative edema (Figure 15).

Clinical periodontal parameters were recorded 1 day before the intervention and 1 month postoperatively. The following parameters were measured:

- recession depth (GR/GD/VGR – distance from the cementoenamel junction (CEJ) to the marginal gingiva)
- periodontal pocket depth (PPD/PD – distance from the marginal gingiva to the base of the periodontal pocket)
- clinical attachment level (CAL = GR + PPD; distance from the CEJ to the base of the periodontal pocket)
- keratinized gingival width (KTW/KMW/WKG – distance from the marginal gingiva to the mucogingival junction (MGJ), according to Lang & Löe)
- gingival biotype (thin ≤ 1.5 mm; thick ≥ 2.5 mm) according to Ochsenbein & Ross
- gingival thickness (GT – distance from the gingival surface to the underlying bone surface, measured in millimeters)

GR, CAL, KTW, and PPD measurements were performed using a Williams graduated periodontal probe (HuFriedy, Chicago, IL, USA) with a rounded tip. GT measurements were performed on the mid-buccal surface of the affected tooth by transgingival probing (TGP) (Vandana & Savitha) using a #15 endodontic reamer with a rubber stop.

After application of surface anesthesia, in the middle of the attached gingiva, at the midpoint of the distance between the mucogingival junction and the base of the interdental papilla, the reamer was inserted into the tissue to a depth of 1–2 mm apical to the marginal gingiva, perpendicular to the tooth axis, until bone contact was reached. The rubber stop was then positioned flush with the gingival surface, and the distance from the tip of the reamer to the inner border of the stopper was measured using a digital Vernier caliper or micrometer.

Results

One day before and one month after the surgical intervention, the following clinical periodontal parameters were measured in the 10 patients:

Statistical analysis

Quantitative parameters were analyzed using mean, median, minimum and maximum values, and standard deviation. Qualitative data were presented as frequencies and percentages. The normality of data distribution was assessed using the Shapiro-Wilk W-test. The Mann-Whitney U test was used to determine differences between the two groups in terms of selected parameters. The data obtained in the study were processed using the SPSS software package (version 22.0 for Windows; SPSS Inc., Chicago, IL, USA). Statistical significance was set at $p<0.05$, using a two-tailed test.

Comparison of therapeutic effect

The comparison of the two groups (SCTG + CAF vs. PRF + CAF) in terms of the PPD parameter indicated that there was no statistically significant difference between the two groups preoperatively ($Z = -1.775$; $p = 0.0758$) as well as one month postoperatively ($Z = -0.940$; $p = 0.3472$). The comparison of the change from baseline to 1 month in each of the two groups (SCTG + CAF vs. PRF + CAF) in terms of PPD also did not indicate a significant difference ($Z = -1.567$; $p = 0.1172$) (Tables 1 and 2).

The comparison of the groups (SCTG + CAF vs. PRF + CAF) in terms of the RD/VR parameter indicated that there was no statistically significant difference between the two groups preoperatively ($Z = 1.358$; $p = 0.1745$), whereas one month postoperatively, the SCTG + CAF group had a significantly higher value compared to the PRF + CAF group ($Z = 1.984$; $p = 0.0472$). The comparison of the change from baseline to 1 month in each of the two groups (SCTG + CAF vs. PRF + CAF) in relation to RD/VR did not indicate a significant difference ($Z = 0.313$; $p = 0.7540$) (Tables 1 and 2).

The comparison of the two groups (SCTG + CAF vs. PRF + CAF) with respect to the CAL parameter indicated that there was no statistically significant difference between the two groups preoperatively ($Z=-0.522$; $p=0.6015$) nor one month postoperatively ($Z=1.566$; $p=0.1172$). The comparison of the change from baseline to 1 month in each of the two groups (SCTG + CAF vs. PRF + CAF) with respect to CAL did not indicate a significant difference ($Z = -1.149$; $p = 0.2506$) (Tables 1 and 2).

