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LOWER LIP MUCOCELA REMOVAL - CASE REPORT

МУКОЦЕЛА НА ДОЛНА УСНА - ПРИКАЗ НА СЛУЧАЈ

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Abstract

Introduction: Mucoceles are one of the most common lesions on the lower lip mucosa salivary glands. Their etiology is the sub-epithelial accumulation of mucous due to the retention or extravasation of mucus from minor salivary glands. Clinically, they appear as an asymptomatic vesicle or bulla with a pink or bluish coloration. They may be treated in both ways, either surgically or non-surgically (cryotherapy). These lesions are often called cysts, but mucoceles are not true cysts because they have no epithelial lining. **Aim:** To emphasize the importance of the most appropriate surgical technique, in order to perform complete surgical elimination of the pathologic lesion. **Case report:** A generally healthy male patient came to our clinic with cyst-like lesion on the lower lip mucosa. He complained of a painless swelling on his lower lip lasting for one year. The patient also had a history of lip-biting. Upon clinical inspection, a soft, round, dome-shaped bluish lesion with a pearly appearance was identified on the left side of the lower labial mucosa. On palpation, the lesion was mobile and non-adherent to the underlying tissues. After the clinical examination, a working diagnosis of mucocele was established, and a surgical excision of the lesion ("in toto") was planned and later performed. A histopathological analysis was performed which proved our working clinical diagnosis. **Conclusion:** Complete surgical removal of mucocele lesions minimizes the reoccurrence rate and reduces local tissue scarification. **Key words:** mucocele, surgical treatment, histopathology, lower lip.

Апстракт

Вовед: Мукоцелите се едни од најчестите лезии на слузницата на долната усна. Нивни етиолошки фактор претставува суб епителијална акумулација на мукос заради негова ретенција или екстравазација од малите плункови жлезди. Клинички тие се појавуваат како асимптоматска везикула или була со розева или плавкаста боја. Може да се третираат на двата начини, хируршки и нехируршки. Овие лезии често се нарекуваат цисти, но всушност мукоцелите не се вистински цисти бидејќи немаат епителна обвивка. **Цел:** Да се нагласи важноста на изборот на најсоодветна хируршка техника, со цел да се изврши целосно хируршко отстранување на патолошката лезија. **Приказ на случај:** Пациент, маж, во генерално добра здравствена состојба дојде со лезија на мукозата на долната усна. После извршените клинички анализи поставена беше работна дијагноза на мукоцела, и извршено беше хируршко отстранување на лезијата intoto. Извршена беше хистопатолошка анализа на отстранетиот примерок, со која се докажа нашата клиничка работна дијагноза. **Заклучок:** Комплетното хируршко отстранување на мукоцела ја минимизира стапката на рецидивирање, како и скарификација на локалното ткиво. **Клучни зборови:** мукоцела, хируршки третман, хистопатологија, долна усна.

Introduction

Mucocele is defined as a sub-epithelial accumulation of mucus secreted from the salivary glands and their ducts in the mucosa of the oral cavity¹.

The term mucocele is derived from the Latin words, mucus and coele meaning cavity².

Mucocele develops as a consequence of mechanical trauma to a minor salivary gland, which is followed by saliva retention and accumulation inside the blocked and dilated excretory ducts of the gland³.

Mucocele can occur as either an extravasation or retention phenomenon, known as a mucus extravasation cyst or

mucus retention cyst. It can also be classified as a superficial mucocele that is located directly under the mucosa, a classic variant located in the upper submucosa, and a deeper mucocele located in the lower corneum.

This is the result of the accumulation of liquid or mucoid material due to alterations of the minor salivary gland, which results in localized swelling⁴, and is characterized by a rounded, well-circumscribed, transparent, and bluish-colored lesion of variable size. Most often, they are soft in consistency and fluctuant on palpation.

Mucocele clinically appears as an asymptomatic vesicle or bulla with a pink or bluish-color, and their size may vary from 1 mm to several centimeters and affect both gen-

ders in all age groups⁵, with a peak age of incidence between 10 and 20 years.

Aim

To emphasize the importance of selecting the most appropriate surgical technique, in order to perform a complete surgical elimination of the pathologic lesion.

Case report

A male patient, 41 years of age, in generally good health, came to our clinic for oral surgery and implantology, at the University Clinical Center "St.Pantelejmon", Skopje, with a complaint of an elevated lesion on the left corner of the lower lip. On clinical examination, it appears as a painless red to bluish bulla of 1 cm diameter in size that had persisted for several months in this location. On clinical palpation, the lesion was soft, fluctuant beneath the finger, and oval in shape.

From this examination, an initial diagnosis was established, and a surgical intervention was planned. The treatment was explained to the patient. Local anesthesia, Scandonest 3% (mepivacaine HCl) was applied. Surgical

removal of the lesion was planned and performed by placing an elliptical incision. After the elliptical incision, the underlying mucosa was separated from the mucocele epithelium, and the lesion was gently removed "in toto" from the base (picture 1, 2, 3).

Dimensions of the excised lesion were around 1 cm in diameter in size (picture 4).



Picture 4. Dimensions of the lesion

Picture 5. Single sutures



Picture 1. Elliptical incision and mucosa separation

Picture 2. Mucocele examination



Picture 3. Mucocele removal "in toto" from the base

Hemostasis using single interrupted sutures was applied (picture 5). The removed mucocele was sent to the Institute for Pathology, Faculty of Medicine, Skopje, for further histopathological examination. Recommendations for monthly follow-up visits were given for the first year after the surgery.

Histopathology confirmed the working diagnosis of mucocele (Picture 6).

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Клиничка дијагноза: 	Материјал: 	
Вид на испитувани материјал: 	Материјал имен: 	
ХИСТОПАТОЛОШКИ НАОД		
MUCOSCELE K114 - K118		
Микроскопски метод: Дистален, в направени исечок од мукоза со димензии 1x0,5cm под кој се наоѓа цистична формација со просечен вид со пречник од 1cm. Материјалот е целосно вклучен за анализа во 1 направени исечок.		
Микроскопски наод: Микроскопската анализа покажува природен соодветен неоперативниот типет на мукозата под кој се наоѓа цистична формација обложена со цврст цистичен без епител, или на места со замнести со инфилтрати со мускул. Во предмет на исечокот се наоѓа ажуриран мускул. Наодот одговара на мукоцеле.		
Подготвител: Пред. д-р Тодорка Поповска Снежана ТИШИЌ	Испитуван: 	Датум: Испитуван: Клиника Снежана ТИШИЌ
Назив и адрес на лабораторијата на. Пред. д-р. Виставина Кривева Снежана ТИШИЌ ул. "Св. Кирил и Методиј" бр. 111/112, Скопје тел. 020-9112-166		

Picture 6. Histopathology

Discussion

Mucocele, as the most common soft tissue lesions of the lower lip, are an aesthetic and functional problem for patients. Therefore, the need for their complete removal (excision in toto) is usually required. The site where they most commonly occur is of utmost aesthetic importance to the patient, and thus choosing the therapeutic modality that ensures a good aesthetic outcome and minimizes tissue scarification is crucial.

The surgical approach to mucoceles and ranulae remains the most common treatment and depends on various factors: the size of the lesion is the most important⁶.

There are three possible surgical approaches to manage mucoceles of the lips, cheeks, and palate: complete excision, marsupialization, dissection⁷.

For avoiding the recurrence of surgically removed mucoceles care must be taken not to injure adjacent minor salivary glands⁸. If the excretory duct of the adjacent minor salivary glands becomes damaged or ruptured, it can lead to an extravasation mucocele, whereas if during suturing of the oral mucosa the excretory duct of the adjacent minor salivary glands is sutured or ligated, a retention mucocele can occur.

Mucocele are the second most common lesions of the oral mucosa after benign tumors such as fibromas, followed by hemangiomas and lymphangiomas⁹.

Literatures shows that oral habits such as lip biting/sucking is one of the etiologic factors for the oral lesions such as irritation fibroma and mucocele¹⁰. Therefore, it is essential to remove potential etiological factors that could contribute to their development, such as sharp edges of retained teeth or poorly fitting conservative/prosthetic restorations, as well as to address any harmful habits, if present.

Conventional treatment is the surgical extirpation of the surrounding mucosa and glandular tissue below the muscle layer. With a simple incision of the mucocele, the content can drain out, but the lesion would reappear as soon as the wound heals¹¹.

Surgical excision with removal of the involved accessory salivary gland has been suggested as the treatment. Marsupialization can result in recurrence¹².

Conclusion

Complete surgical removal of the mucocele lesions minimises recurrence rate and reduces local tissue scarification. CONFLICT OF INTERESTS NIL

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ADVANTAGES AND DISADVANTAGES OF BONE GRAFTS USED IN DENTAL IMPLANTOLOGY

ПРЕДНОСТИ И НЕДОСТАТОЦИ НА КОСКЕНИТЕ ГРАФТОВИ ВО ДЕНТАЛНАТА ИМПЛАНТОЛОГИЈА

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Abstract

Given the increasing popularity of dental implantology and the advancements in modern dental materials, this paper aims to present a comprehensive literature review and analysis of scientific studies. The objective is to assess whether significant differences exist among various types of bone grafts concerning the advantages and disadvantages, as well as to identify an ideal graft material that meets all success criteria. To achieve this objective, an analysis of relevant scientific and professional literature was performed using scientific databases such as PubMed, Web of Science, Google Scholar, EBSCO, and Elsevier, focusing on publications from the past decade. The keywords used for the research included: bone, bone grafts, augmentation, dental implants, and marginal bone loss. A retrospective analysis was conducted after reviewing all collected data, focusing on the significant aspects related to the application of bone graft materials in the comprehensive implant approach. In preparing this paper, the data concerning the bone graft materials used were thoroughly elaborated and processed. By investigating these electronic databases, we organized the data obtained about the advantages and disadvantages of various graft materials. From the literature review regarding the ranking of available graft materials, it can be noted that autologous grafts yield the highest levels of newly formed bone, the smallest percentage of residual graft particles, and the least amount of connective tissue development. **Key words:** bone grafts, bone augmentation, dental implantology, dental implants.

Апстракт

Со оглед на зголемената популарност на денталната имплантологија и на напредокот во современите дентални материјали, овој труд има за цел да презентира сеопфатен преглед на литературата и анализа на научни студии. Целта е да се процени дали постојат значајни разлики меѓу различните видови коскени графтови во однос на нивните предности и недостатоци, како и да се идентификува постојењето на идеален графт-материјал што ги исполнува сите критериуми за успех. За да се исполни целта, била извршена анализа на релевантна научна и стручна литература со користење на клучните бази на податоци како што се PubMed, WebofScience, GoogleScholar, EBSCO и Elsevier, фокусирајќи се на публикации од изминатата деценија. Клучни зборови употребени за пребарувањето: коска, коскени графтови, аугментација, забни импланти и маргинална загуба на коскена маса. Беше спроведена ретроспективна анализа по преглед на сите собрани податоци, фокусирајќи се на значајните аспекти поврзани со примената на материјалите за коскени графтови во сеопфатниот имплантолошки третман. При подготовката на овој труд, податоците во врска со користените материјали за коскени графтови беа темелно разработени и анализирани. Со истражување на овие електронски бази на податоци, ги организиравме добиените податоци за предностите и за недостатоците на различните графт-материјали. Од прегледот на литературата во врска со рангирањето на достапните графт-материјали, може да се заклучи дека аутологните графтови даваат највисоки нивоа на ново формирана коска, најмал процент на преостанати честички од графтоот и најмала количина на создадено сврзно ткиво. **Клучни зборови:** коскени графтови, зголемување на коските, дентална имплантологија, дентални импланти.

Introduction

In the field of modern dentistry, the use of dental implants is the most effective approach for treating the loss of one or more teeth. Due to the numerous advantages, especially the impressive success rates of implant proce-

dures, dental implants have been recognized as the standard of care for replacing missing teeth and for stabilizing different types of fixed or removable prosthetic appliances in patients experiencing total or partial edentulism.

Dental implantology, recognized as a specific field within oral surgery that often requires both horizontal

and vertical augmentation of the alveolar ridge during dental implants placement, raises important questions regarding currently available bone grafts, their characteristics, and their anticipated impact on the success of dental implants. This topic represents the primary focus of this paper, selected due to its critical importance, its recent evolutionary development, and the limited number of published articles addressing these issues.

As a result of alveolar bone loss, there is a significant need to develop materials for alveolar bone augmentation. These materials and techniques aim to establish a reliable foundation for successful dental implant placement. The loss of alveolar bone has led to an increased demand for the development of materials capable of supporting it. These innovations and approaches are designed to create a reliable foundation for the successful placement of dental implants.

Ultimately, it is important to note that the principal function of bone grafting is to provide mechanical support and promote bone regeneration, with the ultimate goal of producing new bone (de-novo). Apart from the well-recognized four key biological properties that enhance the performance of bone grafts: osseointegration, osteogenesis, osteoconduction, and osteoinduction, there are numerous other properties and characteristics that also influence the success of bone grafting, which are not classified under biocompatibility. This additional set includes bioresorption, structural integrity, porosity, vascular inductance, plasticity, ease of handling, resistance to compressive forces, and, of course, the cost of the bone graft material¹.

Considering the increasing acceptance of dental implantology alongside the evolution of contemporary dental materials, this paper has been designed to perform a detailed literature review and analysis of scientific articles for advantages and disadvantages of various bone grafts, and to determine whether an ideal graft material exists meeting all necessary success criteria.

A comprehensive literature review was conducted to gather data from the past decade using databases such as Web of Science, PubMed, Elsevier, Google Scholar, and EBSCO. The research applied the following keywords: bone, bone grafts, augmentation, dental implants, and marginal bone loss.

The scientific papers included in this review were predominantly written in English within the last ten years. The literature search was conducted without a specific timeframe for publication, aiming to present key theoretical principles and recent research spanning the last 15 years. Some older papers were also included to enhance the understanding of the topic or are recognized as fundamental contributions to the field.

Advantages And Disadvantages Of Bone Grafts Used In Dental Implantology

Bone tissue undergoes a continuous process of remodeling through ongoing formation and resorption. During the first year of life, nearly 100 percent of the skeleton is replaced, while in adulthood, the rate is closer to 10 percent annually. This remodeling allows bones to functionally adapt to changes in load. The remodeling of alveolar bone during the placement of dental implants is influenced by several factors: the population of osteoblasts, blood supply, graft stabilization, and the tension of soft tissue following suturing after the intervention².

Osteoblasts are the cells responsible for synthesizing new bone tissue. For the graft to be successful, the graft matrix must contain osteoblasts or stimulate their population. If there is an insufficient number of osteoblasts, the graft is typically unsuccessful³.

During the healing process, mechanical tensions on the grafting materials can lead to a disruption in fibrin clot formation. Movement in the healing regions may result in the creation of fibrous tissue that fills the defect instead of facilitating the formation of bone tissue. The generation of fibrous tissue does not constitute true regeneration. To prevent such inadequate healing, fixation techniques and the removal of connective tissue, such as Guided Bone Regeneration (GBR), can be utilized, or collagen membranes, titanium mesh, and similar materials may be used⁴.

In contemporary dentistry, numerous implant systems have been introduced, each with specific indications that can be effectively integrated. The critical factor for the successful placement of dental implants is the adequate quality and quantity of alveolar bone at the intended implant sites. Bone graft materials play a vital role in addressing this deficiency. As highlighted earlier, there is also a wide range of graft materials available, leading to the understandable divergence of opinions in professional and scientific literature regarding the advantages and disadvantages of various graft materials utilized in dental implantology⁵.

Each material available for augmentation presents specific advantages and disadvantages. Human grafts can be sourced from the patient's own body, necessitating additional surgical procedures, or from cadavers, which is often deemed undesirable by the public. In addition, there are various grafts derived from non-human sources, commonly referred to as xenografts.

Xenografts consist of processed bovine bone, which serves as a supportive matrix for the augmentation of jaw bone tissues when necessary. Bovine bone has been shown to be nearly as effective as human bone in eliciting a satisfactory healing response from adjacent tissues. Following

the regeneration of bone tissue, optimal conditions are established for the insertion of dental implants⁶.

A significant limitation of xenografts lies in their potential to spread infectious diseases among various species. Nevertheless, it should be emphasized that there is limited available literature that points to the risk level of xenografts. As a result, bovine bone is typically the source of xenografts, and it continues to be considered one of the safest materials for their production⁷.

In light of this present, although minimal risk, the need has arisen to create contemporary graft materials of synthetic origin (allograft materials).

Alloplastic graft materials consist of synthetic materials, including the mineral hydroxyapatite. The benefits of these synthetic grafts are their ready availability and potentially lower costs compared to various alternatives. Moreover, their synthetic nature helps protect individuals from the risk of infection or disease transmission from donors⁸.

A disadvantage is that synthetic materials do not function identically to other alternatives, such as human or bovine bone. The key limitation is that the process may take longer. However, the additional waiting period will be beneficial primarily due to its link to the relative safety of this material for grafting⁹.

Table 1. presents the advantages and disadvantages of allografts, autografts, xenografts, and alloplastic materials utilized in dental medicine.

When considering graft materials, autogenous bone has demonstrated the highest density and greatest quantity of newly formed bone. However, the application of demineralized frozen bone and an innovative demineralized allogeneic bone matrix may similarly facilitate bone regeneration in comparison to membranes after a six months recovery period¹⁰.

In many clinical situations, it is essential to combine dental implants with bone grafts and/or bone substitutes. Following the implantation process, the silica-based bone graft particles convert into a coating that is rich in calcium and phosphate, while the inner silicon-rich core is lost. Research by Guglielmottiet al¹¹ reported enhanced reactive medullary bone formation when these graft particles were placed around titanium implants.

Collagen materials are applied in both medical and dental practices due to their recognized biocompatibility and their role in enhancing wound healing. An experimental study was conducted to evaluate the effects of bovine collagen granules on the alveolar wounds healing after tooth extraction in rats. The study's results demonstrated that the trabecular surface area of the bones was larger in the extraction sockets treated with collagen granules compared to the control sockets. In addition, the trabecular bone density was higher in the experimental sockets than in the control ones. Thus, it can be concluded that the research pro-

vided evidence supporting the use of bovine collagen granules as a bone grafting material, representing a therapeutic alternative for filling sockets after dental extractions¹².

One of the most effective techniques for bone augmentation is Guided Bone Regeneration (GBR). To date, procedures utilizing expanded polytetrafluoroethylene membranes (ePTFE) have proven to be the most efficient and predictable surgical method for enhancing deficient bone areas¹³.

Autogenous blocks placed alongside the implants can achieve an excellent long-term implants success rate. Autogenous bone chips or deproteinized bovine bone can be used for fenestration and dehiscence defects when used in conjunction with e-PTFE membranes. In most instances, Teflon membranes are preferred due to their reliable outcomes. The use of collagen membranes, when supported by bone substitutes for space maintenance, yields favorable results, although long-term research is necessary¹⁴.

The vertical augmentation of the alveolar bone through the use of e-PTFE membranes and particulate autografts is recognized as a secure and predictable approach. The rates of success and survival for implants placed in vertically augmented alveolar bone via the GBR technique are similar to those for implants placed in untreated bone under load. Additionally, the success and failure rates of implants in bone that has been regenerated concurrently with sinus lift and vertical augmentation techniques are found to be almost equivalent, even in cases where only vertical augmentation is necessary¹⁵.

In addition to the benefits associated with modifications of soft and hard tissues, the necessity for further bone augmentation, the practicality of implant placement, and the implant survival and success rates may further support the implementation of ridge preservation and augmentation techniques. A recent systematic review indicates that the need for additional bone augmentation during implant placement can vary, with figures ranging from 0% to 15% for ridge preservation and from 0% to 100% for spontaneous healing¹⁶.

It is essential to recognize that the planning of implant therapy is critical, rather than merely placing implants alongside bone graft materials; therefore, the study should emphasize the specific locations of implant placement, the diameters used, and the chosen angulation. Currently, this information is not available to provide adequate scientific evidence, which may lead to an underestimation of the impact of ridge preservation in everyday clinical practice. Overall, the literature supports the use of alveolar ridge preservation to maintain ridge volume, particularly at the hard tissue level, but does not yield additional clinical benefits regarding implant-related outcomes and is associated with an extended healing period (greater than 6 months) and a flap procedure.

Conclusion

Following the review of the literature provided data regarding the ranking of accessible graft materials and their influence on the success of dental implants and their survival rates, the following conclusions can be established: (1) autologous grafts demonstrate the highest percentage of newly formed bone compared to synthetic grafts, xenografts, and allografts; (2) autologous grafts exhibit the lowest percentage of residual graft particles compared to xenografts, synthetic grafts, and allogeneic grafts. Among the graft types, autologous grafts showed the lowest rate of connective tissue formation, succeeded by allogeneic, xenogeneic, and synthetic grafts.

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Table 1. Advantages and disadvantages of different bone grafts

Type of material	Source	Advantages	Disadvantages
Autograft	From the patient himself	Osteogenic material Living cells No possibility of transmission of infectious conditions Contains cortical bone	Pain Infection Complex surgical interventions
Allograft	From another person	Osteoinductivity Osteoconductivity Effective matrix	Risk of infection transmission
Xenograft	From another species (most often bovine)	Hydroxyl apatite is similar to that in humans, which provides bulk stability. Collagen leads to accelerated bone formation.	It acts only osteoconductively.
Aloplast	Synthetic	No risk of infection transmission	It acts only osteoconductively.
	Hydroxy-apatite	Slowly resorbed which preserves bone volume	
	TCP	Contains growth factors	
	Bioglass	Rapid resorption leading to rapid replacement with new bone	

Table 2. Advantages and disadvantages of materials that are used for bone grafting in medicine and dental medicine*

Type of grafting material	Advantages	Disadvantages
Autologous bone	“Gold standard” because it is osteoconductive, osteoinductive and osteogenic	Second surgical site increases risk of infection, and there is a limitation on the amount of material available for grafting
Autologous cancellous bone	Covers large surface area favorable for revascularization	Poor mechanical strength
Autologous cortical bone	Structural support and mechanically stable	Takes longer to remodel than cancellous graft
Autologous vascularized cortical bone	Rapid healing time, preserved osteocytes and osteoprogenitor cells in the graft	Difficult to collect and implant
Bone marrow aspirate	Can be harvested minimally invasively	Fewer stem cells in graft than expected
PRP (platelet-rich plasma)	Available, easy to obtain, induces migration of pluripotent cells directly to the site, reduces the amount of autograft required for harvesting	Variability in preparation methods
Allogeneic graft materials	No secondary surgical site (therefore there is a reduced risk of infection and no additional pain)	Risk of disease transmission or adverse immune response
Allogeneic cancellous bone	Freeze-drying results in a graft with low residual moisture and a shelf life of 4-5 years	Low mechanical strength, difficult to implant as body encapsulates graft in fibrous tissue
Allogeneic cortical bone	Strong, can be used in load-bearing areas of the body	Slow healing due to inflammatory response
Allogeneic demineralized bone matrix	Contains growth factors that make it osteoinductive	Variable amounts of growth factors from different batches and manufacturers
Synthetic graft materials	Many options for creating graft materials (which can be 3D printed or injected)	Lack of growth factors to promote bone growth
Calcium phosphate ceramic	Similar composition to bone tissue	Poor mechanical strength, difficult to shape

Type of grafting material	Advantages	Disadvantages
Tricalcium phosphate	Synthetic graft with the most similar composition to bone tissue, "gold standard" of synthetic grafts	Degrades unpredictably, making it unsuitable for load-bearing areas
Biphasic calcium phosphate	It possesses the advantages of both tricalcium phosphate and hydroxyapatite, resorption rate and mechanical properties	Limitation of mechanical force based on graft mixture
Hydroxy apatite	Very high biocompatibility, higher compressive and tensile strength compared to tricalcium phosphate	Slow graft resorption
Calcium phosphate cement	The temperature reaction of dissolution - precipitation makes them easy to shape	Weak mechanical strength
Calcium sulfate	Cheap and easy to prepare	Resorbs faster than bone resorption, but still has a risk of serous wound drainage, lack of mechanical strength
Bioactive glasses	Forms bonds with bone and tissue, activates genes that control osteogenesis, antibacterial properties	Small range of SiO ₂ content for graft bioactivity
PMMA bone cement	Secures orthopedic implants in place	No intrinsic adhesive properties, heat sensitive, cement fragmentation and foreign body reaction can lead to their resorption and loosening of the implant
Growth factors or bioactive molecules	Have both osteoinductive and osteoconductive properties	Not studied long-term, inflammatory complications, very expensive
BMP-2	Possible better results compared to autografts, good bone regeneration abilities in smokers	Can cause swelling that can close the patient's airway, risk of ectopic bone formation
OP-1 (BMP-7)	-	No longer available on the market
PDGF-BB	Less pain than when applying autografts, giving similar results	Not studied long-term, expensive
iFactor (P-15)	Similar results to autografts	Adverse effects of axial pain, postoperative radiculopathy and dysphagia after treatment