The comparison of the groups (SCTG + CAF vs. PRF + CAF) with respect to the KAW parameter indicated that there was no statistically significant difference between the two groups preoperatively ($Z = 0.835$; $p = 0.4034$) nor one month postoperatively ($Z = -1.044$; $p = 0.2963$). The comparison of the change from baseline to 1 month in each of the two groups (SCTG + CAF vs. PRF + CAF) in relation to KAW also did not indicate a significant difference ($Z = 1.253$; $p = 0.2101$) (Tables 1 and 2).

Regarding the gingival thickness parameter, the comparison of the two groups (SCTG + CAF vs. PRF + CAF) indicated the absence of a significant difference preoperatively ($Z = 1.880$; $p = 0.0601$) as well as one month postoperatively ($Z = 0.0001$; $p = 1.000$). The comparison of the change from baseline to 1 month in each of the two groups (SCTG + CAF vs. PRF + CAF) in relation to gingival thickness indicated a significant difference ($Z=2.507$; $p=0.0122$) in favor of a significantly greater increase in gingival thickness in the PRF+CAF group (Tables 1 and 2).

Table 1. Comparison of SCTG + CAF and PRF + CAF groups at two time points (baseline and 1 month) according to selected parameters

Parameters		Parameters				p
		N	Mean±SD	Min Max	Median(IQR)	
PPD						
before	SCTG+CAF	5	1,60±0,65	1,0/ 2,5	1,5 (1,0-2,0)	Z=(-1,775); p=0,0758
	PRF+CAF	5	3,40±1,78	1,5/ 6,0	3,5 (2,0-4,0)	
1 month	SCTG+CAF	5	0,96±0,62	0,1/ 1,8	1,1 (0,7-1,1)	Z=(-0,940); p=0,3472
	PRF+CAF	5	0,80±0,97	0/ 2,5	0,5 (0,5-0,5)	
RD/VR						
before	SCTG+CAF	5	4,36±1,69	3,0/ 7,0	3,8 (3,0-5,0)	Z=1,358; p=0,1745
	PRF+CAF	5	3,00±1,54	1,5/ 55,5	3,0 (2,0-3,0)	
1 month	SCTG+CAF	5	2,48±0,63	1,8/ 3,2	2,2 (2,1-3,1)	Z=1,984; p=0,0472*
	PRF+CAF	5	1,00±1,06	0,0/ 2,5	1,0 (0,0-1,5)	
CAL						
before	SCTG+CAF	5	5,96±1,53	4,0/ 8,0	6,3 (5,0-6,5)	Z=(-0,522); p=0,6015
	PRF+CAF	5	6,40±1,43	4,5/ 8,0	6,5 (5,5 – 7,5)	
1 month	SCTG+CAF	5	3,44±0,67	2,8/ 4,3	3,2 (2,9-4,0)	Z=1,566; p=0,1172
	PRF+CAF	5	1,80±1,95	0,0/ 5,0	1,5 (0,5-2,0)	
KAW						
before	SCTG+CAF	5	2,18±0,97	0,8/3,0	2,8 (1,5-2,8)	Z=0,835; p=0,4034
	PRF+CAF	5	1,60±1,29	0,0/ 3,0	2,0 (0,5 – 2,5)	
1 month	SCTG+CAF	5	2,58±0,83	1,3/ 3,3	3,0 (2,2-3,1)	Z=(-1,044); p=0,2963
	PRF+CAF	5	4,20±2,77	0,0/ 7,0	5,0 (3,0-6,0)	
Gingival thickenss						
before	SCTG+CAF	5	1,76±1,20	0,5/ 3,1	1,2 (1,0-3,0)	Z=1,880; p=0,0601
	PRF+CAF	5	0,60±0,22	0,5/ 1,0	0,5 (0,5-0,5)	
1 month	SCTG+CAF	5	2,16±1,34	0,9/ 3,5	1,8 (1,4-3,2)	Z=0,0001; p=1,000
	PRF+CAF	5	1,90±0,41	1,5/ 2,6	1,8 (1,8-1,8)	

SD - standard deviation; IQR - Interquartile range
*significant for p<0,05

Table 2. Comparison of the two SCTG+CAF and PRF+CAF RMDQ groups according to the difference in selected-parameters between two times zero/ 1 month