Table 3. Advantages and disadvantages of bone grafts in oral surgery*

Material Type	Product	Advantages	Disadvantages
Hydroxyapatite	Ostim™ Endobon™	Osteoconduction Macroporous structure comparable to human bone Biocompatibility Excellent hydrophilicity	Donor site morbidity Unfavorable mechanical characteristics Delayed resorption rate Limited availability
Tricalcium phosphate ceramics	Cerasorb™ OSferion™ Orthograft™	Osteoconduction Ease of handling Radiolucency allowing healing monitoring Good resorption Low immunogenicity	Poor mechanical properties, especially compressive strength
Biphasic calcium phosphate ceramics	MASTERGRAFT™	Osteoconduction Osteoinduction Resorbability Relatively better mechanical properties than TCP or HA alone	Compressive strength remains lower than that of cortical bone
Bioglass	Perioglas™ Biogran™	Osteoconduction Biocompatibility Antimicrobial activity Porous structure Completely resorbable	Brittle Low mechanical strength Poor fracture resistance
Calcium phosphate cements	Norian™ ChronOS inject™ Hydroset™ BoneSource™	Osteoconduction Self-positioning ability Molarity Biocompatibility	Low rate of cell adhesion Fragility Concern regarding extrusion of material into adjacent tissues
Calcium sulfates	OsteoSet™	Osteoconduction Low cost Readily available High moldability (plasticity) Biocompatibility Short placement time	Rapid resorption that is faster than that of human bone Relatively high risk of infection and inflammation
Polymers	Bioplant HTR Synthetic Bone™	Osteoconductive Biocompatible Adaptable shapes Low immunogenicity Porous structure Radiopacity	Concerns about acidic degradation products

Material Type	Product	Advantages	Disadvantages
Metals	OSS Builder™	Osteoconduction, acts as a membranous barrier for GBR Good mechanical strength Good biocompatibility Corrosion resistance Porous structure that improves cell adhesion	Need for second surgical visit Possibility of soft tissue dehiscence and membrane exposure
Composites Material Type Hydroxyapatite	NanoBone™	Osteoconduction Osteoinduction Resorbability Plasticity Good cell adhesion	Lack of studies investigating the use of NanoBone™ in humans
	Fortoss Vital™ (β-TCP/calcium sulphate)	Osteoconduction Osteoinduction Completely resorbable Plasticity Porous structure Good cell adhesion	Contact with blood will delay the setting time of the paste.
	SmartBone™ (DBM/polymer/collagen)	Similar morphology to human bone Rapid adhesion and proliferation of blood cells due to high hydrophilicity Improved volumetric stability High load resistance for large bone defects	Comes in single-use packages only

* Adapted and modified from:

- Zhao R, Yang R, Cooper PR, Khurshid Z, Shavandi A, Ratnayake J. **Bone grafts and substitutes in dentistry: a review of current trends and developments.** *Molecules.* 2021 May 18;26(10):3007.
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EVALUATION OF PERIODONTAL HEALTH IN CHILDREN UNDERGOING INTERCEPTIVE ORTHODONTIC TREATMENT: A TIME-BASED BPE ANALYSIS AND THE ROLE OF ORAL HYGIENE EDUCATION

ЕВАЛУАЦИЈА НА ПАРОДОНТАЛНОТО ЗДРАВЈЕ КАЈ ДЕЦА СО ИНТЕРЦЕПТИВЕН ОРТОДОНТСКИ ТРЕТМАН: ВРЕМЕНСКА АНАЛИЗА ПРЕКУ БПЕ И УЛОГАТА НА ЕДУКАЦИЈАТА ЗА ОРАЛНА ХИГИЕНА

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Abstract

Background: Interceptive orthodontics plays an essential role in early dental care by guiding the normal growth of the jaws and preventing the development of more severe malocclusions later in life. However, the presence of orthodontic appliances often complicates daily oral hygiene practices for children, increasing the risk of plaque accumulation and gingival inflammation. The Basic Periodontal Examination (BPE) provides a quick and minimally invasive approach for monitoring periodontal health, however, its application in pediatric patients undergoing interceptive orthodontic treatment has not been sufficiently investigated. **Methods:** This prospective observational study included 30 children (17 girls and 13 boys) aged 7–11 years, all undergoing interceptive orthodontic treatment with removable acrylic appliances for the correction of dental crowding. Periodontal status was assessed using the Basic Periodontal Examination (BPE) index at five time points: before appliance insertion (T₀), and after 3 (T₁), 6 (T₂), 9 (T₃), and 12 months (T₄). All examinations were performed by a single calibrated examiner (Cohen's $\kappa = 0.87$) to ensure measurement reliability. At each visit, children and their parents received personalized oral hygiene instructions with an emphasis on effective toothbrushing around the appliance. Statistical analysis was conducted using the Friedman test and posthoc Wilcoxon signed-rank tests with Bonferroni correction ($\alpha=0.05$). **Results:** Significant differences in Basic Periodontal Examination (BPE) scores were observed across the 12-month observation period ($\chi^2=17.42$, $df=4$, $p=0.002$). The scores increased during the first three months (T₀ → T₁, $p=0.018$), reflecting a transient rise in gingival inflammation following appliance placement. Thereafter, a progressive improvement was observed, with scores decreasing at subsequent evaluations (T₁ → T₃, $p=0.021$; T₁ → T₄, $p=0.008$). By the end of the study, no significant difference was noted between baseline and final values (T₀ → T₄, $p>0.05$), indicating recovery and stabilization of periodontal health associated with consistent follow-up and parental support. **Conclusion:** The Basic Periodontal Examination (BPE) proved to be a practical, reliable, and child-appropriate tool for monitoring periodontal health during interceptive orthodontic treatment. Although a short-term increase in gingival inflammation occurred after appliance placement, regular follow-up visits, reinforced oral hygiene instructions, and active parental involvement contributed to significant improvement in periodontal status. These findings highlight the importance of incorporating routine periodontal assessment and continuous hygiene education into all stages of early orthodontic care. **Keywords:** Interceptive orthodontics; Basic Periodontal Examination; Pediatric dentistry; Periodontal health; Oral hygiene; Removable appliances.

Апстракт

Позадина: Интерцептивната ортодонција претставува суштински дел од раната стоматолошка заштита, бидејќи овозможува насочување на нормалниот раст на вилиците и спречување на развојот на потешки малоклузии во подоцнежниот период од животот. Сепак, присуството на ортодонтски апарати често ја отежнува секојдневната орална хигиена кај децата, што го зголемува ризикот од наталожување на плак и појава на гингивална инфламација. Основниот пародонтален преглед (BPE) претставува брза и минимално инвазивен метод за следење на пародонталното здравје, но неговата примена кај деца кои се подложени на интерцептивен ортодонтски третман сè уште не е доволно истражена. **Методи:** Во оваа проспективна опсервациска студија беа вклучени 30 деца (17 девојчиња и 13 момчиња) на возраст од 7 до 11 години, сите со извршен интерцептивен ортодонтски третман со мобилни акрилни апарати поради забна тескоба. Пародонталниот статус беше проценет со помош на индексот BPE во пет временски точки: пред поставување на апаратот (T₀), по 3 (T₁), 6 (T₂), 9 (T₃) и 12 месеци (T₄). Сите мерења ги изврши еден калибриран испитувач (Cohen's $\kappa=0.87$) за да се обезбеди конзистентност на резултатите. На секоја контрола,

децата и нивните родители добиваа индивидуализирани упатства за орална хигиена нагласувајќи ја потребата од правилното четкање околу апаратот. Статистичката анализа беше спроведена со употреба на Friedman тест и пост-хок Wilcoxon signed-rank тест со Bonferroni корекција ($\alpha=0.05$). **Резултати:** Значајни разлики во вредностите на BPE беа забележани во текот на 12-месечниот период на набљудување ($\chi^2 = 17.42$, $df=4$, $p=0.002$). Вредностите се зголемија во првите три месеци ($T_0 \rightarrow T_1$, $p=0.018$), што укажува на привремено зголемување на гингивалната инфламација по поставување на апаратот. Потоа беше забележано постепено подобрување, со намалување на резултатите во следниве мерења ($T_1 \rightarrow T_3$, $p=0.021$; $T_1 \rightarrow T_4$, $p=0.008$). На крајот на студијата не беше утврдена значајна разлика помеѓу почетните и конечните вредности ($T_0 \rightarrow T_4$, $p > 0.05$), што укажува на опоравување и стабилизација на пародонталното здравје преку редовни контроли и поддршка од родителите. **Заклучок:** Основниот пародонтален преглед (BPE) се покажа како практичен, сигурен и соодветен метод за следење на пародонталното здравје кај деца кои се подложени на интерцептивен ортодонтички третман. Иако е забележано краткотрајно зголемување на гингивалната инфламација по поставувањето на апаратот, редовните контроли, постојаното подобрување на хигиенските навики и активното вклучување на родителите доведоа до значително подобрување на пародонталната состојба. Овие резултати ја нагласуваат важноста на вклучување на рутинската пародонтална проценка и континуирана едукација за орална хигиена во сите фази на раната ортодонтичка грижа. **Клучни зборови:** интерцептивна ортодонција; основен пародонтален преглед; детска стоматологија; пародонтално здравје; орална хигиена; мобилни апарати.

Introduction

Interceptive orthodontics plays an essential role in early dental care, focusing on the timely management of developing malocclusions and promoting the balanced growth of children's dental arches. When addressed at the appropriate developmental stage, orthodontic intervention can correct both functional and skeletal irregularities before they progress into more complex conditions. Such early action not only improves oral function and aesthetics but also contributes to long-term oral health stability and a better quality of life^{1,2}.

However, these preventive benefits are often accompanied by challenges, particularly in maintaining good oral hygiene during treatment. Orthodontic appliances, especially removable ones, may interfere with routine brushing and make plaque control more challenging. As a result, plaque accumulation, gingival irritation, and the early signs of periodontal inflammation can appear even in otherwise healthy young patients³⁻⁶. Therefore, continuous evaluation of periodontal health is a vital component of interceptive orthodontic therapy to ensure that preventive efforts are not compromised by secondary complications⁷.

The Basic Periodontal Examination (BPE) is a simple, standardized, and minimally invasive method designed to screen periodontal health and indicate when further assessment or treatment may be required. Although initially developed for adult patients, both the British Society of Periodontology and Implant Dentistry (BSP) and the British Society of Paediatric Dentistry (BSPD) have adapted this approach for younger age groups through the simplified Basic Periodontal Examination (sBPE). This modification limits scoring to codes 0–2 and excludes partially erupted teeth, providing a reliable and age-appropriate method of recording bleeding on probing and detecting calculus or other plaque-retentive factors, key indicators of oral hygiene in pediatric care⁸⁻¹⁰.

While the diagnostic value of the BPE has been extensively documented in adults, its validation and routine use

among children, particularly those undergoing interceptive orthodontic treatment, has not yet been fully validated. Recent studies demonstrate encouraging findings regarding its feasibility in pediatric orthodontics and its potential for early detection of gingival changes¹¹⁻¹³. Nevertheless, compared with the adult population, data on BPE outcomes in growing patients remain relatively limited, emphasizing the need for further longitudinal studies^{14,15}.

It is also important to consider other established clinical indices, such as the Plaque Index by Silness and Løe and the Gingival Index by Løe and Silness, which have long been used to assess plaque accumulation and gingival inflammation^{16,17}. However, the efficiency, simplicity, and reproducibility of the BPE make it a valuable tool for large-scale screening and regular monitoring within daily orthodontic practice^{18,19}.

Taking these aspects into account, the present study aims to assess the periodontal condition of children aged 7–11 years undergoing interceptive orthodontic therapy with removable appliances. The Basic Periodontal Examination (BPE) is used as a practical and objective method for screening and tracking periodontal health throughout the treatment period.

Materials and methods

This prospective observational study included 30 children aged 7 to 11 years, all of whom were undergoing interceptive orthodontic treatment with removable appliances due to dental crowding. Participants were selected from the Orthodontic Department of the University Dental Clinic of Kosovo, based on their scheduled need for early orthodontic intervention. The selection process followed a consecutive sampling approach, meaning that all eligible patients presenting to the clinic during the recruitment period and meeting the inclusion criteria were invited to participate.

Prior to participation, the purpose of the study was explained to both children and their parents or legal

guardians, after which written informed consent was obtained. Ethical approval was granted by the institutional ethics committee, and the study was conducted in accordance with the Declaration of Helsinki for biomedical research involving human subjects.

To ensure consistency and minimize bias, strict eligibility criteria were applied.

Inclusion criteria:

- Children aged 7–11 years in the mixed dentition phase.
- Presence of mild to moderate dental crowding requiring interceptive orthodontic treatment with a removable appliance.
- Good general health and ability to comply with routine follow-up visits.

Exclusion criteria:

- Systemic diseases that could influence periodontal health (e.g., diabetes, autoimmune or immune-related disorders).
- Antibiotic therapy within three months before enrollment.
- Ongoing periodontal treatment or any baseline BPE score ≥ 3 , which could indicate unrelated pathology uncommon in this age group.
- Inability to comply with dental visits or irregular attendance.

Periodontal health was evaluated using the Basic Periodontal Examination (BPE) in accordance with the British Society of Periodontology and British Society of Paediatric Dentistry (BSP/BSPD) Guidelines for Children and Adolescents under 18 Years². All measurements were performed with a WHO periodontal probe (ball-ended, 0.5 mm tip, black band between 3.5 mm and 5.5 mm).

For this pediatric population, only codes 0–2 of the simplified BPE (sBPE) were applied, with partially erupted teeth excluded from probing, as recommended by the BSP/BSPD guidelines and the executive summary of the sBPE for the under-18 population^{2,4}. Six index teeth were assessed^{16,11,26,36,31, and 46}, and scores were recorded for each sextant.

All clinical assessments were performed by a single calibrated examiner (E.C), a specialist in orthodontics, to minimize inter-examiner variability. The intra-examiner agreement was verified using Cohen's kappa coefficient, yielding a value of 0.87, indicating high reliability¹¹.

The BPE was recorded at five time points: T₀: baseline, before appliance insertion; T₁: 3 months after insertion; T₂: 6 months; T₃: 9 months; and T₄: 12 months (at the end of the 12-month observation period).

At the start of treatment (T₀) and during each follow-up visit, children and their parents received standardized oral-hygiene education. Oral-hygiene instruction was based on the Modified Bass tooth-brushing technique, which involves placing the toothbrush bristles at a 45° angle toward the gingival margin and performing gentle vibratory motions to clean the gingival sulcus and adjacent tooth surfaces. This method is widely recommended for effective plaque removal in orthodontic and pediatric patients, as it targets areas most prone to plaque retention and gingival inflammation. Instructions included demonstrations of the Bass tooth-brushing technique using fluoridated toothpaste twice daily, with special attention to areas around the orthodontic appliance. Parents were encouraged to supervise brushing, and the use of soft toothbrushes and interdental brushes (where appropriate) was recommended. This preventive approach aimed to minimize plaque accumulation and gingival irritation throughout treatment^{2,4}.

All collected BPE scores were entered into IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA) for analysis. Descriptive statistics were used to summarize the distribution of BPE scores at each time point. The Shapiro–Wilk test was applied to assess data normality. For comparisons across time intervals, the Friedman test (non-parametric repeated-measures ANOVA) was used, followed by Wilcoxon signed-rank tests for pairwise comparisons with Bonferroni correction to adjust for multiple testing. A p-value < 0.05 was considered statistically significant.

Results

A total of 30 children (17 girls and 13 boys), aged 7 to 11 years (mean \pm SD: 9.0 \pm 1.2 years), completed the 12-month follow-up period. No participant discontinued or missed any scheduled examination, so all 30 children were included in the final analysis.

Overall BPE Score Distribution

The percentage distribution of the highest BPE scores recorded at each time point is presented in Table I. At baseline (T₀), 26.7 % of the children had a BPE score of 0, while 30 % had a score of 2, suggesting the presence of plaque or calculus deposits even before treatment.

At the 3-month examination (T₁), there was a noticeable increase in the proportion of children with BPE 2 (46.7 %), accompanied by a decrease in BPE 0 (16.7 %). This early rise likely reflected the initial challenges children faced in maintaining oral hygiene after the insertion of the orthodontic appliance.

Subsequently, from T₂ through T₄, the percentage of BPE 2 gradually declined, while that of BPE 0 steadily increased. By the end of the 12-month period (T₄), 40 % of

Table 1. Distribution of BPE Scores at Each Time Point

Time Point	BPE 0	BPE 0 (%)	BPE 1	BPE 1 (%)	BPE 2	BPE 2 (%)
T ₀	8	26.7 %	13	43.3 %	9	30.0 %
T ₁	5	16.7 %	11	36.7 %	14	46.7 %
T ₂	6	20.0 %	15	50.0 %	9	30.0 %
T ₃	9	30.0 %	13	43.3 %	8	26.7 %
T ₄	12	40.0 %	14	46.7 %	4	13.3 %

Table 2. Variation in BPE 2 Scores Between Time Points

Time Comparison	Change in Number of Children	Change in Percentage (%)	p-value
T ₀ → T ₁	+5	+16.7 %	0.018*
T ₁ → T ₂	-5	-16.7 %	0.024*
T ₂ → T ₃	-1	-3.3 %	0.374
T ₃ → T ₄	-4	-13.3 %	0.041*
T ₀ → T ₄	-5	-16.7 %	0.036*

*Significant at $p < 0.05$

the children had a BPE 0, and only 13.3 % had BPE 2, indicating an overall improvement in periodontal health.

At baseline, most children showed BPE 0 or 1, typical for this age group, while a smaller portion localized BPE 2 findings, mainly in crowded anterior regions.

After appliance insertion (T₁), shallow calculus deposits and bleeding on probing were noted, especially in areas covered by the appliance.

By T₂ and T₃, periodontal health improved in most participants, particularly those who complied with brushing instructions.

At the final 12-month evaluation (T₄), no BPE ≥ 3 or clinical attachment loss was recorded. The progressive decline of BPE 2 over time reflects effective hygiene reinforcement and adaptation to the appliance.

Using the Friedman test for repeated measures, a statistically significant difference in BPE values across time points was observed ($\chi^2 = 17.42$, $df = 4$, $p = 0.002$).

Post-hoc Wilcoxon signed-rank tests with Bonferroni correction showed that:

- BPE scores increased significantly from T₀→T₁($p=0.018$); then decreased significantly

Table 3. Statistical comparison of BPE scores across evaluation time points

Comparison	Statistical Test	χ^2 / Z Value	df	p-value	Significance ($\alpha = 0.05$)
Overall difference (T ₀ -T ₄)	Friedman test	$\chi^2 = 17.42$	4	0.002	Significant
T ₀ → T ₁	Wilcoxon signed-rank	Z = -2.37	-	0.018	Significant
T ₁ → T ₂	Wilcoxon signed-rank	Z = -2.25	-	0.024	Significant
T ₁ → T ₃	Wilcoxon signed-rank	Z = -2.31	-	0.021	Significant
T ₁ → T ₄	Wilcoxon signed-rank	Z = -2.65	-	0.008	Highly significant
T ₀ → T ₄	Wilcoxon signed-rank	Z = -1.12	-	> 0.05	Not significant

between $T_1 \rightarrow T_3$ ($p = 0.021$) and $T_1 \rightarrow T_4$ ($p = 0.008$); the difference between $T_0 \rightarrow T_4$ was not significant ($p > 0.05$), indicating that periodontal status returned to baseline or improved beyond baseline.

stabilization of gingival health as children adapted to cleaning around their appliances.

Influence of Demographic Factors

No significant differences were found between girls and boys ($p > 0.05$; Mann-Whitney U test), or between younger (≤ 9 years) and older (> 9 years) participants ($p > 0.05$). All children used similar removable acrylic appliances, minimizing device-type variability.

Graphical Overview

Figure 1 shows the reduction in BPE 2 and the corresponding rise in BPE 0 over 12 months.

Figure 2 illustrates percentage distributions, highlighting an early brief deterioration followed by recovery and

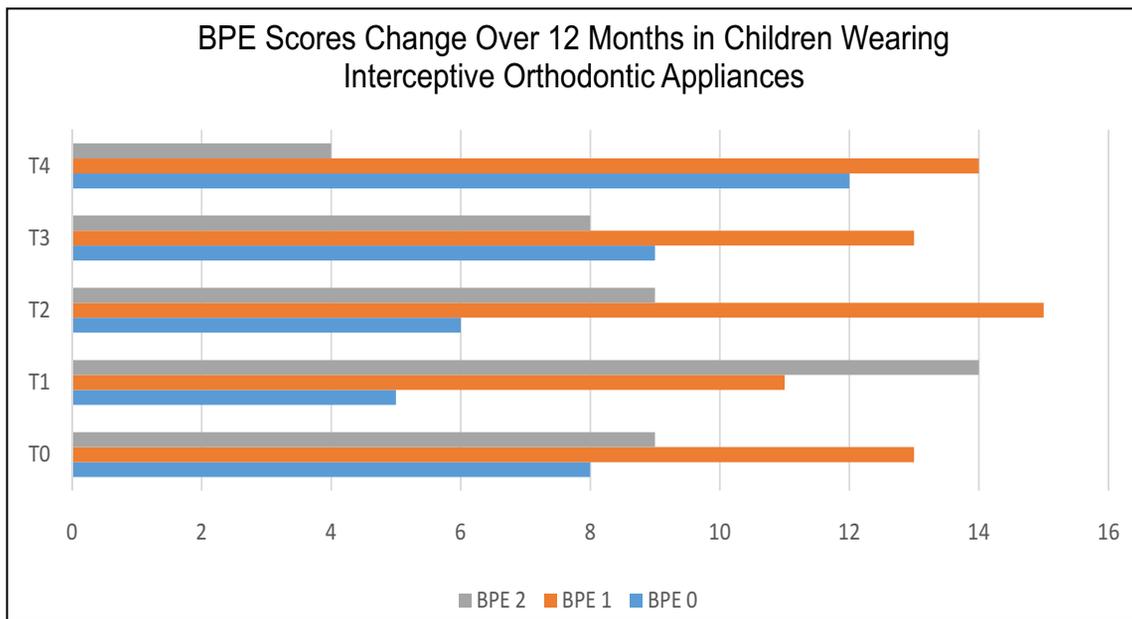


Figure 1. Changes in BPE 0 and BPE 2 scores in children over the 12-month treatment period

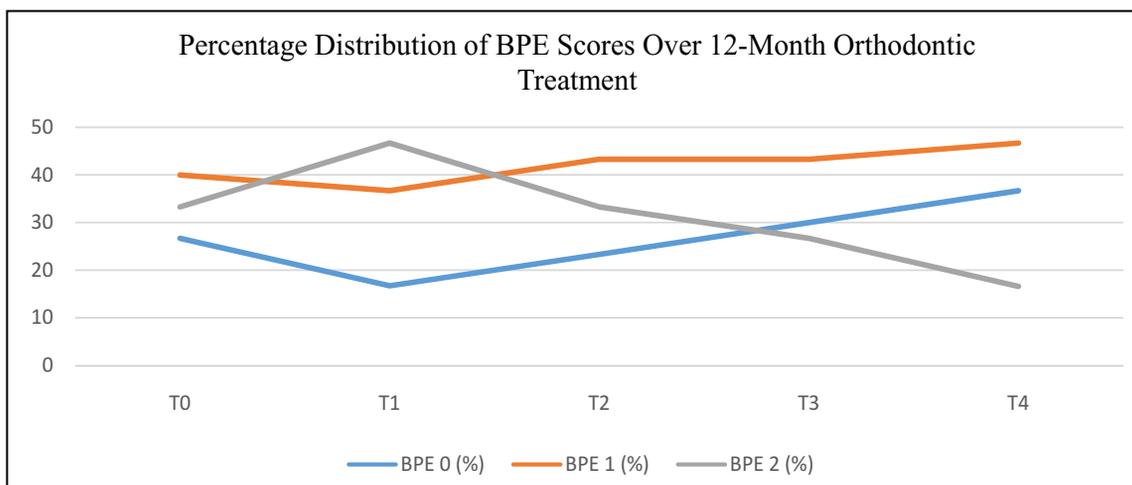


Figure 2. Percentage distribution of BPE scores (0,1,2) across five evaluation time points (T_0 – T_4).