Parameters		Parameters			p
		N	Mean±SD	Median(IQR)	
PPD					
SCTG+CAF	before	5	0,64±0,28	0,70 (0,40-0,90)	Z=(-1,567); p=0,1172
	1 month	5			
PRF+CAF	before	5	2,60±2,38	3,00 (2,00-3,50)	
	1 month	5			
RD/VR					
SCTG+CAF	before	5	1,88±1,18	1,60 (1,29-1,80)	Z=0,313; p=0,7540
	1 month	5			
PRF+CAF	before	5	2,00±2,06	1,50 (0,50-2,00)	
	1 month	5			
CAL					
SCTG+CAF	before	5	2,52±1,35	2,20 (2,10-2,30)	Z=(-1,149); p=0,2506
	1 month	5			
PRF+CAF	before	5	4,60±3,29	4,50 (4,00-7,50)	
	1 month	5			
KAW					
SCTG+CAF	before	5	-0,40±0,20	-0,30 [-0,50-(-0,30)]	Z=1,253; p=0,2101
	1 month	5			
PRF+CAF	before	5	-2,60±2,58	-1,30 [-1,30-(-1,00)]	
	1 month	5			
Gingival thickenss					
SCTG+CAF	before	5	-0,40±0,27	-0,40 [-0,50-(-0,20)]	Z=2,507; p=0,0122*
	1 month	5			
PRF+CAF	before	5	-1,30±0,49	-1,30 [-1,30-(-1,00)]	
	1 month	5			

SD - standard deviation; IQR - Interquartile range
*significant for p<0,05

Regarding the gingival biotype, it was observed that at baseline, the gingival biotype was thin in all subjects in both groups. One month after the intervention, it was observed that in all subjects in the SCTG + CAF group, the gingival biotype remained thin, whereas in the PRF + CAF group, a change from thin to thick biotype was observed in 2 (40%) subjects.

Discussion

A narrow keratinized attached gingiva (KTW < 2 mm) is one of the main contributing factors to gingival recession[9]. The principles of modern aesthetic mucogingival surgery are based on complete and predictable coverage of exposed root surfaces[10,3], the establishment of homeostasis of the mucogingival complex, and regeneration of the lost attachment, including the formation of new cementum, as well as regeneration of the alveolar bone[11]. The goal of periodontal plastic surgery is to develop a minimally invasive surgical technique that promotes and accelerates rapid regeneration, causes minimal postoperative discomfort, and allows maximum aesthetic and functional patient satisfaction[28]. The most commonly used grafts are free gingival graft (FGG) and subepithelial connective tissue graft (SCTG), which are currently recognized as the gold standard in the treatment of this condition, while the most widely accepted and frequently used surgical technique worldwide and in our country is the coronally advanced flap (CAF).

The SCTG harvesting technique is more time-consuming, increasing the risk of morbidity as it involves a second surgical site (donor site) and thus increases patient discomfort in the form of postoperative pain and the risk of bleeding, dehiscence, or flap necrosis[14]. Limitations in the quantity and quality of donor tissue are also disadvantages of SCTG[3]. SCTG (subepithelial connective tissue graft) and PRF (platelet-rich fibrin) share a common autologous origin, representing different therapeutic concepts and strategies; however, the analyzed studies suggest similar clinical outcomes.

The development of platelet concentrates (biological agents) traces its origins to the concept of fibrin adhesives[25]. Their emergence revolutionized the concept of tissue repair and regeneration[29]. Wound healing is a central concept in regenerative surgical science. Healing occurs as a result of a complex interaction between different types of cells (fibroblasts, epithelial cells, osteoblasts) and signaling molecules, which are released from thrombocytes in the form of cytokines and growth factors (GFs)[30].