Table 4. Comparison of mean BPE score changes according to gender and age group.

Variable	Category	Mean BPE Change (T ₀ -T ₄)	Statistical Test	p-value	Interpretation
Gender	Girls (n = 17)	-0.32 ± 0.18	Mann-Whitney U	> 0.05	Not significant
	Boys (n = 13)	-0.28 ± 0.21			
Age group	≤ 9 years (n = 15)	-0.30 ± 0.19	Mann-Whitney U	> 0.05	Not significant
	> 9 years (n = 15)	-0.31 ± 0.20			
Appliance type	Removable	—	—	—	All participants used identical appliance design

Discussion

The findings of this study emphasize the importance of regular monitoring of periodontal health throughout interceptive orthodontic treatment in children. Although removable appliances are a valuable tool for guiding dental and skeletal development at an early age, maintaining adequate oral hygiene during therapy remains a significant challenge, especially in the initial months of appliance use^{20,21}.

In the early treatment phase, a noticeable rise in BPE score 2 was observed in 34% of participants, indicating mild gingival inflammation and the presence of areas prone to plaque accumulation. This transient deterioration corresponds to reports by Tufekci et al. (2011), who noted a 30% prevalence of BPE 2 after the first three months of removable appliance therapy²². Similarly, Ireland et al. (2014) recorded a short-term increase in gingival bleeding and plaque accumulation during the initial phase of treatment, particularly in younger patients who required additional reinforcement of instructions²³. These findings suggest that early gingival changes are largely reversible and closely related to adaptation time and oral hygiene behavior.

By the sixth month of observation, the percentage of children with BPE 2 in our study had decreased to 18%, while the majority (74%) exhibited BPE scores of 0 or 1 at nine months, reflecting the restoration of gingival health. This improvement aligns with the results of Cassetta et al. (2023), who reported a decline in gingival inflammation from 36% to 19% over a six-month follow-up in children treated with removable appliances²⁴. Likewise, Ziebart et al. (2024) found that after continuous hygiene reinforcement, bleeding on probing decreased by approximately 40% compared with baseline values²⁵.

The biological and behavioral mechanisms behind this pattern are well established. The introduction of an orthodontic appliance temporarily alters the oral microenvironment, reducing natural self-cleaning, modifying salivary flow, and changing the bacterial composition of dental biofilm²⁶. Concurrently, young patients must adapt their brushing habits and motor coordination to effectively clean around the appliance. Once these habits improve and parental supervision increases, plaque accumulation decreases and gingival inflammation subsides.

A particular strength of the present study was the inclusion of parents in the oral hygiene education process. Parental participation has been associated with significantly higher adherence and motivation among orthodontic patients²⁷. Families who actively monitored daily brushing demonstrated more stable BPE scores and lower plaque accumulation, confirming the value of shared responsibility among clinicians, parents, and children.

Clinically, these findings underscore that periodontal care should represent an integral part of every interceptive orthodontic plan. Routine follow-up visits, continuous hygiene reinforcement, and early detection of gingival changes are essential to prevent irreversible periodontal changes. Genco et al. (2015) emphasized that sustained plaque control during childhood contributes to the long-term prevention of periodontal disease and supports healthier outcomes in adulthood²⁸.

The Basic Periodontal Examination (BPE) proved to be a practical and effective screening tool for assessing periodontal status in this young population. Despite its adult-based origin, the simplified version (sBPE) has been successfully validated for children and adolescents^{8,11,29}. When used together with the Plaque Index (Silness & Løe) or the

Gingival Bleeding Index, it offers a comprehensive, time-efficient tool for evaluating periodontal health, allowing clinicians to identify children at risk of developing gingival pathology^{16,17,30}.

Study limitations

This study's main limitations include the modest sample size (n=30) and the absence of a control group, which limits the generalizability of findings. Additionally, only one type of removable appliance was evaluated, and the sample represented a narrow age range (7–11 years). These factors may influence the external validity and restrict extrapolation to other age groups or appliance types. Future studies including a control cohort, multiple appliance designs, and longer follow-up periods are needed to confirm these observations.

Clinical implications and concluding remarks

Within the limitations of this study, the results demonstrate that periodontal changes during interceptive orthodontic treatment are mild, transient, and reversible when proper hygiene instruction and regular monitoring are provided. The Basic Periodontal Examination (BPE), due to its simplicity, reproducibility, and diagnostic value, should be considered a standard screening procedure during interceptive orthodontic therapy in children. Regular monitoring with BPE not only facilitates early detection of gingival alterations but also reinforces preventive education, ensuring healthier and more stable orthodontic outcomes in the pediatric population.

Conclusion

The results of this study indicate that the Basic Periodontal Examination (BPE) is a practical, valid, and clinically valuable tool for monitoring periodontal health in children undergoing interceptive orthodontic treatment with removable appliances. A temporary increase in gingival inflammation was observed in the early phase of treatment, but this resolved as patients adapted to improved oral hygiene routines with ongoing guidance and supervision.

Regular follow-up visits, active parental involvement, and ongoing reinforcement of oral hygiene instructions were shown to be decisive factors in maintaining periodontal stability throughout therapy. These findings suggest that incorporating the BPE as a routine screening procedure in interceptive orthodontic care can facilitate the early detection of initial periodontal changes before irreversible alterations occur, supporting timely preventive action and enhancing long-term orthodontic success.

Although this study involved a relatively small sample and a single treatment protocol, its findings provide valuable insight into the use of BPE as a reliable and practical screening tool in pediatric orthodontics. Future studies including larger and more diverse populations, extended observation periods, and complementary periodontal indices are encouraged to further validate its diagnostic applicability in clinical practice.

Conflict of interest

The authors declare no conflicts of interest related to this study. All authors have read and approved the final version of the manuscript.

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Ethical approval

The study protocol was reviewed and approved by the Ethics Committee of the Kosovo Dental Chamber and the Ethics Committee of the University Clinical Stomatological Center of Kosovo. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki for biomedical research involving human subjects. Written informed consent was obtained from all participants' parents or legal guardians prior to enrollment.

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THE EFFECT OF DIFFERENT IRRIGATION PROTOCOLS ON APICAL MICROLEAKAGE IN ROOT CANAL TREATMENT: AN IN VITRO STUDY

ВЛИЈАНИЕТО НА РАЗЛИЧНИ ПРОТОКОЛИ ЗА ИРИГАЦИЈА ВРЗ АПИКАЛНАТА МИКРОПРОПУСТЛИВОСТ КАЈ ТРЕТМАН НА КОРЕНСКИОТ КАНАЛ: ИН ВИТРО СТУДИЈА

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Abstract

Aim: The aim of this in vitro study was to evaluate the effect of different irrigation protocols on apical microleakage in root canals obturated with the single-cone technique.

Materials and Methods: Eighty extracted single-rooted human teeth were randomly divided into four groups according to the irrigation protocol. The protocols included sodium hypochlorite (NaOCl) and ethylenediaminetetraacetic acid (EDTA) with ultrasonic activation, NaOCl with ultrasonic activation, NaOCl with EDTA without activation, and a control group irrigated with saline solution. After irrigation and obturation using the single-cone technique, apical microleakage was evaluated by the methylene blue dye penetration method under light microscopy. **Results:** Ultrasonic activation significantly enhanced the performance of irrigants, producing lower microleakage values compared with non-activated protocols. The NaOCl + EDTA protocol with ultrasonic activation achieved the lowest apical microleakage, whereas the saline control group exhibited the highest values. Statistical analysis confirmed statistically significant differences among the groups, demonstrating the strong influence of irrigation protocols on apical microleakage. **Conclusion:** Activated irrigation, particularly with NaOCl and EDTA, creates cleaner canal walls and provides more favorable conditions for sealer adaptation. Incorporating such protocols into clinical practice can help reduce apical microleakage and support the long-term success of endodontic treatment.

Keywords: root canal irrigation, ultrasonic activation, apical microleakage, single-cone obturation, methylene blue dye penetration.

Апстракт

Цел: Целта на оваа in vitro студија беше да се оцени влијанието на различни протоколи за иригација врз апикалната микропропустливост кај коренските канали оптурирани со техниката single-cone. **Материјал и методи:** Осумдесет екстрахирани еднокорени хумани заби беа случајно поделени во четири групи според применетиот протокол за иригација: натриум хипохлорит (NaOCl) и етилендиаминтетраоцетна киселина (EDTA) со ултразвучна активација; NaOCl со ултразвучна активација; NaOCl со EDTA без активација; и контролна група иригирана само со физиолошки раствор. По завршената иригација и оптурација со техниката single-cone, апикалната микропропустливост беше евалуирана со методот на пенетрација на метиленско сино и беше анализирана со светлосна микроскопија. **Резултати:** Ултразвучната активација значително ја зголеми ефикасноста на иригансите, овозможувајќи пониски вредности на микропропустливост во споредба со неактивирани протоколи. Протоколот со NaOCl + EDTA со ултразвучна активација постигна најниска апикална микропропустливост, додека контролната група третирана со физиолошки раствор имаше највисоки вредности. Статистичката анализа потврди значителни разлики помеѓу групите, укажувајќи на значајното влијание на протоколите за иригација врз апикалната микропропустливост. **Заклучок:** Активираниот иригација, особено со NaOCl и EDTA, обезбедува почисти ѕидови на каналите и создава повољни услови за адаптација на материјалот за оптурација. Вклучувањето на вакви протоколи во клиничката практика може да помогне во намалување на апикалната микропропустливост и да придонесе за долгорочниот успех на ендодонтскиот третман. **Клучни зборови:** иригација на коренски канал, ултразвучна активација, апикална микропропустливост, single-cone оптурација, пенетрација на метиленско сино.

Introduction

Predictable and long-term success in endodontic treatment depends primarily on two key objectives: the complete elimination of microorganisms from the root canal

system and the effective sealing of the canal space to prevent reinfection. Despite thorough mechanical instrumentation, complex anatomical areas such as lateral canals, isthmuses, and apical deltas often remain untouched, allowing residual pulp tissue, debris, and microbial biofilm

to persist¹⁻⁵. Although mechanical shaping is essential for preparing the main canal, it alone cannot ensure complete debridement of these intricate regions⁶. Therefore, a well-designed irrigation protocol that complements mechanical instrumentation is crucial.

One of the main obstacles to achieving an adequate apical seal is the smear layer that forms on the canal walls during preparation. This layer, consisting of both organic and inorganic materials as well as microorganisms, can hinder sealer adhesion to dentinal surfaces and provide a substrate for bacterial proliferation⁷. Effective removal of this layer is thus a critical step in the cleaning and shaping process, as it directly affects the quality of the apical seal and, consequently, the long-term success of the treatment⁸.

Modern endodontic irrigation has evolved from simply choosing suitable chemical agents to optimizing their method of delivery. Sodium hypochlorite (NaOCl) remains the irrigant of choice due to its strong tissue-dissolving and antimicrobial properties⁹. Ethylenediaminetetraacetic acid (EDTA), on the other hand, is typically used to chelate and eliminate the inorganic portion of the smear layer, enhancing the interface between dentin and obturation materials⁷. However, both agents have limitations when used with conventional passive irrigation techniques, especially in the apical third of the canal.

To overcome these limitations, clinicians increasingly employ activation systems such as passive ultrasonic irrigation (PUI), which enhances the dynamics of irrigant flow within the root canal. Ultrasonic activation produces acoustic streaming and cavitation effects that allow irrigants to penetrate more deeply into complex spaces, dislodging debris and disrupting biofilms more efficiently^{10,11}.

The present study evaluates how different irrigation protocols influence apical microleakage. The results confirm that activated irrigation—particularly when NaOCl and EDTA are used in combination with ultrasonic activation—achieves a more effective reduction of apical leakage than non-activated methods. These findings reinforce the importance of selecting an appropriate irrigation protocol to achieve a reliable apical seal and emphasize its critical role in the long-term success of endodontic treatment.

Materials and methods

This *in vitro* study was conducted on 80 extracted single-rooted human teeth. Immediately after extraction, all specimens were cleaned of soft tissue residues and disinfected in 3 % sodium hypochlorite (NaOCl) for 24 hours⁹. The teeth were then stored in distilled water at 4 °C until use. To standardize root length, the crowns were sectioned at the cemento-enamel junction using a low-speed diamond disc under continuous water cooling. Working length was determined by inserting a size #10 K-file into the canal until the tip was visible at the apical foramen, and then subtracting 1 mm from that measurement.

Canal preparation was performed with ProTaper Universal rotary instruments (Dentsply Maillefer), completing instrumentation up to size F2. After each file, 5 mL of the respective irrigant was delivered using a 27-gauge side-vented needle inserted passively into the canal without binding to the canal walls.

The specimens were randomly assigned to four experimental groups according to the irrigation protocol used (Table I):

- **Group 1:** 2.5 %NaOCl + 17 % EDTA with ultrasonic activation^{7,10},
- **Group 2:** 2.5 %NaOCl with ultrasonic activation¹⁰,
- **Group 3:** 2.5 %NaOCl + 17 % EDTA without activation⁷,
- **Group 4:** (Control): physiological saline solution

Following instrumentation, all canals were obturated using the single-cone technique with F2 gutta-percha cones and AH Plus resin-based sealer¹².

The samples were incubated at 37 °C in 100 % humidity for 7 days to ensure complete setting of the sealer.

Once set, the external root surfaces were coated with two layers of nail varnish, leaving a 2 mm window around the apical foramen uncoated to allow dye penetration. The teeth were immersed in 2 % methylene blue for 24 hours, then rinsed under running water and sectioned longitudinally in a bucco-lingual direction using a low-speed diamond disc.

Table 1. Group Division and Protocols

Group	Irrigation Protocol	Obturation Method	Sealer
1	NaOCl+EDTA+ UA	Single-cone	AH Plus
2	NaOCl + UA	Single-cone	AH Plus
3	NaOCl+EDTA	Single-cone	AH Plus
4	Saline	Single-cone	AH Plus

The extent of apical dye penetration was observed under a light microscope at 10× magnification, and measurements were recorded in millimeters. Statistical analysis was performed using SPSS software (version 25.0; IBM Corp., Armonk, NY, USA). Descriptive statistics (minimum, maximum, mean, and standard deviation) were calculated for each group. Differences among the groups were analyzed using one-way ANOVA, followed by Tukey's post hoc test. Statistical significance was set at $p < 0.05$.

Results

Descriptive analysis demonstrated clear differences in the extent of apical dye penetration among the experimental groups. The lowest level of microleakage was recorded in Group 1 (mean value: 1.05 mm), where canals were irrigated with NaOCl and EDTA with ultrasonic activation. This protocol consistently provided the most effective apical seal, reflected by minimal dye penetration values.

By contrast, the highest microleakage was observed in Group 4 (mean value: 2.45 mm), the control group irrigated only with physiological saline solution, which highlighted

the limited capacity of simple saline to adequately clean and prepare the canal walls for sealing.

Intermediate microleakage values were noted in Groups 2 and 3. Specifically, ultrasonic activation of NaOCl Group 2 (mean value: 1.12 mm) produced lower microleakage values compared to NaOCl + EDTA without activation Group 3 (mean value: 1.78 mm), underscoring the beneficial role of activation in enhancing irrigant effectiveness. The inclusion of standard deviation (SD) values in the results provides a clearer understanding of how consistent the data were within each experimental group. When the standard deviation is small, it shows that most of the measured values are close to the average, meaning the samples behaved in a fairly consistent way. On the other hand, a larger standard deviation means that the values were spread out more widely, indicating greater differences in how the samples responded. In the present study, the groups with ultrasonically activated irrigation showed the lowest SD values, suggesting that activation contributed not only to lower mean microleakage but also to more stable and reproducible outcomes across specimens. (Table II).

Table 2. Micro leakage results-minimum, maximum, mean values and s for each group

Group	N	Min (mm)	Max (mm)	Mean (mm)	SD (mm)
1	20	0.2	2.0	1.05	0.51
2	20	0.5	2.1	1.12	0.45
3	20	1.1	2.5	1.78	0.39
4	20	2.2	2.7	2.45	0.25

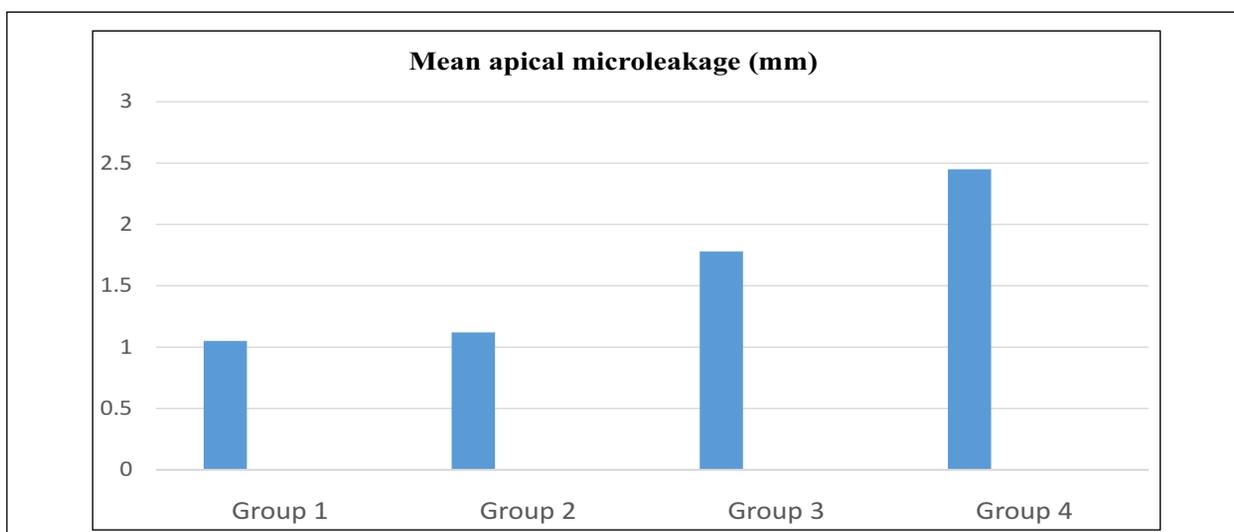


Figure 1. Mean apical microleakage (mm) across all experimental groups

Table 3. Micro leakage results-minimum, maximum, mean values and sfor each group

Comparison	Mean Difference (mm)	p-value	Significance	Interpretation
Group 1 vs Group 2	0.205	0.287	NS	No significant difference
Group 1 vs Group 3	0.760	<0.001	S	Group 1 lower leakage
Group 1 vs Group 4	1.390	<0.001	S	Group 1 much lower leakage
Group 2 vs Group 3	0.555	<0.001	S	Group 2 lower leakage
Group 2 vs Group 4	1.185	<0.001	S	Group 2 much lower leakage
Group 3 vs Group 4	0.630	<0.001	S	Group 3 lower leakage

Statistical comparisons confirmed that the differences among groups were significant, indicating that the type of irrigant used and its activation protocol exert a decisive influence on the degree of apical microleakage. Taken together, the results indicate that activated irrigation, especially with NaOCl and EDTA, not only reduces apical microleakage but also creates cleaner canal walls, thereby supporting improved adaptation and sealing effectiveness of the root canal sealer (Figure 1).

The post hoc Tukey test revealed clear and statistically significant differences among the experimental groups (Table III).

Group 1 (NaOCl + EDTA with ultrasonic activation) demonstrated the lowest level of apical microleakage, showing a statistically significant difference compared to all other groups. Group 2 (NaOCl with ultrasonic activation) also showed favorable results, though slightly less effective than the combined NaOCl + EDTA protocol.

Group 4 (control with physiological saline) recorded the highest microleakage values, confirming that irrigation with saline alone cannot provide an adequate apical seal.

Overall, the intergroup comparisons underline the pivotal role of ultrasonic activation and the combined use of NaOCl and EDTA in minimizing apical microleakage. These findings emphasize that the irrigation protocol plays an important role in reducing apical microleakage by improving canal cleanliness and dentin surface conditions, thereby facilitating a more effective apical seal and contributing to the long-term success of endodontic treatment.

Discussion

The results of this study clearly demonstrate that the irrigation protocol plays an important role in the degree of apical microleakage in teeth obturated with the single-cone technique. Among the tested regimens, the combination of sodium hypochlorite (NaOCl) and ethylenediaminetetraacetic acid (EDTA) with ultrasonic activation provided the lowest levels of microleakage, underscoring the importance of using an enhanced irrigation strategy to optimize canal cleanliness and sealer adaptation. This finding is consistent with previous research that highlights how ultrasonic activation increases the penetration and efficacy of irrigants through cavitation and acoustic streaming, facilitating the removal of smear layer and debris even in anatomically complex areas of the root canal system^{10,11,13}.

In contrast, canals irrigated with physiological saline solution showed the highest levels of microleakage, confirming that the absence of active chemical agents significantly compromises the sealing ability of the obturation. Furthermore, when NaOCl and EDTA were applied without ultrasonic activation, apical microleakage values remained comparatively higher than those observed in the activated groups. This finding suggests that the chemical action of irrigants on its own cannot ensure ideal sealing conditions; activation is necessary to improve canal cleanliness and surface preparation, thereby facilitating a more effective apical seal^{17,8,14}.

Interestingly, NaOCl with ultrasonic activation alone also achieved favorable results, showing significantly less

microleakage compared to non-activated regimens. This suggests that, in certain clinical situations, a simplified irrigation strategy based solely on activated NaOCl could provide a balance between effectiveness and practicality, particularly when access to multiple irrigants is limited^{9,15}.

Taken together, these results highlight that the irrigation protocol plays an important role in reducing apical microleakage. Because persistent microleakage at the apex is one of the leading causes of endodontic failure, our findings underscore the clinical importance of incorporating irrigant activation into routine practice. In particular, ultrasonically activated NaOCl combined with EDTA proved to be the most effective irrigation strategy, providing superior canal cleanliness and minimizing apical microleakage, thereby contributing to more predictable, long-term outcomes in root canal therapy.

Clinically, persistent apical microleakage remains one of the leading causes of endodontic failure. By showing that ultrasonic activation of irrigants, especially NaOCl combined with EDTA, markedly reduces microleakage, this study offers practical implications for everyday dentistry: adopting activated irrigation protocols can support cleaner canals, more effective sealing, and ultimately more predictable, long-term success for patients.

Conclusion

This study demonstrated that the irrigation protocol has a significant impact on apical microleakage in root canal therapy. The combination of sodium hypochlorite (NaOCl) and ethylenediaminetetraacetic acid (EDTA) with ultrasonic activation produced the lowest levels of apical microleakage, consistently outperforming other regimens. This outcome reflects the effectiveness of activated irrigation in enhancing canal cleanliness and creating favorable conditions for reliable sealing.

These findings underline that effective irrigation, particularly when supported by ultrasonic activation, improves cleaning and debridement of the canal system and reduces the risk of persistent microleakage. By doing so, it supports the long-term predictability and success of endodontic treatment. Incorporating such strategies into

routine clinical practice is therefore strongly recommended to optimize treatment outcomes.

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OPTIMIZING TREATMENT OF PALATALLY IMPACTED CANINES: EVIDENCE ON OPEN, CLOSED, AND GOPEX TECHNIQUES

ОПТИМИЗИРАЊЕ НА ТРЕТМАНОТ НА ПАЛАТИНАЛНО ИМПАКТИРАНИ КАНИНИ: ДОКАЗИ ЗА ОТВОРЕНА, ЗАТВОРЕНА И ГОПЕКС МЕТОДА

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Abstract

Objective: Canine impaction is a common clinical challenge in orthodontic practice, with the majority of impacted canines located palatally. When interceptive treatment fails, surgical exposure followed by orthodontic treatment becomes necessary, typically using either open or closed exposure techniques. This review aims to compare the open versus closed exposure techniques, with a focus on optimizing clinical outcomes and patient-reported experiences. **Methods:** A comprehensive literature search was conducted using the following databases: Cochrane Library, PubMed, and Google Scholar. Reference lists from selected articles were hand-searched for additional relevant studies. The search focused on meta-analyses, systematic reviews, and clinical trials, evaluating of clinical outcomes such as orthodontic treatment duration, periodontal health, and pain levels. **Results:** The selected articles revealed comparable results between the open and closed exposure techniques, with a slight preference for the open exposure technique. The choice between these methods was often influenced by clinician preference. The modified open exposure technique demonstrated an average eruption time of 8.5 months for GOPEX compared to 11.5 months for closed exposure ($p = 0.002$). The GOPEX technique also resulted in reduced postoperative pain, with patients requiring fewer analgesics. **Conclusions:** Both the open and closed exposure techniques yield effective results. Although the GOPEX demonstrates advantages in treating palatally impacted canines, careful patient selection is crucial. This review highlights the importance of individualizing treatment plans based on clinical presentation and patient factors. **Keywords:** Orthodontics; Tooth, Impacted; Tooth Eruption; Oral Surgical Procedures; Glass Ionomer Cements.

Апстракт

Цел: Импакијата на канините претставува честа клиничка состојба во ортодонтската пракса, при што најголем процентод импактираните канини се палатално поставени. Кога интерцептивниот третман е неуспешен, неопходна е хируршка експозиција проследена со ортодонтски третман, најчесто со примена на отворена или на затворена техника на експозиција. Овој преглед има за цел да ги спореди отворената и затворената експозиција, со фокус на оптимизирање на ортодонтскиот третман на палатинално импактирани канини. **Методи:** Спроведено е сеопфатно пребарување на литературата во базите: CochraneLibrary, PubMed and GoogleScholar. Листата на референци на избраните трудови беше дополнително рачно проверена за релевантни студии. Пребарувањето беше насочено кон мета-анализи, систематски прегледи и клинички испитувања, од аспект на времетраење на ортодонтскиот третман, пародонтално здравје и болката. **Резултати:** Досегашната литература укажува на споредливи резултати меѓу отворената и затворената техника на експозиција, со преференца кон отворената експозиција. Изборот меѓу методите често е детерминиран од личниот избор на клиничарот. Модифицираната отворена техника покажа просечно време на ерупција на импактираниот канин од 8,5 месеци, наспроти 11,5 месеци кај затворената експозиција ($P = 0,002$). Техниката GOPEX, исто така, беше поврзана со помала болка по спроведената хируршка интервенција. **Заклучоци:** И отворената и затворената хируршка техника даваат ефективни резултати. Иако техниката GOPEX нуди одредени предности при третман на палатинално импактирани канини, клучна е внимателната селекција на пациентите. Овој преглед ја потенцира важноста на индивидуализирањена планот на третман според клиничката презентација и карактеристиките на пациентот. **Клучни зборови:** ортодонтска; импактиран заб; ерупција на заб; орално хируршки процедури; гласјономерни цемента.

Introduction

Maxillary canines play a vital role both functionally and aesthetically. In terms of occlusion, they are responsible for

canine guidance as well as arch form and stability. Their esthetic contribution includes the support of the upper lip and maintenance of facial contour¹. Due to their strategic position, canine impaction holds significant clinical importance.

Impaction of maxillary canines is a common clinical challenge, affecting approximately 2-3 % of the general population². They are the second most frequently impacted teeth after the third molars, with nearly two-thirds of these cases involving palatal impaction³. Maxillary canines are approximately twice as likely to be impacted as mandibular canines⁴.

While the etiology of the impacted canines is not fully elucidated, there are two main theories: the guidance theory, which suggests that the canine eruption path depends on the presence and correct development of the maxillary lateral incisor root and the genetic theory, which proposes that canine impaction is a manifestation of a broader genetic developmental pattern².

Even though impacted maxillary canines can be asymptomatic for a long period of time, they can pose a risk for the adjacent teeth. The most common complications include root resorption and cyst formation⁵. Root resorption associated with impacted canines is reported to occur more frequently in females and typically presents unilaterally. The maxillary lateral incisors are most commonly affected, although central incisors may also be involved in some cases⁶.

Impacted canines significantly increase the burden of orthodontic treatment as well. These cases often require a combination of surgical and orthodontic interventions, which can prolong treatment duration, increase cost, and increase both biological and patient-related complications⁷.

Interceptive treatment for palatally impacted canines between the ages of 10 to 13 most commonly involves extraction of the primary canine and/or gaining space with rapid palatal expansion and/or headgear traction. These treatment modalities have gained considerable popularity both historically and in current practice^{2,8}. This approach has been widely studied and can, in many cases, successfully redirect the eruption path of the permanent canine. However, it is not always effective, and when it fails, surgical exposure combined with orthodontic treatment becomes necessary.

There are two main surgical techniques for exposing palatally impacted canines: the open exposure technique and the closed exposure technique. Kokich and Mathews⁹ have outlined criteria to guide the choice between these methods, primarily based on the position of the impacted canine. Another important aspect is the timing of traction, whether immediate traction is applied or spontaneous eruption is allowed. However, in clinical practice, the decision is often less objective.

In reality, clinician preference plays a major role in selecting the exposure method. A study by Naoumova et al.¹⁰ evaluated which surgical technique orthodontists prefer for treating palatally impacted canines. The study reported an almost equal distribution among respondents:

28% preferred the open technique, 23% the closed, and 49% used both methods. This contrasts with findings from a UK-based survey, where 50% of clinicians favored the open exposure technique¹¹.

Therefore, the aim of this review is to analyze the latest literature comparing the open versus closed exposure techniques for palatally impacted maxillary canines, focusing on three key outcomes: orthodontic treatment duration, periodontal health, and pain.

Materials and methods

A comprehensive literature search was performed across the following databases: PubMed, Cochrane Library, and Google Scholar. The search aimed to identify relevant meta-analyses, systematic reviews, and clinical trials evaluating the management of palatally impacted canines, with particular focus on the open and closed exposure techniques. Search terms included combinations of “*palatally impacted canines*,” “*open exposure*,” “*closed exposure*,” “*GOPEX*,” “*pain*,” “*periodontal outcomes*,” and “*treatment duration*.”

Only studies published in English were included. Reference lists of the selected articles were manually screened to identify additional studies relevant to the topic.

Results

The findings from selected literature are presented based on the main outcomes investigated: orthodontic treatment duration, periodontal health and pain.

1. Orthodontic treatment duration

Three studies compared the overall orthodontic treatment duration between the open and closed exposure techniques^{12,10,13}.

In a randomized controlled trial, Björksved et al.¹² found that total treatment time was similar between open and closed exposure groups, with a mean difference of -0.1 months (95% CI -3.2 to 2.9; P = 0.93), averaging approximately 26.3 months in both groups.

A retrospective study by Naoumova et al.¹⁰ supported the finding that total treatment duration did not differ significantly between the groups. However, this study demonstrated a statistically significant (p = 0.002) shorter eruption time (8.5 months) and shorter active orthodontic treatment time in the modified open exposure group- GOPEX compared to the closed exposure group (11.5 months).

A controlled prospective study by Smailiene et al.¹³ supports previous literature that neither technique is clearly superior when looking at the total orthodontic treatment duration. In the study, the total treatment time was longer in the closed group, but the difference was not statistically significant (28.41±4.96 months in the open

exposure group and 32.19±11.73 months in the closed exposure group).

These findings are supported by the systematic review by Parkin et al.⁷, which concluded that while the total treatment time appears similar between techniques, the available evidence remains of low to moderate quality, and further well-designed RCTs are needed to confirm a true difference.

2. Periodontal health

Björksved et al.¹² found small but statistically significant differences between the groups. The open group showed deeper pocket depths at the lateral incisor: mesiopalatal: +0.5 mm (P=0.007) and palatal: +0.4 mm (P=0.042).

In contrast, alveolar bone levels were better preserved in the open group, with 0.3 mm less bone loss at the mesial surface of the previously impacted canine (P = 0.01).

Smailienė et al.¹³ evaluated periodontal parameters after the open and closed exposure of impacted canines. No significant differences were found in probing depth or clinical attachment level. However, the width of keratinized gingiva was significantly greater in the open group (4.05±1.57 mm) compared with the closed group (3.23±1.37 mm, P<0.05).

3. Pain

In the randomized controlled trial by Björksved et al.¹², patient-reported pain differed significantly between the open and closed exposure groups. During the initial phase from surgery to eruption (T1–T2), the closed group reported higher median VAS pain scores (19.0 mm; range 5–34) compared with the open group (2.0 mm; range 0–9; P<0.001). During the traction phase (T2–T3), pain scores remained higher in the closed group (10.0 mm; range 5–25.5) than in the open group (6.0 mm; range 1–12; P=0.014). Over the entire treatment period (T1–T3), cumulative pain was lower in the open group (median 4.5 mm; range 0–10.25) compared with the closed group (11.0 mm; range 5–27; P<0.001).

Discussion

This study aimed to evaluate the clinical efficiency of the open versus closed surgical exposure techniques in the management of palatally impacted maxillary canines, with a particular focus on orthodontic treatment duration, periodontal health, and pain.

While total orthodontic treatment duration was generally reported as comparable between the two methods, with most patients completing treatment in about 26 to 28 months, the underlying phases of treatment were distributed differently depending on the technique used.

Both Naoumova¹⁰ and Björksved¹² reported that eruption time was significantly shorter in the open exposure group, with a 3-month advantage observed from surgery to the point at which the canine crown became visible. In addition, active

traction time was shorter in the open group in Naoumova's study and supported by fewer appointments¹⁰.

So how is it possible that eruption is faster in the open group, yet total treatment time remains comparable? According to Björksved et al.¹², this is because the second part of treatment, from visible eruption to full alignment-takes longer in the open group. When the canine is left to erupt spontaneously, it often emerges more palatally or in a less controlled position, so it takes more time to align it correctly. On the other hand, in the closed group, traction starts early and guides the tooth more directly toward its final position in the dental arch.

One important point raised by Smailienė et al.¹³ is that the shorter eruption time observed in the open exposure group may not be entirely due to the surgical technique itself, but rather influenced by the fact that a higher percentage of canines in this group were more superficially positioned (81.8% vs. 61.9%). Although this difference was not statistically significant, these teeth may have required less time to erupt simply because they did not need to penetrate as much soft tissue.

This brings up a bigger issue: the differences between studies in how patients are selected and how outcomes are measured. As highlighted in the Cochrane review by Parkin et al.⁷, the heterogeneity in study design makes it difficult to compare results directly or to draw broad conclusions.

One of the key factors influencing the choice of a surgical exposure technique is the anatomical nature of the overlying soft tissue. In some cases, clinicians prefer to keep the tissue intact to support better healing. According to a survey by Naoumova et al., many orthodontists who preferred the closed technique believed it offered better protection for periodontal health¹⁰.

Björksved et al. reported statistically significant differences in pocket depth and alveolar bone levels between groups; however, these differences were small and considered not clinically relevant, as they did not exceed 3 mm. Specifically, deeper pockets were observed at the lateral incisor in the open group, while lower mesial bone levels were found in the closed group at the site of the previously impacted canine. Ideally, surgical-orthodontic approaches should mimic the natural eruption pathway through the attached gingiva. Since the palatal mucosa primarily consists of attached gingiva, both open and closed exposure techniques are considered periodontally acceptable in this region¹³.

Although pain is a subjective outcome, it provides valuable insight into the patient's overall experience during orthodontic treatment. Patients treated in the closed exposure group reported statistically significantly higher levels of pain and discomfort compared with those in the open exposure group, particularly during the orthodontic traction phase¹². From a clinical perspective, these findings high-

light the importance of effective patient communication and expectation management throughout treatment. Patients should be informed that discomfort may occur at different stages depending on the chosen technique: open exposure tends to be associated with greater pain immediately after surgery due to the open wound, whereas closed exposure is associated with greater pain during the active orthodontic traction phase. This distinction has practical implications for the timing of pain management strategies and patient support, ensuring that discomfort is anticipated and appropriately managed at the stage when it is most likely to occur.

While both open and closed exposure techniques have shown comparable outcomes, modifications of the open technique have recently been introduced to enhance biological healing and patient comfort, most notably the GOPEX approach.

The GOPEX (Glass Ionomer Open Exposure) technique is a modified version of the standard open exposure method. Unlike the conventional approach, which uses a surgical dressing, GOPEX employs a glass ionomer as a long-term biocompatible dressing. Glass ionomer is strong, resistant to salivary dissolution, and can safely remain in the oral cavity until the canine erupts onto the palatum. This modification provides a stable and durable exposure, supporting the spontaneous and physiological eruption of the impacted canine¹⁰.

From the results, the open exposure technique has been shown to provide faster eruption and lower pain levels compared with the closed technique. The GOPEX builds on these benefits and offers several additional advantages. It promotes spontaneous and more physiological eruption, reduces the risk of root resorption in adjacent teeth, and, importantly, allows for effective pre-orthodontic surgical exposure. This means that the technique can be performed even before comprehensive orthodontic treatment begins, making it suitable for use in the mixed dentition stage. Because GOPEX shortens the period of active orthodontic traction, it reduces overall chair time, which indirectly translates into lower costs for both the healthcare system and the patient^{10,14}.

Nevertheless, as with all techniques, GOPEX has limitations. Its success is closely related to patient age, being most appropriate for individuals up to approximately 16 years of age, since the risk of ankylosis increases with advancing years. Furthermore, it is not recommended in cases of complex impactions or when the canine is positioned very close to the roots of the central or lateral incisors, where the risk of resorption is higher. In such situations, a preliminary orthodontic distalization of the impacted canine should be considered before exposure.

These findings emphasize that refinements such as GOPEX could represent an important step forward in opti-

mizing outcomes, though proper case selection remains essential.

Conclusion

Both open and closed exposure techniques are well-established and effective approaches for the treatment of palatally impacted canines, with evidence supporting their clinical validity. The GOPEX technique, although not entirely novel, has been the subject of increasing investigation in recent years and appears to confer additional advantages that are clinically significant. By integrating the principles of open exposure with the use of a glass ionomer as a durable and biocompatible dressing, GOPEX facilitates spontaneous eruption and may reduce treatment-related discomfort and chair time. These findings suggest that GOPEX represents a valuable adjunct to current clinical practice, warranting careful consideration in appropriately selected patients.

At the same time, the evidence base remains limited by methodological constraints. The Cochrane Review⁷ emphasized the lack of stratification by the severity of impaction as a major limitation in the literature. Supporting this, Grisar et al.¹⁵ found that the initial canine position, particularly vertical height and sector location, significantly affects eruption outcomes. Together, these findings highlight the need for future studies to classify cases by impaction severity when comparing open and closed techniques, allowing for more personalized and clinically relevant treatment decisions.

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PRESENCE OF CANDIDA SPECIES IN THE ORAL MICROBIOME AND THEIR INFLUENCE ON THE EXTRACTION SOCKET HEALING

ПРИСУСТВО НА ВИДОТ КАНДИДА ВО ОРАЛНИОТ МИКРОБИОМ И НИВНОТО ВЛИЈАНИЕ ВРЗ ЗАЗДРАВУВАЊЕТО НА ЕКСТРАКЦИОНИТЕ РАНИ

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Abstract

Introduction: The positive finding of *Candida* in the oral cavity does not represent a pathological finding per se. This fungus has all the characteristics of the opportunistic pathogen, meaning it may cause an infection in the mouth when conditions altering the local oral environment and mucosal resistance arise. Under normal conditions, the balance between microbial colonization and host immune response ensures successful re-epithelialization and tissue regeneration in post-extraction sites. **Aim:** The aim of this review is to provide comprehensive comparison of the contemporary studies on candida colonization, oral microbiome dysbiosis and wound healing impairment. **Materials and methods:** To provide a comprehensive review of the *Candida* overgrowth, oral microbiome and wound healing, we have conducted an extensive literature search in multiple databases including PubMed, Google Scholar and Web of Science. **Results:** *Candida* adheres to epithelial and dental surfaces through adhesins and forms complex biofilms composed of yeast and hyphal morphotypes embedded in an extracellular matrix, facilitating persistent infection. Interactions of *Candida* with oral bacteria can promote biofilm formation. Biofilm contribute to increased virulence and resistance to antimicrobial agents. Clinical and in vivo studies have confirmed that fungal colonization of extraction sockets correlates with prolonged healing time, delayed epithelial coverage, and an increased risk of secondary infection such as alveolar osteitis, or chronic non-healing ulcers in severe cases. **Conclusion:** Effective management of post-extraction wounds in the presence of *Candida* requires maintaining optimal oral hygiene, controlling predisposing factors, promoting a balanced oral microbiome and supporting local immune responses, which are essential for favorable wound healing outcomes. **Key words:** candida species, oral microbiome, wound healing, socket healing.

Апстракт

Вовед: Позитивниот наод на *Candida* во усната шуплина не претставува патолошки наод сам по себе. Оваа габа ги има сите карактеристики на опортунистички патоген, што значи дека може да предизвика инфекција во устата кога ќе се појават услови што ги менуваат локалната орална средина и мукозната отпорност. Во нормални услови, рамнотежата помеѓу микробната колонизација и имунолошкиот одговор на домаќинот обезбедува успешна реепителизација и регенерација на ткивата на местата по екстракција. **Целта** на овој ревијален труд е да се обезбеди сеопфатна споредба на современите студии за колонизацијата со *Candida* species, дисбиозата на оралниот микробиом и за нарушувањето на физиолошкото заздравување на постекстракционите рани. **Методи на пребарување:** За да се обезбеди сеопфатен преглед на прекумерниот раст на *Candida*, оралниот микробиом и на заздравувањето на раните, спроведовме обемно пребарување на литературата во повеќе бази на податоци, вклучувајќи ги PubMed, Google Scholar и Web of Science при што се вклучени околу педесетина трудови. **Резултати:** *Candida* се атхерира на епителните и на денталните површини преку адхезини и формира сложен биофилм составен од квасни и од хифални морфотипови вградени во екстрацелуларен матрикс. Ваков комплексен состав на биофилмот овозможува услови за перзистентна инфекција. Интеракцијата на *Candida* со бактерии од оралниот микробиом придонесува за зголемена вирулентност и за отпорност на антимикробни агенси. Клиничките и *in vivo* студиите потврдуваат дека габичната колонизација на екстракционите рани е во корелација со продолженото време на заздравување, одложената епителна пролиферација и со зголемениот ризик од секундарна инфекција, како што е алвеоларен остеоитис или хронични рани без тенденција за

заздравување. **Заклучок:** Ефикасното управување со постекстракционите рани во присуство на *Candida*, подразбира одржување на оптимална орална хигиена, контрола на предиспонирачките фактори, промовирање на избалансиран орален микробиом и поддршка на локалните имунолошки одговори, за да се добие оптимален ефект во заздравувањето на раните. **Клучни зборови:** *candida* вид, орален микробиом, заздравување на екстракциона рана, заздравување на алвеола.

Introduction

Oral microbiome is vibrant ecosystem and microbial consortium of over 700 known bacterial species¹. The oral microbiome acts as a protective barrier, preventing the colonization of harmful pathogens and potential infections in the oral cavity².

The oral microbiome is composed of **Gram-positive cocci** *Abiotrophia*, *Peptostreptococcus*, *Streptococcus*, and *Stomatococcus* assume pivotal roles (*Streptococcus sanguinis* and *salivarius*), **Gram-positive rods** *Actinomyces*, *Bifidobacterium*, *Corynebacterium*, *Eubacterium*, *Lactobacillus*, *Propionibacterium*, *Pseudoramibacter*, and *Rothia*, **Gram-negative cocci** *Moraxella*, *Neisseria*, and *Veillonella* and **Gram-negative rods**, *Campylobacter*, *Capnocytophaga*, *Desulfobacter*, *Desulfovibrio*, *Eikenella*, *Fusobacterium*, *Hemophilus*, *Leptotrichia*, *Prevotella*, *Seimonas*, *Simonsiella*, *Treponema*, and *Wolinella*^{3,4,5}.

Fungi are less than 0.1% of the total oral microbial population⁶. *Candida* species is most observed fungus. Additionally, fungi species are identified in oral microbiome as *Cladosporium*, *Saccharomycetales*, *Aspergillus* and *Cryptococcus*⁷.

Viruses (Herpesviridae, Papillomaviridae, Anelloviridae, Redondoviridae) can be present either as free phage particles (virions) or as prophages integrated within bacterial lysogens⁸.

Physical interactions between fungi and bacteria in the oral cavity influence the oral microbiota diversity. *Candida* and other oral fungi act as bridging organisms facilitating bacterial adhesion to epithelial cells surfaces. Additionally, these interactions contribute to bacterial resistance against antimicrobial agents⁹.

There are a numerous factors influencing the oral microbiome composition and leading to disturbance: diet, alcohol consumption, lifestyle choices, smoking, poor oral hygiene practices, medical conditions and medications.

The oral microbiome in healthy conditions thrives in a favorable commensal association with its environment. Disruptions in the oral microbiota balance (dysbiosis) are under the influence of harmful factors. In the state of dysbiosis, opportunistic microorganisms within the oral microbiome undergo a transformation into harmful pathogens and a decline in beneficial microorganisms¹⁰.

Significant progress has been made in understanding the impact of the oral microbiome in the development of

oral and systemic diseases by innovative genomic technologies such as next-generation sequencing (16S rRNA sequencing, metagenomics, shotgun metagenomics, quantitative real-Time PCR) and advanced bioinformatic tools⁸.

Latest research also indicates potential links between oral microbiome dysbiosis and systemic health conditions including metabolic endocrine diseases such as diabetes, obesity, gastrointestinal disorders-inflammatory bowel disease, cardiovascular disease, adverse pregnancy outcomes, Alzheimer's and Parkinson's disease, autism spectrum disorders, systemic lupus erythematosus, rheumatoid arthritis, and even cancer⁸.

A high increase of fungal infections has been reported over the last decades. The most common infections are caused by *Candida species* (candidiasis). *Candida albicans* is the most common one, but *Candida krusei*, *Candida stellatoidea*, *Candida tropicalis*, *Candida glabrata*, *Candida guilliermondii* and *Candida dubliniensis* are other species that can also be present in oral candidiasis lesions¹¹.

The positive finding of *Candida* in the oral cavity does not represent a pathological finding per se. This fungus has all the characteristics of an opportunistic pathogen, meaning it may cause an infection in the mouth when conditions that alter the local oral environment and mucosal resistance arise (changes in the host's immune system, smoking, hyposalivation, inadequate oral hygiene, various types of dentures, antibiotics administration, diabetes, or advanced age¹².

Materials used for prosthetic rehabilitation can directly affect the presence of *Candida* in an oral environment due to their properties (surface structure, degree of porosity, roughness, hydrophobicity, surface-free energy, all of which affects the adhesion of microorganisms and plaque formation)¹³.

The ability of *Candida* species to colonize host tissues is influenced by diverse virulence factors, including biofilms development. *Candida albicans* biofilms have been associated with persistent high virulence factors and drug resistance. In biofilms, *Candida* is a very important factor involved in the adherence of bacteria to soft tissues and further in the deep invasion, invading the connective tissue in association with anaerobic microorganisms (*Porphyromonas gingivalis*, *Prevotella intermedia*, and *Aggregatibacter actinomycetemcomitans*)¹⁴.

The process of oral wound healing following tooth extraction represents a highly coordinated cascade of cel-

lular and molecular events involving hemostasis, inflammation, proliferation, and remodeling phases. The post-extraction socket provides a transient yet complex microenvironment, characterized by changes in pH, oxygen tension, nutrient availability, and microbial composition. Under normal conditions, the balance between microbial colonization and host immune response ensures successful re-epithelialization and tissue regeneration. However, microbial dysbiosis—particularly the overgrowth of opportunistic fungi such as *Candida* species—can significantly impair the healing trajectory and lead to pathological outcomes. The colonization of extraction sockets by *Candida* species disrupts the balance of the oral microbiome and leads to prolonged mucosal erythema, delayed epithelial closure, and increased susceptibility to alveolitis¹⁵.

Aim

The aim of this review is to provide a comprehensive comparison of the contemporary studies on *Candida* colonization, oral microbiome dysbiosis and wound healing impairment.

Search methods

To provide a comprehensive review of the *Candida* overgrowth, oral microbiome and wound healing, we have conducted an extensive literature search. We used the following keywords: candida, oral microbiome, wound healing, oral care. Our search spanned multiple databases including PubMed, Google Scholar and Web of Science.

Inclusion criteria: This review paper included case-control studies, cross-sectional studies, retrospective and prospective cohort studies, and randomized controlled trials that examined the composition of and factors that influence oral microorganisms, connections between oral candida and wound healing. Exclusion criteria: non-peer-reviewed articles and articles not available in English.

Results and discussion

The simplest oral surgery intervention—ooth extraction—initiates changes in the oral cavity environment and increases the risk of fungal growth. The wound area after extraction becomes susceptible to infection with *Candida* species. The contamination of the socket by microorganisms results in delayed wound healing. *Candida* species play an important role as an opportunistic component in wounds. Decreased immunity directly affects the prevention of mucosal infections by *Candida* species which is primarily mediated by the innate immune response function.

Experimental and clinical studies have demonstrated that *Candida*-associated post-extraction sites exhibit

increased proinflammatory cytokine levels (such as IL-1 β , TNF- α , and IL-6), elevated oxidative stress markers, and delayed epithelial closure compared to non-infected wounds¹⁶.