Since no anticoagulant is required in the A-PRF preparation procedure, and due to the concentration of platelets (up to 97%) and leukocytes (up to 50%) from the original blood volume[31,32], PRF is also defined as an autologous platelet- and leukocyte-rich fibrin biomaterial[20,31]. The advantages of PRF over PRP include a shorter preparation time, absence of biochemical modification or exogenous anticoagulants (resulting in a more cost-effective procedure without the risk of blood-borne diseases or immune reactions), and the ability to allow natural polymerization similar to a physiological blood clot[33].

PRF membranes possess mechanical adhesive properties and a biological function similar to fibrin glue, thereby maintaining the flap in a stable position and enhancing angiogenesis[34]. These biological properties correspond to the findings of Al Jasser R et al.[35], as well as the studies by Anton Sculean et al.[36] and Madi M and Ahmed M. Elakel[37], and are further supported by the study by Rucha Sh et al.[25].

Regarding the statistically significant decrease in the RD/VR value in the (PRF + CAF) group, i.e., a significant increase in the value of vertical recession in the (SCTG + CAF) group ($Z = 1.984$; $p = 0.0472$) observed in our subjects and compared between the two groups one month postoperatively, these findings indicate concordance with the results of Eren G. & Atilla G. (14), Mijiritsky E. et al.[21], and the randomized controlled clinical study by Sonam Mufti et al.[38], in which a significant decrease in VGR/GR/VR values was reported in the (PRF + CAF) group and a comparative increase in the (SCTG + CAF) group. However, these findings are contrary to those reported by Macedo Iunes, C. T. et al.[39] in their split-mouth randomized clinical study, where significantly lower GR/RD/VR values were observed in the control (SCTG + CAF) group, with values progressively decreasing in the postoperative period.

There is also agreement with the significant reduction in RD values reported by Ucak T. Ö. et al. (40), where GR/RD values significantly decreased in the test group (CAF + CTG + PRF), as well as in the randomized parallel-controlled clinical study by Keceli G. H. et al. (41), where a significant intragroup reduction in VR/RD values was observed at 1 month postoperatively.

Panda S. et al.[42], as well as the studies by Madi M. and Ahmed M. Elakel[37], reported a non-significant reduction in RD values. Similarly, Al Jasser R. et al.[35] and Kumar A. et al.[28] conducted comparative analyses, and their results indicated a non-significant reduction in VGR/GR values, most pronounced in the (PRF + CAF) group.

A discrepancy between our results and those reported by Moraschini V. et al.[30], Hernan S. Garzon et al.[43], Collins R. J. et al.[44], as well as Culhaoglu R. et al.[45], was observed. The systematic review by Amine K. et al.[46], based on multiple randomized clinical trials, reported that the obtained values of complete root coverage (CRC) and recession reduction (RecRed) in the (PRF + CAF) modality were comparable to those observed in CAF + SCTG surgical treatment.

A reduction in PPD values was reported in the studies by Madi M. and Ahmed M. Elakel[37], Mijiritsky E. et al.[21], and Miron R. J. and Zucchelli G. et al.[47], while a significant reduction was also observed in the study by Kumar A. et al.[28], who conducted a comparative analysis and reported significant decreases in this parameter during the first 3 months postoperatively, specifically in the group treated with the (PRF + CAF) modality.

The non-significant changes in PPD values between the two compared groups (baseline to 1 month postoperatively), as well as the comparison of changes within the same group over time, observed in our study, correspond with the unchanged PPD values reported by Keceli G. H. et al.[41], Macedo Lunes C. T. et al.[39], Culhaoglu R. et al.[45], Collins R. J. et al.[44] in their randomized split-mouth study, Miron J. R. and Sculean A. et al.4[8], as well as Eren G. and Atilla G.[14].

The CAL values showed a tendency to decrease in the studies by Eren G. and Atilla G.[14], Madi M. and Ahmed M. Elakel[37], and Mijiritsky E. et al.[21], but a significant decrease was reported in Panda S. et al.[42], as well as in the randomized parallel-controlled clinical study by Keceli G. H. et al.[41]. CAL values remained unchanged in the studies by Moraschini V. et al.[30] and in the randomized controlled clinical studies by Culhaoglu R. et al.[45] and Macedo Lunes C. et al.[39].