Clinical and in vivo studies have confirmed that fungal colonization of extraction sockets correlates with prolonged healing time, delayed epithelial coverage and increased risk of secondary infection such as alveolar osteitis or chronic non-healing ulcers in severe cases¹⁷.

Candida adheres to epithelial and dental surfaces through adhesins and forms complex biofilms composed of yeast and hyphal morphotypes embedded in an extracellular matrix, facilitating persistent infection. Additionally, *Candida albicans* biofilms formed on the wound surface exhibit enhanced resistance to antifungal agents and immune clearance. The fungal biofilm architecture composed of dense yeast and hyphal networks within an extracellular polysaccharide matrix acts as a physical and chemical barrier, facilitating chronic infection and delayed tissue repair^{18,19}.

Candida species exhibit morphological plasticity, transitioning between yeast, pseudohyphal, and hyphal forms, which enhances its tissue invasiveness and persistence. The hyphal phase is associated with the secretion of virulence factors, including aspartyl proteases (SAPs), phospholipases, and hemolysins, which contribute to epithelial degradation, disruption of the extracellular matrix, and modulation of the inflammatory response. These pathogenic mechanisms can prolong the inflammatory phase, delay epithelial proliferation and migration, and impair angiogenesis and collagen deposition within the granulation tissue^{20,21}.

Unlike *C. albicans*, most non-*albicans Candida* (NAC) species (*C. glabrata*, *C. tropicalis*, *C. krusei*, *C. parapsilosis*) are incapable of forming true hyphae. They compensate through strong adhesion ability, biofilm formation, and intrinsic resistance to commonly used antifungal agents, such as azoles²². *C. glabrata*, for example, adheres to host tissues via cell wall adhesins and survives in the host cells macrophages, evading immune detection²³.

C. tropicalis has been associated with higher proteolytic and lipolytic enzyme activity compared with *C. albicans*, contributing to extensive epithelial disruption and inflammation²⁴. *C. krusei* and *C. tropicalis* are associated with strong biofilm formation and intrinsic resistance to antifungal agents, complicating eradication and contributing to chronic infection²⁵. These species can induce a subtle yet sustained inflammatory response that interferes with fibroblast proliferation and angiogenesis during the proliferative healing phase²⁶.

Co-infection by *C. albicans* and NAC species can lead to synergistic virulence, enhancing biofilm density and resistance profiles. Clinical evidence suggests that mixed

infections, where *C. albicans* coexists with NAC species, may produce synergistic pathogenic effects, resulting in more pronounced inflammation and delayed tissue regeneration²⁷. Moreover, the biofilm matrix produced by NAC species can protect *C. albicans* from antifungal agents and host immune responses, thereby sustaining infection within the healing socket²⁸.

While both *C. albicans* and NAC species delay wound healing, their mechanisms differ. *C. albicans* primarily causes tissue invasion and immune activation through hyphal formation and enzyme secretion, whereas NAC species contribute through persistent colonization, metabolic stress, and drug resistance. The resulting inflammatory microenvironment, characterized by sustained leukocyte infiltration and oxidative stress, disrupts fibroblast proliferation, angiogenesis, and collagen synthesis—key factors in tissue repair. Understanding these species-specific pathogenic mechanisms is therefore essential for targeted therapeutic interventions and the prevention of fungal complications in oral surgery patients²⁸.

Candida may cause various forms of infections, ranging from superficial to systemic conditions, which in extreme cases may lead to death. The occurrence of infection is influenced by factors altering the local oral environment, host's immune system as well as mucosal resistance. Colonization with *Candida* species and the respective infections are also more frequent among transplant patients compared to non-transplant patients²⁹. Furthermore, *Candida* is also closely associated with potentially malignant and malignant oral lesions. Patients who wear dentures are more predisposed to having their mucosa colonized by *Candida* species compared to the denture-free patients³⁰.

The occurrence of clinical oral signs and symptoms depends on the presence [quantity] of *Candida* species. Local and systemic factors create an imbalance in the natural flora of the mouth, allowing the *Candida* fungus to overgrow and cause an infection. Low *Candida* counts might have no clinical manifestations. Symptoms reported by patients can vary from mild to severe. Symptoms commonly include dry mouth, altered taste, glossalgia and red lesions of oral mucosa and tongue³¹.

The symptoms of oral candidiasis may also include white patches on the tongue, inner cheeks, and roof of the mouth, as well as redness and soreness in the affected areas. In severe cases, it can cause difficulty swallowing and a burning sensation in the mouth³².

Several processes contribute to *Candida albicans* pathogenicity. Initially, it adheres to host surfaces through weak and reversible interactions that are influenced by both hydrophobic and electrostatic forces³³.

Agglutinin-like sequence (Als) genes encode cell-surface proteins in *Candida* fungi and are primarily involved

in adhesion to host tissues and biofilms, representing a key factor in fungal virulence and infection. HWP1 (hyphal wall protein) is a surface expressed adhesin in certain *Candida* species, particularly *Candida albicans*, which facilitates adhesion to host cells by acting as a substrate for host transglutaminases, forming covalent cross-links with epithelial cells.

The process of adhesion is facilitated through the presence of specific host tissue receptors. *C. albicans* can adhere to epithelial cells by using various host cell receptors, such as EphA2 (through β -glucan) and E-cadherin. EphA2 is an epithelial cell pattern recognition receptor for fungal β -glucans (PRRs). E-cadherin is a crucial calcium-dependent glycoprotein that forms the main component of epithelial adherens junctions, maintaining tissue integrity by linking epithelial cells together (cellular adhesion and polarity maintenance). E-cadherin is expressed in almost all epithelial cells. Loss of E-cadherin expression is associated with gain of fungal (or tumor) invasiveness³⁴.

Interaction of *Candida* with oral bacteria can promote biofilm formation. Biofilms contribute to increased virulence and resistance to antimicrobial agents. *Streptococcus gordonii* and *Streptococcus mutans* are common residents that interact with *C. albicans* in the oral cavity, promoting the formation of hyphal structures and biofilms. *C. albicans* can be transformed into an invasive filamentous form after adhering to host surfaces, which significantly improves its ability to penetrate epithelial tissue^{35,36}.

C. albicans causes host tissue damage by releasing enzymes outside the cell (aspartyl proteinases-SAPs, phospholipases, and lipases). These enzymes degrade host immune factors, such as antibodies and antimicrobial peptides, thereby reducing the effectiveness of host defenses. For tissue invasion, the shift to the hyphal form is crucial³⁷. Hyphae can infiltrate and harm the epithelial cells. Thigmotropism (directional growth response to surface contact) is also characteristic of hyphal cells and their ability to successfully explore and infiltrate host tissues³⁸. *Candida* can release candidalysin, a hypha-specific toxin that promotes immunological activation and tissue destruction. In addition to this, *Candida* engages in a complementary, passive process called endocytosis^{39,40}.

Invasive infections from *Candida* only occur in immuno-compromised patients or when barrier leakage is impaired. Yeasts can enter the bloodstream and cause fungaemia and subsequent infections. *Candida* is the most common fungal pathogen that produces fungaemia. Tight adherence to human cells from skin, epithelium or endothelium is the first step in *Candida* infections. The efficacy to bind to those host tissues or catheters/prosthetic devices depends on adhesins located in fungal cell walls and encoded by genes⁴¹.

The first stage of *Candida* infection is colonization due to epithelial adhesion and nutrient acquisition. The second stage includes superficial infection as a result of epithelial penetration and degradation of host proteins. Subsequent third stage of infection is deep-seated infection due to tissue penetration, vascular invasion and immune evasion or escape. The last stage and the most serious one is disseminated infection with endothelial adhesion, infection of other host tissues and activation of blood clotting cascades (coagulation).

Since antifungal resistance is a rising clinical problem worldwide, management strategies should therefore include accurate and precise biochemical identification of the involved *Candida* species. Infections with non-albicans *Candida* species often require alternative antifungal regimens due to intrinsic resistance patterns of some *Candida* species. While *C. albicans* infections typically respond to azoles such as fluconazole, non-albicans *Candida* species, particularly *C. krusei* and *C. glabrata* may require use of echinocandins or amphotericin B⁴². Therefore, antifungal susceptibility testing is necessary if acquired drug resistance is suspected, or when the patient is unexpectedly failing therapy. For each of these scenarios, knowing the in vitro susceptibility pattern would inform the clinician when making therapeutic choices or changes in therapy.

Adjunctive therapies targeting biofilm disruption and modulation of the local inflammatory response may further improve healing outcomes. Additional measures, such as probiotics, antiseptic mouth rinses, and laser phototherapy have also been investigated for their potential to restore microbial balance and enhance mucosal repair⁴³.

Management of post-extraction wounds complicated by *Candida* infection requires a multifactorial approach. This includes identification and control of predisposing factors (e.g., xerostomia, systemic disease, or prolonged antibiotic use), maintenance of optimal oral hygiene, and administration of antifungal agents, topical (e.g., nystatin, miconazole) or systemic (e.g., fluconazole)⁴⁴.

Effective management involves both antifungal therapy and modulation of local environmental factors that favor fungal growth. Topical antifungals such as nystatin and miconazole remain the first-line agents for localized infections, whereas systemic agents like fluconazole or echinocandins are indicated in refractory or disseminated cases. Given the rising antifungal resistance among **non-albicans *Candida* species**, susceptibility testing and identification at the species level are critical for treatment success. Adjunctive approaches, including probiotics, chlorhexidine rinses, and photobiomodulation therapy, have demonstrated potential in enhancing healing by reducing microbial load and modulating local immunity¹⁵.

Conclusion

Both *Candida albicans* and non-*albicans Candida* species can adversely affect oral wound healing following tooth extraction, albeit through distinct pathogenic mechanisms. *C. albicans* primarily induces acute inflammation and epithelial damage through hyphal invasion and enzymatic activity, whereas non-*albicans Candida* species promote chronic inflammation and persistence through biofilm formation and antifungal resistance.

Effective management of post-extraction wounds in the presence of *Candida* requires maintaining optimal oral hygiene, controlling predisposing factors, and, when necessary, using antifungal therapy, such as topical nystatin or systemic fluconazole. Additionally, promoting a balanced oral microbiome and supporting local immune responses are essential for favorable wound healing outcomes. Understanding these species-specific interactions is crucial for accurate diagnosis, targeted antifungal therapy, and optimization of post-extraction healing outcomes.

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AESTHETIC REHABILITATION USING NON-PREPARATORY FELDSPATHIC VENEERS AFTER ORTHODONTIC TREATMENT: A CASE REPORT

ЕСТЕТСКА РЕХАБИЛИТАЦИЈА СО ФЕЛДСПАТ ФАСЕТИ БЕЗ ПРЕПАРАЦИЈА НА ЗАБИ ПО ОРТОДОНТСКА ТЕРАПИЈА: ПРИКАЗ НА СЛУЧАЈ

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Abstract

Introduction: Feldspathic porcelain veneers have emerged as a premier aesthetic material for custom veneer restorations due to their superior translucency, natural optical properties, and ability to be fabricated in ultra-thin layers (≤ 0.3 mm). These characteristics allow a minimally invasive approach that preserves natural tooth structure while achieving highly aesthetic results. Advances in adhesive dentistry and ceramists' techniques have further improved the predictability and longevity of these restorations, making them a preferred choice for anterior aesthetic rehabilitation. **Case Report:** A 25-year-old female presented with microdontia and multiple diastemas in the intercanine regions of both the maxilla and mandible, resulting in unbalanced anterior tooth proportions and an aesthetic concern. Orthodontic treatment was performed over nine months, followed by a two-month retention period, to align teeth and optimize spacing. After orthodontic alignment, minimal enamel finishing was performed, and feldspathic veneers were fabricated and bonded using a standardized adhesive protocol. The final restorations successfully closed the diastemas, improved tooth proportions, and restored harmonious anterior aesthetics and occlusion. **Discussion:** Careful case selection is critical when deciding between non-prep and conventional veneers. In this case, orthodontic alignment created optimal conditions for non-prep feldspathic veneers, allowing minimal tooth reduction while achieving predictable bonding and functional stability. The success of feldspathic veneers relies on the combination of preserved enamel, precise adhesive technique, and the ceramist's skill in reproducing natural translucency and morphology. **Conclusion:** Feldspathic veneers can provide highly aesthetic, conservative, and predictable results when clinical conditions are appropriate. In selected cases, integration with orthodontic therapy enhances treatment outcomes, offering a reliable long-term solution for anterior aesthetic rehabilitation while preserving natural tooth structure. **Key words:** feldspathic veneers, orthodontic therapy, microdontia, diastemas.

Апстракт

Вовед: Фелдспат порцеланските фасети претставуваат врвен естетски материјал за индивидуализирани реставрации, благодарение на нивната супериорна прозирност, природни оптички својства и на можноста за изработка во ултратени слоеви ($\leq 0,3$ mm). Овие карактеристики овозможуваат минимално инвазивен пристап со максимално зачувување на природната структура на забот, при што се постигнуваат високоестетски резултати. Напредокот во адхезивната стоматологија и современите техники дополнително ја зголемија предвидливоста и долговечноста на овие реставрации, што ги позиционира како материјал од прв избор при естетска рехабилитација на предните заби. **Приказ на случај:** Пациентка на возраст од 25 години се јави со микродонција и дијастеми во интерканинската регија на горната и долната вилица, со нарушени пропорции на предните заби и изразено естетско незадоволство. Спроведена е ортодонтска терапија во времетраење од девет месеци, проследена со двомесечен период на ретенција, со цел задржување на правилната позиција на предните заби. По завршување на ортодонтската терапија, извршено е минимално зарамнување на глеѓта, а потоа беа изработени и адхезивно цементираните фелдспат фасети согласно со стандарден протокол за цементирање. Финалните реставрации овозможиле целосно затворање на дијастемите, постигнување на правилни пропорции и воспоставување хармонична естетика и оклузија на предниот сегмент. **Дискусија:** Прецизниот избор на клинички случај е суштински при одлучување меѓу фасети без препарација и без конвенционални фасети. Во прикажаниот случај, ортодонтската терапија создаде оптимални услови за изработка на фелдспатни фасети без препарација, целосно сочувување на тврдото забно ткиво, предвидлива адхезија и стабилна функција. Успехот на фелдспатните фасети зависи од комбинацијата на зачувана глеѓ, од прецизната адхезивна техника и од умешноста на забниот техничар да ја репродуцира природната транспарентност, текстура и морфологија на забот. **Заклучок:** Фелдспатните фасети претставуваат високоестетско, конзервативно и предвидливо решение, при соодветни клинички услови. Во селектирани случаи, комбинирањето со ортодонтска терапија може значително да го подобри естетскиот и функционалниот исход, овозможувајќи сигурна и долготрајна рехабилитација на предните заби со зачувување на природната забна структура. **Клучни зборови:** фелдспат, фелдспатни фасети, ортодонтска терапија, микродонција, дијастеми.

Introduction

Since their introduction in the early 1980s, porcelain laminate veneers have become one of the most reliable treatment modalities in restorative and aesthetic dentistry due to their ability to replicate a natural appearance, longevity, strength, and high success rates¹. Porcelain laminate veneers of minimal thickness provide satisfactory aesthetic results and biocompatibility². Initially regarded as thin coverings for anterior teeth to improve appearance, their indications have expanded significantly, encompassing a broader range of restorative challenges such as closing diastemas, correcting tooth shape, and enhancing smile aesthetics. These advances have been supported by improvements in adhesive dentistry, ceramic technology, and a better understanding of occlusal principles, allowing veneers to become a versatile and predictable treatment option.

Feldspathic porcelain veneers, produced through a meticulous layering and firing process of glass-based ceramics, offer exceptional optical properties, including translucency, fluorescence, and natural light transmission, closely mimicking the optical characteristics of enamel. The layering technique allows ceramists to create restorations with depth, lifelike color gradation, and fine internal characterization, resulting in highly natural outcomes. This material allows for the fabrication of thin veneers, often below 0.5 mm in thickness, on refractory dies, ensuring high translucency and exceptional aesthetic integration³. Modern fabrication techniques also permit ultrathin restorations, sometimes as thin as 0.3 mm, allowing the preservation of the underlying tooth structure while achieving excellent aesthetic integration. This combination of minimal invasiveness and superior aesthetics has contributed to a renewed interest in feldspathic veneers, particularly among patients seeking conservative, high-quality smile enhancement.

Despite these advantages, feldspathic porcelain remains a relatively fragile material compared to other ceramic systems, making case selection, enamel preservation, and precise adhesive protocols critical to success. Feldspathic porcelains are intrinsically fragile but may obtain additional strengthening when cemented to the dental structure using resin-based luting agents. Feldspathic porcelain veneers thinner than 1 mm can be adhesively bonded to tooth tissues and present high clinical survival, with the adhesive cementation playing an important role in the clinical performance of these restorations⁴. In addition, the skill and artistry of the dental ceramist play a pivotal role, as the aesthetic quality of the final restoration depends on the ability to reproduce natural translucency, depth, and surface texture. Interdisciplinary treatment planning, including orthodontics when necessary, can further

enhance outcomes by optimizing tooth position and spacing before restorative intervention.

In this report, we present the case of a young patient with small teeth and multiple anterior diastemas, managed through a combination of orthodontic treatment and feldspathic veneers. This approach allowed for conservative preparation, optimal aesthetic results, and functional harmony, illustrating the potential of minimally invasive, high-aesthetic restorative dentistry when guided by careful planning and collaboration between the clinician and the ceramist.

Case Report

A 25-year-old female presented to the clinic with a chief complaint of dissatisfaction with her smile, specifically citing the spacing between her anterior teeth in both the maxilla and mandible. On initial clinical examination, the most prominent finding was a pronounced midline diastema between the maxillary central incisors. Additional disproportionate spacing was observed among the remaining anterior teeth, resulting in unbalanced dental and smile aesthetics.

After a comprehensive evaluation and discussion of treatment options, an interdisciplinary approach was chosen. The primary treatment objective was to close the anterior diastemas and improve tooth proportions while preserving as much natural tooth structure as possible. Orthodontic alignment was considered a prerequisite to optimize spacing and reduce the need for aggressive tooth preparation (Figure 1).



Figure 1. Post-orthodontic treatment result

Orthodontic therapy was carried out using fixed appliances over a period of nine months. A retention period of two months followed, during which a removable retainer was worn to stabilize the achieved results. Once satisfactory alignment was confirmed, the patient transitioned to the prosthetic phase.

In preparation for veneers, only minimal enamel modification was performed. Sharp incisal edges and irregular

surfaces were lightly smoothed using fine-grit red diamond burs (cylindrical shape, size 014, Acurata) and polishing discs. The objective was to maximize enamel preservation to ensure optimal bonding conditions, particularly at the margins. An analog impression was made using A- silicones (medium and light body- Kulzer). An interim removable orthodontic retainer was provided during the laboratory phase to maintain tooth position until definitive restoration.

The veneers were fabricated from feldspathic porcelain using the conventional layering technique, selected

for its superior aesthetic properties and ability to replicate the translucency of natural enamel (Figure 2 a, b).

Prior to cementation, both the teeth and the restorations underwent standardized adhesive protocols. The enamel surfaces were cleaned and etched with 37% orthophosphoric acid, followed by application of a universal bonding agent (3M Single Bond Universal). The internal surfaces of the veneers were cleaned with alcohol and chlorhexidine, etched with 10% hydrofluoric acid for 60 seconds, rinsed thoroughly, and treated with a silane coupling agent for 20 seconds (Figure 3). A thin layer of adhesive was then applied to the internal surfaces to enhance micromechanical and chemical bonding.

For cementation, VariolinkAesthetic Light (Ivoclar Vivadent), a light-cured resin cement specifically developed for thin, highly aesthetic veneers, was selected. Each veneer was carefully positioned, and adjacent teeth were isolated with Teflon tape to prevent accidental bonding. An initial light cure of 3 seconds was performed to achieve a gel state, enabling easy removal of excess resin. Final polymerization was then completed with 20 seconds of light exposure per surface, ensuring thorough curing. Residual cement was meticulously removed, and margins were polished to achieve a seamless integration with the natural dentition.

Following cementation, the patient was provided with both fixed and removable retainers to maintain orthodontic and prosthetic stability. The final outcome achieved closure of the diastemas, enhanced proportionality of the anterior teeth, and established a harmonious smile line.

At the two-week follow-up, the patient reported high satisfaction with both aesthetic and functional outcomes,



Figure 2. Try-in of the final feldspathic porcelain veneers: (a) on the maxillary teeth; (b) on the mandibular teeth.

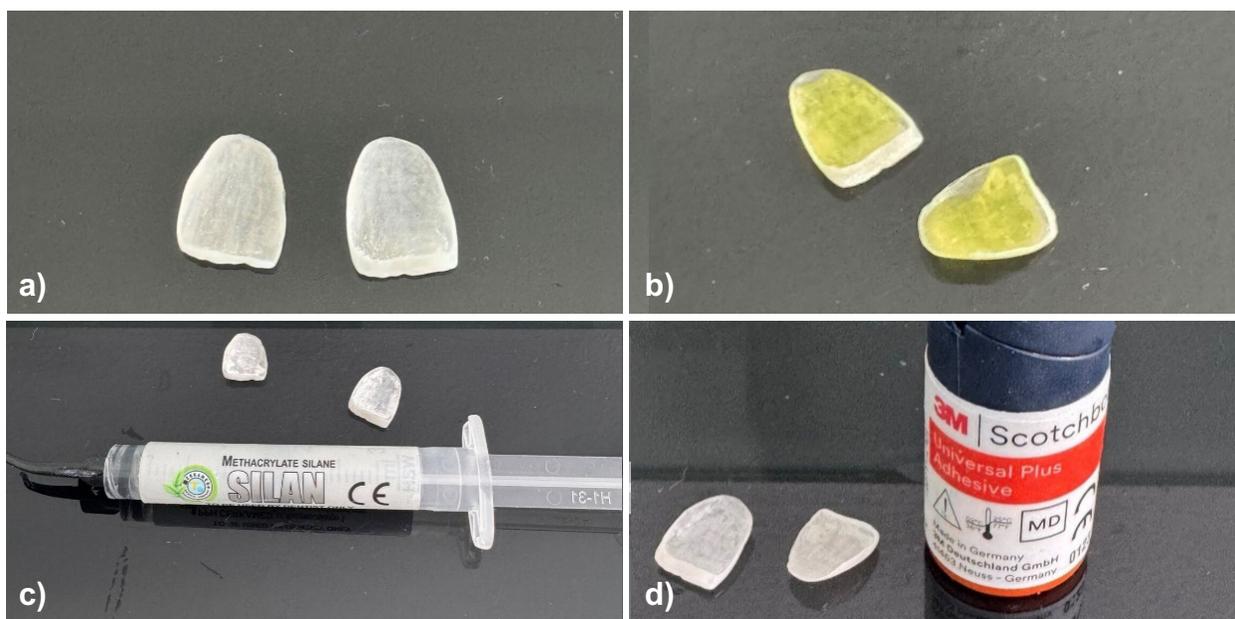


Figure 3. Preparation for cementation: (a) internal surface; (b) etching; (c) adding silane; (d) bonding agent

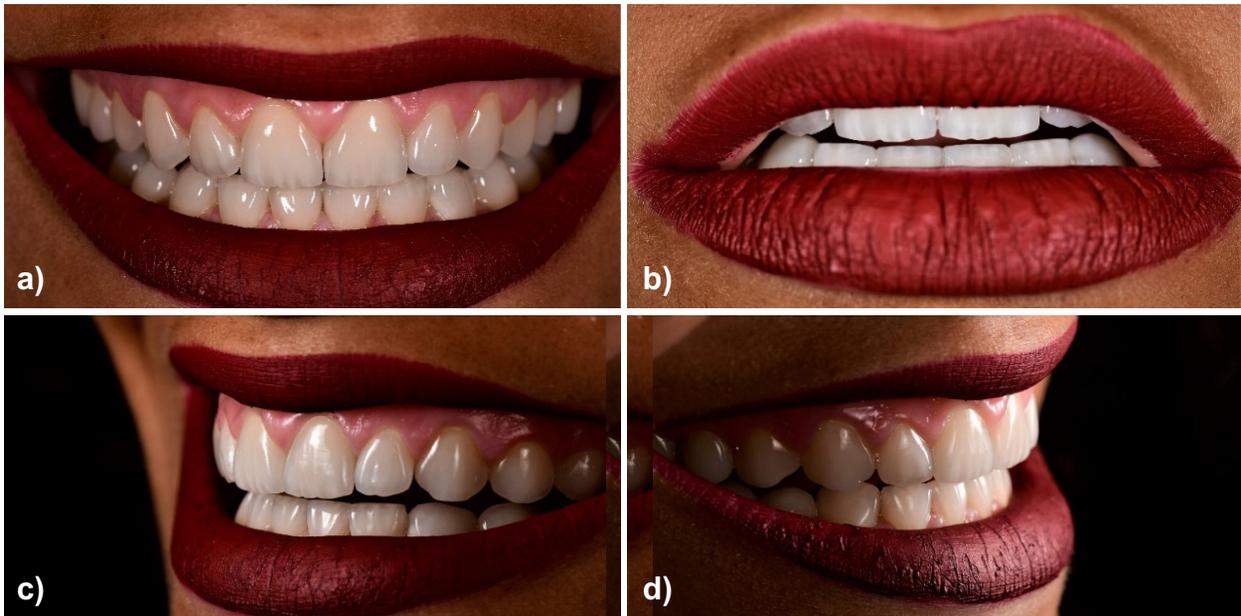


Figure 4. Final aesthetic outcome following orthodontic treatment and feldspathic porcelain veneers: (a) frontal view with full smile; (b) frontal view with lips slightly parted; (c) left lateral view; (d) right lateral view.

noting a significant improvement in self-confidence when smiling and speaking. The restorations blended seamlessly with the natural dentition, demonstrating excellent color match and surface gloss. At subsequent recalls, the veneers remained intact, with no evidence of marginal discoloration, debonding, or gingival irritation.

This case demonstrates the effectiveness of a multidisciplinary approach in managing anterior spacing, where orthodontic treatment followed by feldspathic porcelain veneers allowed for minimally invasive, highly aesthetic, and durable results (Figure 4).

Discussion

Feldspathic porcelain materials remain among the most aesthetic and widely used dental ceramics⁵. Their composition and microstructure account for their unique optical properties and clinical behavior. Feldspathic porcelain is produced by layering glass-based (silicon dioxide) powder and liquid materials. Silicon dioxide, also referred to as silica or quartz, often contains varying of alumina. In nature, these aluminum silicates may also incorporate potassium and sodium, forming feldspars. The dental porcelains derived from feldspars typically contain 60–64% silicon oxide and 20–23%⁶ aluminum oxide, which are modified to create glass matrices suitable for dental restorations. Within this glassy matrix, fluorapatite crystals are dispersed, contributing to the material's translucency, fluorescence, and overall ability to mimic natural enamel. The layering and firing process allows ceramists to develop veneers with

exceptional optical integration, making feldspathic porcelain the benchmark for highly aesthetic restorations.

Over the last four decades, feldspathic veneers have undergone a considerable evolution. Initially regarded as thin shells to improve anterior aesthetics, they are now applied in more complex rehabilitations, provided that careful case selection and preparation principles are respected. Modern adhesive dentistry has renewed interest in feldspathic veneers, particularly with the growing demand for minimally invasive procedures. Patients increasingly request treatments that combine natural aesthetics with maximal preservation of tooth structure, driving a resurgence in the use of ultra-thin feldspathic veneers, sometimes as thin as 0.3 mm. Advances in adhesive systems and luting cements have enhanced the bonding predictability, allowing long-term stability even in veneers fabricated at minimal thicknesses.

Despite these advantages, feldspathic porcelain is considered the most delicate ceramic material, particularly in terms of flexural strength and fracture resistance. This fragility underscores the importance of strict adherence to evidence-based protocols for preparation, bonding, and occlusal management. The amount of preserved enamel layer plays a paramount role in the survival and success rates of veneers, and glass-ceramic veneers with minimal or no preparation have been shown to exhibit the highest survival rates⁷. The literature emphasizes that at least 50% of the bonding surface should consist of enamel, and ideally 70% of the veneer margin should terminate in enamel. Bonding to enamel ensures a stronger and more durable

adhesive interface compared to dentin, reducing the risk of debonding or fracture. Preserving critical anatomical structures, such as the cingulum and lingual marginal ridges, is equally essential, as these provide more than 80% of the natural tooth's strength.

Space requirements also represent a significant consideration in treatment planning. When creating a feldspathic porcelain veneer, it is necessary to realize that the space required for shade change ranges from 0.2 mm to 0.3 mm per shade⁸. Insufficient space compromises aesthetics by limiting the ceramist's ability to build depth and translucency into the restoration, while over-reduction undermines the conservative philosophy that makes veneers so desirable. In the present case, the combination of orthodontic alignment and conservative veneer placement create adequate space and optimal tooth positioning to achieve the desired aesthetic result without aggressive tooth preparation.

Mechanical risk assessment is another critical factor. Flexural risk increases significantly when bonding to dentin, as dentin is more flexible than enamel. Teeth with pre-existing craze lines, deep overbites, or heavy occlusal loads are particularly susceptible to flexure, which may compromise the integrity of feldspathic porcelain. Similarly, restorations placed in distal regions are exposed to higher tensile and shear stresses due to functional loading, making feldspathic porcelain a less favorable option for molars. Bruxism and other parafunctional habits further elevate the risk of fracture or debonding, and in such cases, pressed or CAD/CAM-milled glass ceramics with higher strength may represent more appropriate alternatives. Magne et al. reported that the success rate of veneers is reduced to approximately 60% in patients with bruxism activity⁹.

Another aspect that influences success is the artistry of the dental ceramist. Feldspathic veneers are traditionally built up using the powder/liquid layering technique, which requires high levels of manual skill and experience. Unfortunately, many modern training programs place less emphasis on this craft, leading to a decline in the number of ceramists proficient in fabricating thin, lifelike feldspathic veneers. The aesthetic excellence of feldspathic restorations depends heavily on the ceramist's ability to create depth of color, internal effects, and translucency. This artistic contribution is as critical as the clinical steps performed by the dentist.

In addition to aesthetics, bonding protocols remain central to clinical longevity. Every stage, from isolation to adhesive selection and light curing, plays a role in ensuring long-term adhesion and marginal integrity. Failures in bonding or seal integrity can quickly lead to restoration loss, marginal discoloration, or secondary caries. For this reason, strict adherence to adhesive protocols-including

appropriate acid etching, silanization, use of compatible bonding agents, and careful light-curing sequences-is non-negotiable.

The present case illustrates many of these principles. Orthodontic treatment was first undertaken to optimize spacing and alignment, reducing the need for invasive preparation. Feldspathic veneers were then chosen to close the diastemas, improve tooth proportions, and enhance overall aesthetics. Minimal finishing was performed to preserve enamel, creating an ideal substrate for bonding. The cementation was carried out using a meticulous adhesive protocol, ensuring predictable adhesion and long-term stability. The outcome not only achieved harmonious aesthetics and function but also fulfilled the patient's desire for a minimally invasive solution.

In summary, feldspathic veneers represent the pinnacle of aesthetic restorative dentistry when used under the right clinical conditions. Their advantages, superior translucency, lifelike optical properties, and conservative preparation, make them ideal for anterior aesthetic rehabilitations, particularly in young patients with high aesthetic expectations. However, their inherent fragility requires thorough biomechanical assessment, careful patient selection, and precise bonding protocols. Furthermore, the collaboration between dentist and ceramist remains essential in achieving optimal outcomes. In cases like the one presented, where orthodontics, conservative preparation, and adhesive techniques are integrated, feldspathic veneers can provide long-term functional and aesthetic success.

Conclusion

No-prep and minimally invasive feldspathic veneers offer highly aesthetic, conservative solutions for anterior restorations, but require careful case selection, precise adhesive protocols, and close collaboration between clinician and ceramist. When adequate enamel remains and functional stress is low, these veneers provide excellent translucency and predictable outcomes. In this case, orthodontic alignment combined with feldspathic veneers successfully closed diastemas, improved tooth proportions, and restored functional harmony, achieving high patient satisfaction. The long-term success of these restorations depends not only on their aesthetic quality but also on the durability of the adhesive bond, which preserves function and reinforces patient confidence.

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APPLICATION OF AUTOLOGOUS PLATELET-RICH FIBRIN (PRF) TO ENHANCE HEMOSTASIS, COAGULUM STABILITY, AND WOUND HEALING AFTER EXTRACTION OF TEETH 11–12–13 IN A PATIENT UNDER ANTIPLATELET THERAPY

ПРИМЕНА НА АВТОЛОГЕН ТРОМБОЦИТИТНО ЗБОГАТЕН ФИБРИН (ПРФ) ЗА ПОДОБРУВАЊЕ НА ХЕМОСТАЗАТА, СТАБИЛНОСТА НА КОАГУЛУМОТ И ЗАЗДРАВУВАЊЕТО НА РАНАТА ПО ЕКСТРАКЦИЈА КАЈ ПАЦИЕНТИ НА АНТИТРОМБОЦИТНА ТЕРАПИЈА

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Abstract

Introduction: Patients undergoing antiplatelet therapy are at increased risk of prolonged bleeding, impaired clot formation, and delayed wound healing following dental extractions. Traditional local hemostatic strategies may be insufficient, especially in elderly patients with comorbidities or during extractions involving multiple adjacent teeth. Platelet-Rich Fibrin (PRF), a second-generation autologous platelet concentrate, has demonstrated clinically significant benefits in enhancing hemostasis, stabilizing the initial clot, and accelerating soft tissue regeneration. **Case report:** In this paper, we present a case of minimally traumatic extraction of teeth 11, 12, and 13 in a 74-year-old patient on ongoing aspirin therapy, followed by the immediate placement of autologous PRF membranes into the extraction sockets. Prompt hemostasis, stable clot formation, and excellent postoperative healing were observed. This case illustrates the clinical value of PRF as an adjunctive biomaterial in oral surgery for patients with impaired hemostatic capacity. **Conclusion:** The use of PRF proved to be effective in achieving local hemostasis, improving clot stability, enhancing soft tissue healing, and reducing postoperative pain and complications. As an autologous biomaterial, PRF carries no risk of allergic reactions and represents a safe and biologically favorable adjunct in oral surgical procedures for medically compromised patients. PRF should be considered a valuable hemostatic and regenerative biomaterial in the surgical management of patients maintained on antiplatelet therapy. **Keywords:** platelet-rich fibrin, antiplatelet therapy, aspirin, dental extraction, hemostasis, wound healing.

Апстракт

Вовед: Пациентите кои се на антитромбоцитна терапија се изложени на зголемен ризик од продолжено крвавење, попречена коагулација и одложено заздравување на раните по екстракцијана заби. Традиционалните локални хемостатски стратегии може да бидат недоволни, особено кај постари пациенти со коморбидитети или екстракцијана повеќе соседни заби. Фибрирот богат со тромбоцити (PRF) кој претставува автологен концентрат на тромбоцити од втората генерација, покажува значајни придобивки во подобрување на хемостаза, стабилизирање на иницијалната фаза на коагулација и забрзување на регенеративното дејство кај меките ткива. **Приказ на случај:** Во овој труд презентираме случај на атрауматска екстракција на забите 11, 12 и 13 кај 74-годишен пациент на континуирана терапија со аспирин, проследено со итно поставување на автологни PRF мембрани во постекстракционите алвеоли. Забележана е брза хемостаза, стабилно формирање на крвен коагулум и одлично постоперативно заздравување. Овој случај ја илустрира клиничката вредност на PRF како дополнителен автологен биоматеријал во оралната хирургија кај пациенти со нарушена хемостаза. **Заклучок:** Употребата на PRF се покажа како ефикасна метода во постигнување локална хемостаза, подобрување на стабилноста на крвниот коагулум, забрзување на регенеративниот процес кај меките ткива и

намалување како на постоперативната болка така и на постоперативните компликации. Како автологен биоматеријал, PRF не носи ризик од алергиска реакција и претставува безбеден и биолошки поволен додаток во оралнохируршките процедури за медицински компромитирани пациенти. PRF треба да се смета за вреден хемостатски и регенеративен биоматеријал во хируршкиот третман на пациенти кои користат антиромбоцитна терапија. **Клучни зборови:** фибрин богат со тромбоцити, антиромбоцитна терапија, аспирин, екстракција на заб, хемостаза, заздравување на рани.

Introduction

Antiplatelet therapy is widely used for the prevention of thromboembolic events, particularly in elderly patients with coronary artery disease, coronary stents, or a history of myocardial infarction or ischemic stroke^{1,2}. Aspirin, the most commonly prescribed antiplatelet agent, irreversibly inhibits cyclooxygenase-1(COX-1), suppressing thromboxane A₂ production and platelet aggregation³. While cardioprotective, this pharmacologic effect increases the risk of perioperative bleeding during dental procedures, particularly during tooth extractions.

Multiple studies have reported that patients on aspirin, clopidogrel, ticagrelor, or dual antiplatelet therapy exhibit prolonged bleeding times, reduced early clot stability, and delayed epithelialization following oral surgery⁴⁻⁶. Despite these risks, current clinical guidelines strongly advise against the discontinuation of antiplatelet therapy for routine dental extractions, as its interruption can precipitate major cardiovascular complications, including myocardial infarction or stent thrombosis^{3,7,8}. Postoperative bleeding is typically mild, controllable with local hemostatic measures, and rarely requires systemic intervention^{5,6,9}.

To address these challenges, autologous platelet-derived biomaterials have gained attention for their hemostatic and regenerative potential. Platelet-Rich Fibrin (PRF), introduced by Choukroun et al., is prepared without anticoagulants, forming a dense fibrin scaffold containing platelets, leukocytes, cytokines, and growth factors such as PDGF, TGF- β 1, and VEGF¹⁰. PRF accelerates angiogenesis, enhances soft tissue regeneration, stabilizes the coagulum, and reduces postoperative inflammation—clinically relevant advantages in patients with compromised hemostasis^{11,12}.

Recent randomized clinical trials and systematic reviews have demonstrated that PRF improves hemostasis, reduces postoperative bleeding, accelerates epithelialization, and decreases postoperative complication rates such as alveolar osteitis, in patients on antiplatelet or anticoagulant therapy¹³⁻¹⁵. Given the increased bleeding tendency in elderly patients taking aspirin, especially in highly vascularized anatomical regions such as the anterior maxilla, PRF represents a safe, autologous, and effective approach to support hemostasis and tissue regeneration.

Case presentation

The patient, a 74-year-old female taking long-term antiplatelet therapy with acetylsalicylic acid (aspirin, 100

mg/day) for cardiovascular prophylaxis, presented to the dental clinic with complaints of pain, discomfort, and increased mobility of the maxillary anterior teeth 11, 12, and 13. Clinical examination revealed advanced periodontal destruction, chronic periapical inflammation, and severe loss of alveolar bone support affecting all three teeth. To accurately assess the extent of bone resorption and root condition, both panoramic radiography (orthopantomography) was performed, confirming extensive vertical and horizontal bone loss that rendered the teeth non-restorable and indicated the need for extraction (Figure 1, 2).



Figure 1. Pre-operative panoramic radiograph presentation prior to PRF application



Figure 2. Intraoral clinical

Considering the patient's age, systemic status, and continuous aspirin therapy, the treatment plan followed current evidence-based clinical recommendations, which advise against discontinuation of single-antiplatelet therapy prior to routine dental extractions due to increased thromboem-



Figure 3. Immediate post-extraction socket



Figure 4. Blood taken for PRF preparation



Figure 5. Autologous PRF membrane prepared for application

bolic risk. The patient was informed of the procedure, the possible bleeding risks, and the proposed measures for local hemostasis. Informed consent was obtained.

Atraumatic extraction of teeth 11, 12, and 13 was performed under local anesthesia, with careful preservation of the surrounding socket walls (Figure 3.). Immediately after extraction, platelet-rich fibrin (PRF), prepared from the patient's venous blood, was placed into all three extraction sites. PRF was selected to enhance clot stability, reduce postoperative bleeding, and promote softtissue and bone

healing, serving as a bioactive scaffold rich in growth factors (Figure 4, 5.). The membranes were adapted into the sockets and stabilized with gentle pressure to ensure optimal tissue adaptation (Figure 6, 7.).

Appearance before PRF placement



Figure 6.



Figure 7.

Figure 6, 7. Intraoperative placement of autologous PRF into the extraction socket



Figure 8. Clinical appearance on follow-up demonstrating early soft-tissue healing after PRF application

No immediate postoperative bleeding or complications were observed. Hemostasis was achieved through local measures without the need to alter aspirin therapy. The patient received postoperative instructions including avoidance of vigorous rinsing, monitoring of bleeding, and the use of analgesics compatible with antiplatelet therapy. At the 48-hour follow-up, the surgical sites showed satisfactory initial healing with no signs of infection or secondary hemorrhage. After one week, significant softtissue epithelialization and stabilization were evident (Figure 8.).

One month after the procedure, complete softtissue regeneration was observed, with stable and healthy mucosa covering all extraction sites and no late complications. The outcome demonstrated that the use of PRF in patients maintained on aspirin therapy provides effective local hemostasis and accelerates tissue repair, making dental extractions safe without interruption of antiplatelet medication.

Discussion

Dental extractions in patients under antiplatelet therapy are challenging due to impaired platelet function and prolonged hemorrhage risk. Stopping aspirin is generally contraindicated, as thromboembolic events carry a higher morbidity and mortality risk than minor postoperative hemorrhage^{3,7}.

PRF enhances outcomes via several mechanisms. First, its dense fibrin matrix acts as a mechanical hemostatic plug and scaffold for platelet aggregation, stabilizing the initial clot in patients with reduced platelet function. Second, PRF provides sustained growth factor release, including PDGF, TGF- β 1, and VEGF, which stimulate angiogenesis, fibroblast proliferation, collagen formation, and epithelial migration. Third, PRF reduces postoperative complications such as alveolar osteitis, infection, and delayed wound closure, while also minimizing pain and inflammation^{11,12}.

Several studies (2020–2025) have confirmed these findings: Varghese et al. demonstrated that PRF is superior to chitosan dressings in antiplatelet patients, achieving better hemostasis and faster epithelialization¹⁰. Andrade et al., in a systematic review, reported that PRF consistently reduces postoperative bleeding and promotes soft-tissue healing in patients on anticoagulant or antiplatelet therapy¹¹. Rahman et al., in a meta-analysis of split-mouth randomized clinical trials, highlighted the efficacy of PRF in accelerating wound healing and reducing complications after dental extractions¹². Compared with other local hemostatic agents, such as gelatin sponges or tranexamic acid, PRF provides both hemostatic and regenerative benefits, making it ideal for systemically compromised patients^{13–15}.

The presented case aligns with these findings. PRF allowed atraumatic extractions of three adjacent anterior teeth in a high-risk patient without discontinuation of aspirin, achieving rapid hemostasis, stable coagulum formation, and excellent soft tissue healing.

Conclusion

In this case, PRF demonstrated clinical efficiency as an adjunct in dental extractions for a patient on continuous aspirin therapy. It provided prompt and reliable hemostasis, stabilized the primary clot, accelerated soft tissue healing, and minimized postoperative complications, all without interrupting antiplatelet medication. PRF should be considered as a valuable adjunctive measure in similar clinical cases where patients present with impaired hemostasis.

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“ALL-ON-6”, “ALL-ON-4” CONCEPT IN IMPLANT-PROSTHETIC REHABILITATION: CLINICAL CASE REPORT

КОНЦЕПТОТ „ALL-ON-6“ И „ALL-ON-4“ ВО ПРОТЕТСКАТА РЕХАБИЛИТАЦИЈА СО ИМПЛАНТИ: ПРИКАЗ НА КЛИНИЧКИ СЛУЧАЈ

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Abstract

Introduction: Restoration of total edentulism in jawbones with dental implants has emerged as an advanced therapeutic solution, utilizing strategically positioned dental implants to support fixed prosthetic restoration, which closely replicates the appearance and function of natural teeth. **Aim:** The aim of the paper is to assess the clinical and radiological outcomes of the “All-on-6” and “All-on-4” concepts using three-dimensional digital planning and treatment with dental implants, emphasizing the high success rate, patient satisfaction and the functional and esthetic benefits of restoring oral function and aesthetics by using advanced technologies. **Material and methods:** This clinical case report presents the comprehensive treatment of a 60-year-old male patient with complete edentulism, with six dental implants in the maxilla and four in the mandible (Neodent Helix GM). After a six-months healing period, precise prosthetic procedures were performed, including an intraoral digital scan (Aoralscan Elite Shinning 3D) using photogrammetric technology at the multi-unit abutment level, ensuring optimal accuracy, functionality, and esthetic outcomes. **Conclusion:** The definitive prosthetic restorations resulted in significant improvements in the patient’s masticatory efficiency, speech, and overall oral health-related quality of life. This case study highlights the transformative potential of the full-arch implant rehabilitation, beginning with the 3D analysis (CBCT) analysis, meticulous planning, and implant-supported prosthetic therapy in both jaws. **Key words:** implant-prosthetic rehabilitation, “All-on-6” concept, “All-on-4” concept, 3D CBCT imaging, oral health-related quality of life.

Апстракт

Вовед: Реставрацијата со употреба на импланти при појавата наречена еден тулизам (без забост) се појавила како напредно решение, користејќи стратешки поставени денални импланти за поддршка на фиксната протетска реставрација, кои го реплицираат изгледот и функцијата на природните заби. **Цел:** Целта на трудот е да се оценат клиничкиот и ренгенолошки исход од два концепти познати како “All-on-6” и “All-on-4” користејќи тродимензионално планирање и третман со помош на денални импланти, при тоа истакнувајќи ја високата стапка на успех, задоволството на пациентите и повеќекратните придобивки од враќањето на оралната функција и естетика со употреба на напредни технологии. **Материјал и метод:** Овој клинички случај го опишува сеопфатното лекување на 60 годишен машки пациент, со целосен едентулизам, со употреба на шест денални импланти во горната и четитири во долната вилица (Neodent Helix GM). По шест месеци период на заздравување беа извршени прецизни протетски процедури, вклучувајќи скенирање со интраорален скенер (Aoralscan Elite Shinning 3D) со употреба на фотограметријата на ниво на абатменти (multi-unit), со цел да се обезбеди максимална точност, функционалност и естетика. **Заклучок:** Дефинитивните протетски реставрации резултираа во значителни подобрувања во ефикасноста на мастикацијата, говорот и целокупниот квалитет на живот поврзан со оралното здравје. Овој приказ на случај го истакнува трансформативниот потенцијал на целокупниот рехабилитациски процес, од 3D анализа (CBCT), планирање и терапија со денални импланти и протетски реставрации на двете вилици. **Клучни зборови:** импланто-протетска рехабилитација, “All-on-6” концепт, “All-on-4” концепт, 3D, CBCT, квалитет на живот поврзан со оралното здравје.

Introduction

The loss of natural teeth, known as edentulism, is a significant clinical condition that affects the functional and

aesthetic aspects of patients' lives. Edentulism not only affects the ability to chew and speak, but also negatively impacts the overall quality of life, leading to psychological, emotional, and social consequences. Traditional solutions

such as conventional complete dentures often do not meet the requirements for adequate stability and functional performance needed for optimal oral health¹. Full-mouth implant-supported rehabilitation represents a revolutionary approach to addressing this clinical limitation, involving the strategic placement of dental implants for a complete fixed reconstruction, offering a stable, long-term solution that closely resembles natural teeth, in both function and appearance. It also contributes to the restoration of masticatory efficiency and speech function, while enhancing patient self-confidence and overall well-being².

The original Branemark surgical-prosthetic protocol was based on the placement of four implants in the mandible and six implants in the maxilla in cases with minimal to moderate alveolar bone resorption³.

In 2003, the concept of full-arch prosthetic rehabilitation was introduced, based on the use of only four implants, with two implants placed axially in the anterior region of the jaws and two implants placed in the posteriorly part of the jaws, placed obliquely at an angulation⁴. The stability of the fixed prosthetic construction is further enhanced by placement of longer implants⁵. This concept avoids augmentative bone procedures, reduces surgical intervention time, and lowers the overall treatment cost⁶. In addition, a 10-year follow-up study demonstrated high success rates of fixed prosthetic restorations, reaching 99.2% of the patients⁷.

The “All-on-4” concept has been extensively investigated by numerous authors, and has been further refined to maximize the utilization of available jaw bone while reducing surgical and prosthetic complications, particularly avoiding augmentative procedures that increase treatment cost and patient morbidity^{8,9}.

Aim

The aim is to present a clinical case with “All-on-6” and “All-on-4” concept in implant-prosthetic rehabilitation with accent on three-dimensional planning and teamwork.

Material and method

The patient in this case study was 60-year-old male with complete edentulism in both jaws, and a documented history of advanced periodontitis, which results in tooth loss one year prior to presentation. The patient’s primary complaints included intolerance to previously made complete acrylic dentures, dissatisfied with his facial appearance, and impaired masticatory function. Consequently, the patient required a fixed implant-supported prosthetic solution to improve both his aesthetic outcomes and oral function.