The findings of our study, in which there was no statistically significant change in CAL values between the groups (baseline to 1 month postoperatively), as well as within the same group over time, correspond with the non-significant changes in CAL reported in the meta-analysis by Miron J. R. and Sculean A. et al.[48]. In contrast, significant increases in CAL values were reported in the studies by Oncu E. et al.[49], Miron R. J. and Zucchelli G. et al.[47], and Sonam Mufti et al.[38]. Similar findings were also reported by Kumar A. et al.[28].

A positive trend in KTW values, although not statistically significant, was reported in the study by Panda S. et al.[42]. A similar pattern was observed in the study by Eren G. and Atilla G.[14], whose results remained stable up to three months postoperatively.

A statistically significant increase in KTW values was reported by Culhaoglu R. et al.[45] in the control group of subjects treated with (SCTG + CAF), as well as by Sonam Mufti et al.[38]. Similar results were also demonstrated by Miron J. R. and Sculean A. et al.[48] in their meta-analysis and review, as well as by Mancini L. et al.[50], Mijiritsky E. et al.[21], Miron R. J. et al.[47], and Oncu E. et al.[49].

In the study by Macedo Lunes C. et al.[39], a split-mouth randomized clinical trial, a significant increase in KTW values was observed in the (PRF + CAF) group, as was also reported in the study by Ucak T. Ö. et al.[40], where a significant increase in KTW values was detected in the test group treated with PRF.

In the randomized parallel-controlled clinical study by Keceli G. H. et al.[41], a significant increase in KTW values was observed after intra-group comparison in both groups at one month postoperatively. Borderline statistical significance of increased KTW values was reported in the study by Al Jasser R. et al.[35].

Our findings correspond to those reported by Moraschini V. et al.[30] and the split-mouth randomized clinical study by Hernan S. Garzon et al.[43], in terms of the absence of statistically significant changes in KTW values in both within-group and between-group comparisons.

The results of Eren G. and Atilla G.[14] tend toward a moderate increase in GT values, whereas a significant increase in GT/VSTT/TKT (keratinized tissue thickness) was reported by Sonam Mufti et al.[38], Oncu E. et al.[49], Mancini L. et al.[50], Mijiritsky E. et al.[21], Panda S. et al.[42], and Shivakumar et al.[51], which correspond with our findings in this study, where a statistically significant difference in gingival thickness (GT) was observed, with the (PRF + CAF) group showing ($Z = 2.507$; $p = 0.0122$) compared to the change within the same group (baseline to 1 month postoperatively).

A statistically significant increase in tissue thickness (TT) was observed intra- and inter-group in the postoperative period, as documented in the randomized parallel-controlled clinical study by Keceli G. H. et al.[41]. A significant increase in TT/VSTT was also demonstrated by Kumar A. et al.[28], but in favor of the therapeutic procedure (SCTG + CAF).

Non-significant changes in GT/VSTT values were reported by Collins R. J. et al.[44] in their randomized split-mouth study, as well as in the randomized controlled clinical study by Culhaoglu R. et al.[45], and also by Macedo Lunes C. et al.[39].

The findings obtained in our study regarding gingival biotype (thin/thick) indicate a clear shift in gingival phenotype in 40% of subjects in the PRF + CAF group one month postoperatively.

Conclusion

The second generation of platelet-rich fibrin (PRF; A-PRF and I-PRF), as an adjunct to the widely accepted CAF surgical method in the treatment of localized Miller Class I and II gingival recessions, is not only a substitute for the established "gold standard" for the treatment of this type of gingival defects (SCTG), but also an equally effective alternative, considering the wide spectrum of advantages which unequivocally demonstrate the influence of this 3D matrix as a promoter of early neoangiogenesis, an initiator of rapid soft tissue regeneration and repair, and an accelerator of overall wound healing, which is a central concept in mucogingival surgery.

Autologous biological membranes (PRF) are cost-effective, available in optimal quantities unlike SCTG, easy to handle from a surgical perspective, and associated with superior patient comfort due to the elimination of postoperative discomfort and the absence of donor site morbidity.

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