The general medical history, arterial hypertension was noted and regulated with Covarit HCT tablets (Aplodopine/

Valsartane/Hydrochlorothiazide 5mg/160mg/12.5mg) administered once daily. The patient’s systemic condition was monitored by a specialist in internal medicine. The patient denied other systemic illnesses, was a non-smoker, and demonstrated good oral hygiene.

The preoperative orthopantomography provided a two-dimensional radiographic assessment of the jawbone structures, shown in Figure 1.

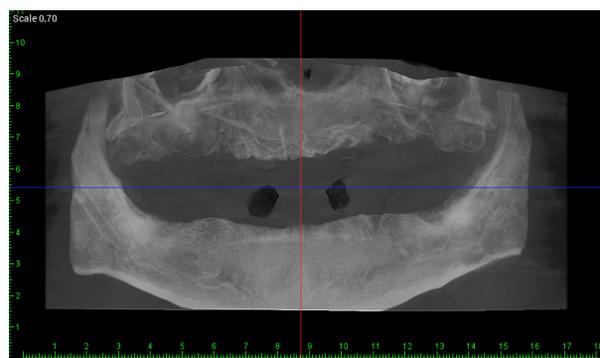


Figure 1. Orthopantomography image

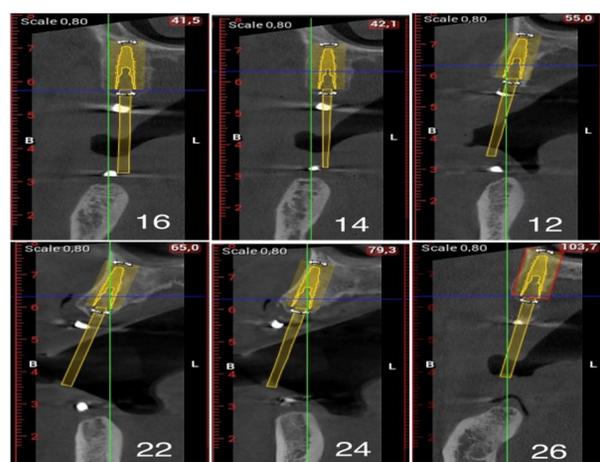


Figure 2. CBCT analyses in the maxilla

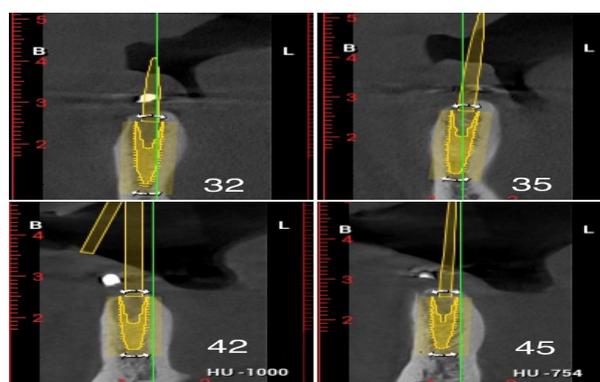


Figure 3. CBCT analyses in the mandible

Patient examination revealed a decrease in the vertical dimension of occlusion and loss of adequate lip support. Clinically, both the mandible and maxilla exhibited horizontal alveolar bone resorption accompanied by a partial reduction in vertical dimension. Analyses for precise treatment planning were performed by a CBCT scan, which confirmed the anticipated alveolar ridge bone resorption one year following tooth loss (Figures 2 and 3).

The DVT (Digital Volume Tomography) analysis was done with the existing dentures worn by the patient, and each tooth was marked with a gutta-percha markers to indicate the exact position and axial orientation (Figure 4).

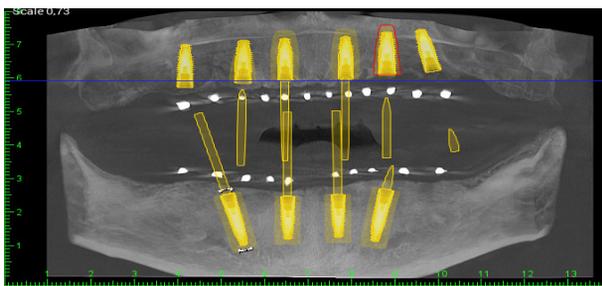


Figure 4. Digital Volume Tomography

The position of six implants in the maxilla and four implants in the mandible was planned based on radiological findings. In the posterior mandible, there was insufficient horizontal bone width for endosseous implant placement without augmentation; therefore, it was decided to use the “All-on-4” concept.

One hour prior to surgery, the patient received antibiotic prophylaxis of amoxicillin-clavulanic acid (Alkaloid Ad Skopje) and postoperative antibiotic therapy for another six days. The surgical procedure was performed under local anesthesia using articaine with epinephrine 1:100,000 (Artinibsa 4%).

For prosthetically guided implant positioning, the patient's existing acrylic dentures were utilized as a surgical reference, with pre-drilled openings corresponding to the planned implant sites.

With a classical surgical procedure, the incision was made along the crestal part of the ridge, and a full-thickness



Figure 5. Postoperative orthopantomogram

mucoperiosteal flap was elevated. A total of 10 endosseous implants (Neodent Helix GM) were placed—6 in the maxilla and 4 in the mandible (Figure 5).

The maxillary implants had the following dimensions:

- #12: 3.75x13mm;
- #14: 4.0x13mm;
- #16: 4.0x13;
- #22: 3.75x13mm;
- #24: 3.75x13mm;
- #26: 3.5x13mm.

The implants in the mandible were as follows:

- #32: 3.5x13mm;
- #35: 3.75x16mm;
- #42: 3.75 x13mm;
- #45: 4.0x16mm.

All implants were inserted with a torque value from 40 to 60 N/cm achieving adequate primary stability.

Multi-unit abutments were placed to correct implant angulation and provide optimal support for prosthetic support (Figure 6.). Straight abutments were replaced with a torque value of 32N/cm and the angulated one tightened to 25N/cm, as specified in the manufacturer's protocol.



Figure 6. Abutments installed on the inserted implants

Six months after implantation, following successful osseointegration, the prosthetic phase of the rehabilitation was initiated. The digital impression was taken using Aoralcan Elite Shinning 3D intraoral scanner photogrammetry. Diagnostic models of temporary restoration served as a reference for the occlusal relationships and aesthetic parameters achieved.

The metal framework was designed using Exocad software and was milled from a cobalt-chromic disc. It was clinically examined for its passive pressure on the abutments, through X-ray verification. Subsequently this framework was shaped with highly aesthetic ceramic materials. The definitive prosthetic restoration was screw-retained, allowing for simplified maintenance. (Figures 7 and 8)



Figure 7. Final prosthetic fixed workmanship

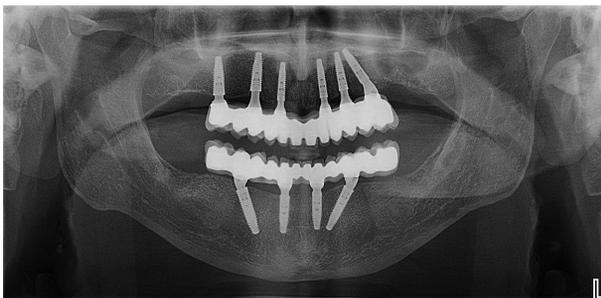


Figure 8. Orthopantomogram one year after intervention

Discussion

The rehabilitation of partial or total toothlessness in the jaw bones with dental implants is an established and widely accepted procedure in modern dentistry, offering a comprehensive therapeutic solution for individuals who have lost their natural teeth for various reasons. The technique involves surgical placement of dental implants in the bones of the jaws that act as anchors for temporary and permanent prosthetic restorations, as the implants mimic the function of the roots of natural teeth, providing a stable foundation that supports prosthetics with long-term durability and reliability¹⁰.

The benefits of implant-supported dental rehabilitation systems are well documented in the literature. Functionally, such rehabilitations restore the ability to chew and articulate, offering significantly improved masticatory performance compared to conventional removable dentures. The stability provided by the implants helps to evenly distribute occlusal forces throughout the jawbone, which not only improves chewing efficiency but reduces the risk of progressive bone resorption and subsequent facial collapse over time¹¹.

The aesthetic aspects are just as important, because the prosthetic is designed to fit and complement the patient's individual anatomical and facial characteristics. A natural smile not only increases self-esteem, it fully restores

patient's confidence, but also improves the aesthetics of the face by maintaining adequate lip support and face contour¹².

This procedure requires a sufficient volume of healthy alveolar bone to support the implants. Patients with insufficient bone volume and density require additional procedures such as bone augmentation, sinus floor elevation, and an appropriate drilling protocol for implant placement in lower density bone, in order to create an adequate osseous foundation for implant placement¹³. In addition, the treatment process itself requires precise planning and an appropriately trained multidisciplinary team consisting of implantologist, oral surgeon, prosthodontist, and dental technician.

Although the costs associated with the rehabilitation of both jaws with the help of implants are higher compared to traditional dentures, many patients consider it a worthwhile long-term investment in their oral health and quality of life. Implants are known for their exceptional durability and longevity, often lasting a lifetime with proper care and maintenance. This durability, along with the restoration of physiological chewing function and natural aesthetics, significantly improves the oral quality of life and patient satisfaction of individuals seeking a permanent solution for their tooth loss¹⁴.

The "All-on-4" therapy presents a significant advancement in dentistry, especially for patients with complete edentulism and limited bone volume. It offers several advantages including reduced treatment costs, shorter intervention times, improved treatment efficiency, and reduced patient morbidity¹⁵. This technique uses four implants to support fixed prosthetics, making it a sustainable option in restoring toothless jaws. While the All-on-4 technique has a high implant success rate of up to 99%, prosthesis survival is somewhat lower due to problems such as porcelain crown failure, prosthesis fracture, screw loosening, and distal cantilevers¹⁶. To overcome these shortcomings, the "All-on-6" technique was developed, which provides enhanced prosthetic support and more favorable stress distribution over a larger surface area¹⁷.

The "All-on-6" approach is designed to maximize the utilization of available alveolar bone to accelerate functional recovery and eliminate the need for additional augmentation procedures, which would increase the overall treatment cost¹⁸. By avoiding cantilevers, the "All-on-6" concept reduces the risk of biomechanical complications, such as prosthetic screw loosening and implant overloading.

Considering the case described here and the patient's clinical condition of severe maxillary atrophy, a combination of six implants in the upper jaw and four in the lower jaw was considered the most appropriate therapeutic approach. By placing more implants in the maxilla, the expected survival rate of maxillary prosthetic rehabilitation

is anticipated to be very high similar to that of mandibular prosthetic rehabilitation. The maxilla generally withstands lower occlusal forces than the mandible due to the relatively thin cortical bone layer and low bone density of the cancellous bone¹⁹. Thus, when the “All-on-4” concept is applied in both jaws, the failure rate is usually significantly higher for maxillary implants compared to mandibular implants²⁰. The number of implants recommended in the maxilla for a fixed prosthetic restoration is a minimum of six implants²¹.

The length of all implants exceeds 10 mm, a well-documented dimension associated with a high implant survival rate, and it corresponds to the existing bone quality, especially in the maxilla²². In addition, according to two studies, the proximity of critical anatomical structures, in cases with moderate to severe jawbone resorption, was the primary factor affecting the implant length²³. Therefore, the implant lengths in this case are 13 mm and 16 mm, respectively, according to DVT (Digital Volume Tomography) analysis, performed using advanced 3D virtual planning software. By using DVT, it is possible to assess not only bone density, but also the anticipated bone-to-implant contact, distinguishing between areas of different bone quality and thickness. This makes it possible to predict the primary implant stability prior to the surgical procedure.

Regarding distally placed implants, many authors have reported that they can be placed at different angles of 15°, 25°, 30° and 45° between the implant and the prosthetic abutment^{24,25}. These degrees of angulation are also determined by local bone quality and quantity, in terms of the length and width of the available bone for implantation, and by the surrounding anatomical structures (maxillary sinus in the maxilla and mental foramen in the mandible)²⁶. One study found that the distribution of peri-implant cortical bone pressure increases with increasing angulation between the implant and abutment and with decreasing number of implants²⁷. Other studies, however, have not found differences in cortical bone pressure between angulated and axially placed implants, as well as between connected and unconnected implants²⁸.

Despite the limitations and challenges offered by “All-on-6” and “All-on-4”, the clinical predictability of the intervention remains high if all protocols are strictly followed and the procedure is performed by a highly experienced multi-disciplinary team.

Conclusion

The rehabilitation of toothless jaws with dental implants significantly improves both oral function and facial aesthetics. Dental implants provide a stable and long-lasting foundation for prosthetic restorations, offering clear advantages over traditional total acrylic dentures.

Accurate planning with CBCT and precise surgical execution are crucial for the placement of dental implants but also for the long-term success of implant-supported fixed restorations.

The “All-on-6” and “All-on-4” concepts provide effective, and predictable implant-prosthetic treatment options in edentulous patients.

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INTENSITY OF DENTAL CARIES AND BACTERIAL STRAINS *S. MUTANS*, *S. SOBRINUS*, *S. SALIVARIUS*, *S. MITIS* IN SALIVA OF CHILDREN WITH PERMANENT DENTITION

ИНТЕНЗИТЕТ НА ДЕНТАЛЕН КАРИЕС И БАКТЕРИСКИТЕ СОЕВИ *S. MUTANS*, *S. SOBRINUS*, *S. SALIVARIUS*, *S. MITIS* ВО ПЛУНКА НА ДЕЦА СО ТРАЈНА ДЕНТИЦИЈА

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Abstract

Introduction: Dental caries is one of the most common chronic multifactorial disease affecting the human population. The appearance of a caries lesion is determined by the coexistence of three main factors: acidogenic and acidophilic microorganisms, carbohydrates derived from the diet, and host factors. Caries develops as a result of an ecological imbalance in the stable oral microbiome. *Streptococcus mutans*, other *streptococci* belonging to the non-mutans streptococci group, *Actinomyces*, and *Lactobacillus* species play a key role in this process. **The aim** of our research is to detect the bacteria *Streptococcus mutans*, *Streptococcus sobrinus*, *Streptococcus salivarius*, and *Streptococcus mitis* in saliva and to analyze the interdependence between dental status and the degree of dental caries activity with each examined parameter separately. **Material and method:** The study included 71 children (26 females and 45 males) aged 12 years. We selected the 12-year-old age group based on WHO recommendations, which identify this age for global monitoring of dental caries and apply only to children with permanent dentition. **Results:** The data relating to the detection of *Streptococcus mutans* in the saliva of children with permanent teeth showed that in the experimental group of 40 children (56.30%), *Streptococcus mutans* was isolated in 28 children (39.40%) and in 12 children (16.90%) it was not isolated from the saliva. In the presented distribution of data relating to the detection of *Streptococcus mutans* in the saliva of children with permanent teeth, there is a significant difference between the two groups ($p < 0.01$). **Conclusions:** *Streptococcus mutans* and *Streptococcus sobrinus* are considered the main etiological factors in the development of dental caries. **Keywords:** *Streptococcus mutans*, dental caries, saliva, permanent dentition.

Апстракт

Вовед: Забниот кариес е едно од најчестите хронични и мултифакторни заболувања кај човечката популација. Појавата на кариесната лезија е определена од коезистенцијата на три главни фактори: ацидогени и ацидофилни микроорганизми, јаглехидрати добиени од исхраната и фактори поврзани со носителот. Кариесот се развива како резултат на еколошка нерамнотежа во стабилниот орален микробиом. *Streptococcus mutans*, други стрептококи од т.н. група на не-*Mutans streptococci*, *Actinomyces* и *Lactobacillus*, играат клучна улога во овој процес. **Целта** на ова истражување е детектирање на бактериите *Streptococcus mutans*, *Streptococcus sobrinus*, *Streptococcus salivarius*, *Streptococcus mitis* во плунката и анализирање на меѓузависноста на денталниот статус и степенот на активност на денталниот кариес со секој испитуван параметар поодделно. **Материјал и метод:** Во истражувањето се вклучени 71 дете (26 од женски и 45 од машки пол) на возраст од 12 години. Возрасната група од 12 години е избрана според препораките на СЗО која ја препорачува оваа возраст при глобален мониторинг на забен кариес, а кои се однесуваат само на деца со трајна дентичија. **Резултати:** Податоците кои се однесуваат на детекцијата на *Streptococcus mutans* во плунката на децата со трајни заби, покажаа дека во експерименталната група од вкупно 40 деца (56,30%), кај 28 од нив (39,40%) е изолирана е *Streptococcus mutans*, додека кај 12 (16,90%) истата не е изолирана. Во прикажаната дистрибуција на податоци кои се однесуваат на детекцијата на *Streptococcus mutans* во плунката кај децата со трајни заби, постои значителна разлика помеѓу двете групи ($p < 0,01$). **Заклучоци:** *Streptococcus mutans* и *Streptococcus sobrinus* се сметаат за главен етиолошки фактор за појава на забен кариес. **Клучни зборови:** *Streptococcus mutans*, дентален кариес, плунка, трајна дентичија.

Introduction

Dental caries is one of the most common chronic multifactorial disease affecting the human population. The appearance of a caries lesion is determined by the coexistence of three main factors: acidogenic and acidophilic microorganisms, carbohydrates derived from the diet, and host factors. Caries develops as a result of an ecological imbalance in the stable oral microbiome. Oral microorganisms form dental plaque on the surfaces of teeth, which is the primary cause of the caries process and exhibits characteristics of the classic biofilm. *Streptococcus mutans*, other streptococci belonging to the so-called non-mutans streptococci group, *Actinomyces*, and *Lactobacillus* species, play a key role in this process¹. Dental caries remains the most common chronic disease in children and the exact etiology is not fully understood. Although *Streptococcus mutans* is an important factor in the initiation and progression of caries, its presence is not always associated with the disease. The existence of caries in which *Streptococcus mutans* counts do not correlate with caries experience, poses a challenging problem². Dental caries is an infectious and transmissible disease caused by a group of phenotypically similar bacteria collectively known as mutans streptococci, which are the main bacterial components responsible for the initiation and development of caries. The earliest time at which cariogenic *mutans streptococci* can appear and act is during tooth eruption, which requires exposed hard tooth surfaces, streptococcal colonization, and their multiplication, which are the main bacterial components responsible for the initiation and development of caries. The earliest time at which cariogenic *mutans streptococci* can appear and act is during tooth eruption, which requires exposed hard tooth surfaces, streptococcal colonization, and their multiplication³. Current concepts of the etiology of dental caries have focused on the fermentation of carbohydrates by cariogenic bacteria into organic acids. Plaque bacteria produce a variety of metabolic end products that may vary depending on the diet. In the presence of fermentable carbohydrates, the most common organic acids produced are lactic, formic, and acetic acids. These acids cause a drop in plaque pH, resulting in tooth demineralization and the creation of an environment favorable for further growth of *mutans streptococci*. In addition to acid production, *mutans streptococci* possess a wide range of virulence factors that are responsible for the overall cariogenic potential of dental plaque^{4,5,6,7,8}.

Microorganisms play an important role in the development and progression of caries. Bacteria in the oral cavity are in microbial balance, but the risk of caries increases if the number of certain bacteria (*Streptococcus*

mutans, *lactobacilli*) increases significantly while protective factors do not function normally. It has been established that the largest number of cariogenic bacteria belongs to the group of streptococci, especially *Streptococcus mutans* and *Streptococcus sobrinus* as well as lactobacilli. Mutans streptococci are considered significant determinants of plaque cariogenicity and are associated with the initial development of caries, while the number of *lactobacilli* increases during the progression of caries^{9,10}. The aim of our research is to detect the bacteria *Streptococcus mutans*, *Streptococcus sobrinus*, *Streptococcus salivarius*, and *Streptococcus mitis* in saliva and to analyze the interdependence between dental status and the degree of dental caries activity with each examined parameter separately.

Material and method

To achieve the set goal, children were randomly selected from primary schools in the city of Shtip. The study included 71 children (26 females and 45 males) aged 12 years. We selected the 12-year-old age group based on WHO recommendations, which identify this age for global monitoring of dental caries and apply only to children with permanent dentition¹¹. Dental examinations were performed using portable 60 W white-blue light bulbs and sterilized periodontal probes No. 5, as well as a mirror. To avoid visual fatigue, a maximum of 15 children were examined per day. The examinations were performed after verbal consent was obtained from the subjects and their parents, and they were divided into two groups: a control group (31 subjects without caries, fillings, or extractions; DMFT=0) and an experimental group (40 subjects with caries, fillings, and tooth extractions).

In the study, we used widely accepted index of the presence or absence of carious process, the Klein – Palmer index, designated as DMFT, which is the sum of Decayed (carious), Missing (extracted) and Filled (filled) teeth. We registered clearly visible lesions on the surfaces of the teeth as caries, while changes in transparency and initial demineralization with an intact surface and without cavitation were recorded as healthy tooth. According to the data obtained from the clinical examination, we determined the intensity (presence or absence of dental caries, which were recorded and interpreted them as follows¹²:

- a. 0.0 - 0.9 - very low caries risk
- b. 1.0 - 2.4 - low caries risk
- c. 2.5 - 3.8 - moderate caries risk
- d. 3.9 - 5.5 - high caries risk
- e. ≥ 5.6 - very high caries risk

The assessment of *Streptococcus mutans*, *Streptococcus sobrinus*, *Streptococcus salivarius*, and *Streptococcus mitis*

in saliva was performed by applying saliva to sterile paper No. 50, which was held with sterile beaked-ended tweezers and placed under the tip of the child's tongue for 1 min to soak in saliva. Each paper was then transferred to sterile Eppendorf tubes with sterile tweezers, which were transported to a portable freezer at a temperature of -80°C. Undiluted saliva samples with sterile swabs were plated on Mitis Salivarius agar (Fluka, a medium with sucrose, glucose, tryptan blue, and crystal violet) which is recommended for the isolation of mixed streptococcal cultures, such as *Streptococcus mitis*, *Streptococcus mutans*, *Streptococcus salivarius*, *Enterococcus faecalis*, etc. The plates were incubated under microaerophilic conditions (5-10% CO₂) for 48 hours at 37°C. The characteristic colony morphology and standard microbiological techniques were used to identify the isolates. Specific characteristic of Mitis Salivarius agar include the appearance of blue colonies due to absorption of tryptan blue dye. *Streptococcus salivarius* is characterized by large, pale-blue, smooth colonies with a diameter of 1-5 mm, which resemble “chewing gum” due to the production of levan from sucrose. Colonies of *Streptococcus mutans* were raised, convex, pale-blue and granular, resembling “ground glass”. Sometimes the surface

of the colony had a “mesh-like” appearance, due to the synthesis of glucan from sucrose. *Streptococcus mitis* forms small, tiny colonies. Suspect colonies were sub-cultured on blood agar and finally identified with the Vitek 2 system, especially *Streptococcus salivarius*. DNA isolation of *Streptococcus mutans* and *Streptococcus sobrinus* from saliva samples was done with the genomic ChargeSwitch® Forensic DNA Purification Kit, (Invitrogen Corporation, 1600 Faraday Avenue, Carlsbad).

Results

A total of 71(100.00%) children comprised the study population with permanent dentition. Of these, 40 (56.30%) belong to the experimental group, in which 16 (22.50%) children were female and 24 (33.80%) children were male. The data relating to the detection of *Streptococcus mutans* in the saliva of children with permanent teeth showed that in the experimental group, out of a total of 40 (56.30%) children, *Streptococcus mutans* was isolated in 28 (39.40%) children, and in 12 (16.90%) children it was not isolated from the saliva. In the control group, out of a total of 31(43.70%) children, *Streptococcus mutans*

Tabele 1. Group / *Streptococcus mutans*

			<i>Streptococcus mutans</i>		Total
			Yes	No	
Group	Experimental	Count	28	12	40
		% of Total	39,4%	16,9%	56,3%
	Control	Count	12	19	31
		% of Total	16,9%	26,8%	43,7%
Total		Count	40	31	71
		% of Total	56,3%	43,7%	100,0%

Tabele 2. Group / *Streptococcus sobrinus*

			<i>Streptococcus sobrinus</i>		Total
			Yes	No	
Group	Experimental	Count	30	10	40
		% of Total	42,3%	14,1%	56,3%
	Control	Count	12	19	31
		% of Total	16,9%	26,8%	43,7%
Total		Count	42	29	71
		% of Total	59,2%	40,8%	100,0%

Tabele 3. Group / *Streptococcus salivarius*

		<i>Streptococcus salivarius</i>		Total	
		Yes	No		
Group	Experimental	Count	35	5	40
		% of Total	49,3%	7,0%	56,3%
	Control	Count	10	21	31
		% of Total	14,1%	29,6%	43,7%
Total		Count	45	26	71
		% of Total	63,4%	36,6%	100,0%

was isolated from the saliva of 12 (16.90%) children and in 19 (26.80%) children *Streptococcus mutans* was not isolated from the saliva. In the presented data distribution relating to the detection of *Streptococcus mutans* in saliva in children with permanent teeth, there is a statistically significant difference between the two groups for Pearson's chi-square=6.95 and $p < 0.01$ ($p = 0.008$) (Table 1).

The data relating to the detection of *Streptococcus sobrinus* in saliva in children with permanent teeth for the experimental group of 40 (56.30%) children, in 30 (42.30%) children *Streptococcus sobrinus* was isolated from the saliva and in 10 (14.10%) *Streptococcus sobrinus* was not isolated. In the control group of 31 (43.70%) children, in 12 (16.90%) children *Streptococcus sobrinus* was isolated from the saliva and in 19 (26.80%) children *Streptococcus sobrinus* was not isolated from the saliva. In the presented distribution of data relating to the detection of *Streptococcus sobrinus* in saliva in children with permanent teeth, there is a statistically significant difference between the two groups, with Pearson's chi-square=9.53 and $p < 0.01$ ($p = 0.002$) (Table 2).

The data relating to the detection of *Streptococcus salivarius* in the saliva of children with permanent teeth indi-

cate that in the experimental group of 40 (56.30%) children, *Streptococcus salivarius* was isolated from the saliva of 35 (49.30%) children and was not isolated in 5 children (7.00%). In the control group of 31 (43.70%) children, *Streptococcus salivarius* was isolated from the saliva of 10 (14.10%) children and was not isolated in 21 (29.60%). In the presented distribution of data relating to the detection of *Streptococcus salivarius* in the saliva of children with permanent teeth, with Pearson chi-square=22.96 and $p < 0.001$ ($p = 0.000$), there is a statistically significant difference between the two groups (Table 3).

The results of the detection of *Streptococcus mitis* in the saliva of children with permanent teeth indicate that in the experimental group of 40 (56.30%) children, *Streptococcus mitis* was isolated from the saliva of 37 (52.90%) children and *Streptococcus mitis* was not isolated from 2 (2.90%) children. In the control group of 31 (43.70%) children, *Streptococcus mitis* was isolated from the saliva of 8 (11.40%) children and *Streptococcus salivarius* was not isolated from the saliva of 23 (32.90%) children.

In the presented distribution of data relating to the detection of *Streptococcus mitis* in saliva in children with permanent teeth, with Pearson chi-square=16.14 and p

Tabele 4. Group / *Streptococcus mitis*

		<i>Streptococcus mitis</i>		Total	
		Yes	No		
Group	Experimental	Count	37	2	40
		% of Total	52,9%	2,9%	56,3%
	Control	Count	8	23	31
		% of Total	11,4%	32,9%	43,7%
Total		Count	45	25	71
		% of Total	64,3%	35,7%	100,0%

Tabele 5. DMFT index / Cariogenic bacteria

Cariogenic bacteria								95% C.I.for EXP(B)	
Step		B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Lower
1*	<i>S.mutans</i> (1)	18,76	28420,71	,000	1	,999	,000	,000	
	<i>S.sobrinus</i> (1)	20,39	28420,71	,000	1	,999	7,180E8	,000	
	<i>S.salivarius</i> (1)	1,18	,89	1,76	1	,185	3,268	,57	18,82
	<i>S.mitis</i> (1)	3,37	1,00	11,36	1	,001	29,139	4,10	207,00
	Constant	-3,75	,99	14,07	1	,000	,024		

*Variable(s) entered on step 1: *S.mutans*, *S.sobrinus*, *S.salivarius*, *S.mitis*

<0.001(p = 0.000), there is a statistically significant difference between the two groups (Table 4).

The data relating to the predictive values of the detected *Streptococcus mutans*, *Streptococcus sobrinus*, *Streptococcus salivarius* and *Streptococcus mitis* in saliva in children with permanent teeth for the presence of dental caries (DMFT index) indicate that there is a statistically significant association between the detected bacteria in saliva *Streptococcus mutans*, *Streptococcus sobrinus*, *Streptococcus salivarius*, *Streptococcus mitis* and the presence of dental caries, with Pearson chi-square=48.13 and p <0.001(p = 0.000). When determining the significance of the contribution of each bacterium to the presence of dental caries, it was determined that the greatest influence has *Streptococcus mitis* (Wald=11.36 / p <0.01(p = 0.001), *Streptococcus salivarius* (Wald=1.76 / p>0.05(p = 0.19), while *Streptococcus mutans* (Wald=0.00 / p>0.05(p = 0.99) and *Streptococcus sobrinus* (Wald=0.00 / p>0.05(p = 0.99) showed no predictive value for the presence of dental caries. Children in whose saliva *Streptococcus mitis* was detected compared to children in whose saliva *Streptococcus mitis* was not detected have a significantly higher probability of the presence of dental caries by 29.14 times (Exp(B)=29.14)(95%CI:4.10-207.00). Children in whose saliva *Streptococcus salivarius* was detected compared to children in whose saliva *Streptococcus salivarius* was not detected have a 3.27-fold (Exp(B)=3.27) insignificantly higher probability of having dental caries (95%CI:0.57-18.82) (Table 5).

Discussion

Previous experimental and clinical research indicates that the occurrence of dental caries is responsible for several different risk factors that can act independently or in

association at the same time^{13,14}. Yabao et al. emphasize the relatively well-known etiopathogenesis of dental caries, according to which the cariogenic flora, in the presence of fermentable carbohydrates, produces organic acids that reduce the pH of saliva and disrupt the complex dynamic balance of dental plaque, causing demineralization of enamel, the onset of initial caries, and the formation of cavities in the teeth¹⁵. Data regarding the intensity of dental caries in children with permanent dentition in the experimental group showed that out of a total of 40 (56.30%) children, 32 (45.10%) children had a low caries risk (1.0-2.4), 1 (1.40%) child had a moderate caries risk (2.5-3.8) and 7 (9.90%) children had a high caries risk (3.9-5.5) compared to the control group, where the subjects were without dental caries and with a very low caries risk. There was a statistically significant difference between the two groups (p<0.001)¹⁶. The bacterial load in saliva and the amount of plaque are directly related to the occurrence of caries in each individual. Particularly strong indicators are the number of pathogenic *mutans streptococci* present in plaque, saliva, and fissures on the occlusal surfaces of the teeth, which place each patient at high risk for caries. Other important *Streptococcus species* involved in the occurrence of caries are *Streptococcus mitis* and a group of acidophilic *streptococci* that act only at low pH such as *Bifidobacterium* isolated from the white spot lesions of teeth¹⁷. In the presented distribution of data relating to the detection of *Streptococcus mutans* in saliva in children with permanent teeth, there is a significant difference between the two groups (p<0.01)¹⁸. *Streptococcus mutans* and *Streptococcus sobrinus* are considered the main etiological factors for the occurrence of dental caries. Oda, using the polymerase chain reaction (PCR) method, compared the levels of these bacteria in 145 patients aged 12 to 20 years and compared them with the occurrence of caries, deter-

mining that children in whom *Streptococcus mutans* and *Streptococcus sobrinus* were isolated had a significantly higher incidence of dental caries than those with *Streptococcus mutans*¹⁹.

Conclusion

The number of bacteria in saliva and the amount of plaque are directly related to the occurrence of caries. Particularly strong indicators are the number of pathogenic *mutans streptococci* present in plaque, saliva, and fissures on the occlusal surfaces of the teeth, which make each patient at high risk for the occurrence of caries. The data we obtained for the detection of *Streptococcus mutans* in saliva in children with permanent teeth in the experimental group, out of a total of 40 (56.30%) children, in 28 (39.40%) children *Streptococcus mutans* was isolated from the saliva and in 12 (16.90%) children *Streptococcus mutans* was not isolated. In the control group, out of a total of 31 (43.70%) children, in 12 (16.90%) children *Streptococcus mutans* was isolated from the saliva and in 19 (26.80%) children *Streptococcus mutans* was not isolated. In the presented distribution of data relating to the detection of *Streptococcus mutans* in saliva in children with permanent teeth, there is a statistically significant difference between the two groups ($p < 0.01$).

Data relating to the detection of *Streptococcus sobrinus* in saliva in children with permanent teeth, in the experimental group of 40 (56.30%) children in total, in 30 (42.30%) children *Streptococcus sobrinus* was isolated from saliva and in 10 (14.10%) children *Streptococcus sobrinus* was not isolated from saliva. In the control group of 31 (43.70%) children in total, in 12 (16.90%) children *Streptococcus sobrinus* was isolated from saliva, however in 19 (26.80%) children it was not isolated from saliva. The distribution of data for the detection of *Streptococcus sobrinus* in saliva in children with permanent teeth indicates that there is a statistically significant difference between the two groups ($p < 0.01$).

Data refer to the detection of *Streptococcus salivarius* in the saliva of children with permanent teeth. In the experimental group of a total of 40 (56.30%) children, in 35 (49.30%) children *Streptococcus salivarius* was isolated from the saliva and in 5 (7.00%) children *Streptococcus salivarius* was not isolated from the saliva. In the control group of a total of 31 (43.70%) children, in 10 (14.10%) children *Streptococcus salivarius* was isolated from the saliva and in 21 (29.60%) children *Streptococcus salivarius* was not isolated from the saliva.

The detection of *Streptococcus salivarius* in the saliva of children with permanent teeth indicated that there was

a statistically significant difference between the two groups ($p < 0.001$).

Further is the data regarding the detection of *Streptococcus mitis* in the saliva of children with permanent teeth. In the experimental group of 40 (56.30%) children in total, in 37 (52.90%) children *Streptococcus mitis* was isolated from the saliva and in 2 (2.90%) children *Streptococcus mitis* was not isolated. In the control group of 31 (43.70%) children in total, in 8 (11.40%) children *Streptococcus mitis* was isolated from the saliva and in 23 (32.90%) children *Streptococcus salivarius* was not isolated from the saliva.

In the control group of 31 (43.70%) children, *Streptococcus salivarius* was isolated from the saliva in 10 (14.10%) children and in 21 (29.60%) it was not isolated. Data relating to the detection of *Streptococcus salivarius* in the saliva of children with permanent teeth indicated that there is a statistically significant difference between the two groups ($p < 0.001$).

The data relating to the detection of *Streptococcus mitis* in saliva in children with permanent teeth showed that in the experimental group of 40 (56.30%) children, in 37 (52.90%) children *Streptococcus mitis* was isolated from the saliva, in 2 (2.90%) children *Streptococcus mitis* was not isolated from the saliva. In the control group of 31 (43.70%) children, in 8 (11.40%) children *Streptococcus mitis* was isolated from the saliva and in 23 (32.90%) children *Streptococcus salivarius* was not isolated from the saliva.

The data relating to the detection of *Streptococcus mitis* in saliva in children with permanent teeth indicate a statistically significant difference between the two groups of subjects ($p < 0.001$). When determining the significance of the contribution to the presence of dental caries of each bacterium, it was determined that *Streptococcus mitis* $p < 0.01$ had the greatest influence, followed by *Streptococcus salivarius* $p > 0.05$, while *Streptococcus mutans* $p > 0.05$ and *Streptococcus sobrinus* $p > 0.05$ had no predictive value for the presence of dental caries.

Children in whose saliva *Streptococcus mitis* was detected compared to children in whose saliva *Streptococcus mitis* was not detected, had a 29.14-fold significantly higher probability of presence of dental caries. Children in whose saliva *Streptococcus salivarius* was detected compared to children in whose saliva *Streptococcus salivarius* was not detected, had a 3.27-fold insignificantly higher probability of dental caries occurrence.

This study provides evidence that *Streptococcus mutans* may play a role in shaping the salivary microbial community. Our results highlight that future caries research should consider additional species as health/disease microbial mark-

ers, in conjunction with *Streptococcus mutans*, to improve diagnosis and caries management of the caries-discordant population.

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CONSERVATIVE APPROACH IN THE TREATMENT OF RECURRENT ODONTOGENIC KERATOCYST IN THE MANDIBLE

КОНЗЕРВАТИВЕН ПРИСТАП ВО ТРЕТМАН НА РЕКУРЕНТ НА ОДОНТОГЕНА КЕРАТОЦИСТА ВО МАНДИБУЛА

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Abstract

Odontogenic keratocyst (OKC) is a developmental jaw cyst of epithelial origin, characterized by aggressive biological behavior, a high recurrence rate, and a tendency for infiltrative growth. Unlike other jaw cysts, OKC exhibits a thin but highly proliferative epithelial lining and is often associated with PTCH1 gene mutations, placing it among tumor-like cystic lesions. The aim of this paper is to present a clinical case of a recurrent odontogenic keratocyst in a male patient born in 1981, treated at the University Clinic for Maxillofacial Surgery, five years after the initial surgical intervention. Several surgical treatment modifications for OKC have been described, each with specific advantages and limitations depending on the size, location, and relationship to adjacent anatomical structures. In this case, a conservative approach with decompression and marsupialization was applied to achieve gradual reduction of the cystic cavity while preserving important anatomical and neurovascular structures. A second-stage surgical procedure involving complete cyst removal and peripheral osteotomy is planned to minimize the risk of further recurrence. This case emphasizes the importance of an individualized treatment strategy, a staged surgical approach, and long-term follow-up in the management of this clinically challenging lesion. **Keywords:** odontogenic keratocyst, marsupialization, recurrence, mandible.

Апстракт

Одонтогената кератоциста (ОКЦ) претставува развојна циста на вилицата со епително потекло позната по своето агресивно биолошко однесување и висока стапка на рецидиви тенденција за инфилтративен раст. Заразлика од другите вилични цисти, ОКЦ се карактеризира со тенок, ноактивно пролиферативен епител и честа поврзаност со мутации во РТСН1 генот што ја вбројува во групата на туморски лезии со цистична морфологија. Целта на овој труд е да се прикаже клинички случај на рецидивирачка одонтогена кератоциста кај пациент роден 1981 година, третиран во Универзитетската клиника за максилофацијална хирургија, пет години по иницијалната хируршка интервенција. Постојат повеќе модификации во хируршкото лекување на ОКЦ, секоја со свои предности и недостатоци, во зависност од големината, локацијата и односот со анатомските структури. Во овој случај применет е конзервативен пристап со декомпресија и марсупијализација со цел постепено намалување на димензиите на цистичната празнина и зачувување на невровакуларните структури. Во наредната фаза е планирано целосно хируршко отстранување односно енуклеација со периферна остеотомија со цел минимизирање на ризикот од повторен рецидив. Овој случај ја нагласува важноста на индивидуализираниот третмански пристап, мултифазното хируршко управување и долгорочното следење на оваа клинички предизвикувачка патологија. **Клучни зборови:** одонтогена кератоциста, марсупијализација, рецидив, долна вилица, третман.

Introduction

Odontogenic keratocysts (OKCs) are among the most challenging cystic lesions encountered in oral and maxillofacial surgery¹. First described by Philipsen in 1956, OKCs originate from remnants of the dental lamina. Histologically, they are characterized by a parakeratinized stratified squamous epithelial lining (Philipsen, 1956; Neville, 2016)^{2,3,4}.

Clinically, OKCs often develop silently, sometimes persisting for long periods before being detected, and are frequently discovered incidentally during routine imaging^{5,6}. This silent growth can lead to large lesions at the time of diagnosis. OKCs are known for their potential to cause local bone destruction and their high recurrence rate⁷. The posterior mandible, particularly the angle and ramus, is the most common location⁸. Radiographically, OKCs may

appear as unilocular or multilocular radiolucencies with well-defined corticated borders⁹. Treatment ranges from conservative approaches such as marsupialization or enucleation to more radical interventions including resection, with the choice influenced by lesion size, location, and proximity to critical anatomical structures¹⁰.

Aim of the Study

The primary objective of this paper is to provide an in-depth clinical and surgical overview of a recurrent odontogenic keratocyst located in the posterior mandible, managed via marsupialization. The decision to present this case is based on the cyst's well-documented histopathological characteristics, high risk of recurrence, and notable local extension. This report contributes to the academic discussion regarding the balance between conservative and radical approaches for OKCs and emphasizes individualized treatment planning, thorough intraoperative assessment, and vigilant postoperative follow-up to optimize patient outcomes.

Materials and Methods

The patient was evaluated and treated at the University Clinic for Maxillofacial Surgery. Full informed consent was obtained prior to inclusion in this case report.

Clinical Examination:

Extraoral inspection showed mild facial asymmetry over the right mandibular body, without cutaneous changes or lymphadenopathy.

Intraoral examination revealed a firm, non-fluctuant swelling in the right posterior mandible, with intact mucosa and no signs of infection.

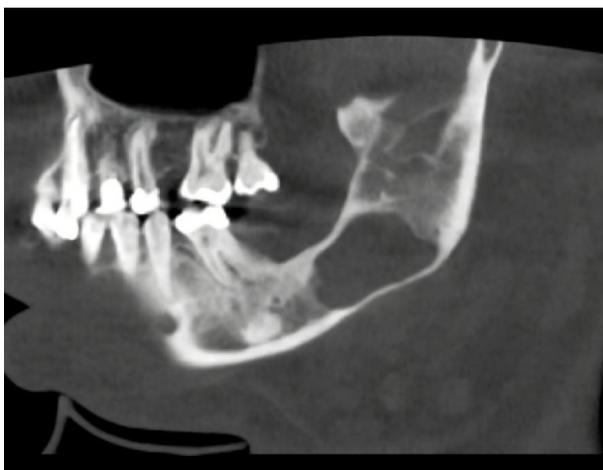


Figure 1. Sagittal CBCT view showing a multilocular radiolucent lesion in the right posterior mandible

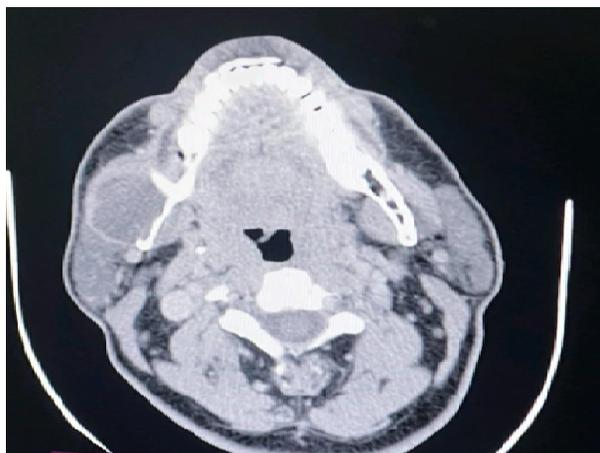


Figure 2. Axial CT view demonstrating a well-defined radiolucent

Radiographic Evaluation: Cone Beam Computed Tomography (CBCT) was obtained for detailed assessment (Figure1).

Evaluation in axial, coronal, and sagittal sections demonstrated a well-defined, corticated, multilocular radiolucent lesion.

Axial views: marked thinning of both buccal and lingual cortical plates, with subtle outward buccal expansion and preserved cortical continuity (Figure 2).

Coronal views: maintaining an intact corticated outline, with no evidence of neurovascular invasion.

Sagittal views: extension toward the mandibular ramus, with absence of cortical perforation.

Histopathological Analysis: Microscopic examination of the sections shows a cyst wall whose luminal surface is lined by stratified squamous epithelium, in areas displaying an undulating parakeratotic surface. The basal layer consists of palisaded cuboidal to columnar cells with nuclear hyperchromasia. Within the cyst wall, there is marked fibrosis with areas of myxoid degeneration and a moderate-to-dense lymphocytic inflammatory infiltrate.

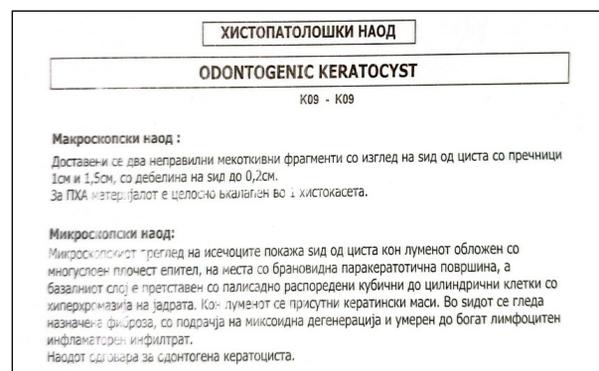


Figure 3. Histopathological findings characteristic of an odontogenic keratocyst.

The findings are consistent with an odontogenic keratocyst (Figure 3).

Surgical Procedure

The cyst was treated with marsupialization (cystotomy – Partsch I) under general anesthesia¹⁰. This technique involves partial excision of the cystic saccus, removing only the superficial portion of the cyst wall together with a thin bony layer or periosteum.

It was indicated due to the large size of the cystic lesion and the potential risk of: pathologic fracture of the jaw and, injury to the important anatomical structures¹¹.

Extended linear incision was made along the edge of the bony defect. A mucoperiosteal flap was gently elevated to expose the bone. The thin bone covering the cyst was removed. The superficial portion of the cyst wall was removed using a scalpel and the cyst contents were aspirated; the cavity was thoroughly irrigated.

The mucoperiosteal flap was then repositioned into the bony defect so that it lined the upper part of the cavity.

The edges were sutured with simple interrupted stitches, creating a permanent opening for drainage.

The cavity was firmly packed with an iodoform gauze drain, which was secured to the surrounding tissue with sutures to keep it in place.

Eight days after surgery, the packing was trimmed and removed. The cavity was cleaned, irrigated, and a new iodoform packing was placed to maintain the opening and allow further healing.

Case Report

A 43-year-old male (born 1981) presented with a recurrent swelling on the right posterior mandible, referred to our clinic five years after a previous intervention which had

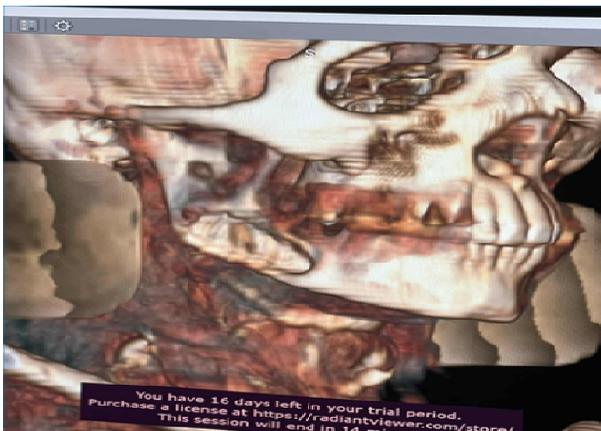


Figure 4. 3D CT reconstruction showing destruction and thinning of the mandibular bone caused by the lesion

been performed following a diagnosis of an odontogenic keratocyst and according to the patient, involved a complete removal. The swelling developed gradually over several weeks causing mild discomfort but no acute pain or paresthesia. Extraoral examination revealed facial asymmetry. Intraorally, a firm, non-fluctuant swelling was observed, extending toward the ramus, with missing teeth in the affected area. CT confirmed a large multilocular lesion with buccal cortical thinning⁵ (Figure 4).

Radiographic Evaluation: CBCT revealed a well-defined, corticated radiolucent lesion in the right posterior mandible toward the ascending ramus. The lesion measured approximately 5.5 cm, with a multilocular appearance and scalloped internal borders, radiographically characteristic of an odontogenic keratocyst.

There was marked thinning of the buccal and lingual cortical plates, with mild buccal expansion but no cortical perforation. No teeth were present in the region, and no calcifications or secondary infection were observed. The overall radiographic pattern-multilocularity, scalloped margins, cortical thinning, and extension into the ramus which actually is a characteristic of OKC, as described in CBCT literature^{11,12}.

Histopathology: Analysis confirmed an odontogenic keratocyst with a typical parakeratinized epithelial lining.

Surgical Procedure: Surgical management was initiated under general anesthesia. After localizing the projection of the cystic cavity, a conservative mucoperiosteal incision was created to expose the underlying lesion while minimizing disruption of the surrounding tissues. Elevation of the flap provided a direct access to the thinned cortical bone, which was carefully removed to reveal the cystic lumen (Figure 5).

A limited window was fashioned in the cyst wall, and a portion of the lining was excised to allow decompression. The opening was then adapted and sutured to the oral mucosa forming a stable marsupialization opening intended to maintain continuous drainage and pressure reduction within the cavity. The procedure was carried out with delib-



Figure 5. Intraoperative view during marsupialization of the odontogenic keratocyst

erate focus on preserving critical anatomical structures in close relation to the lesion¹³.

An iodoform drain was placed through the newly created opening to secure patency during the early healing phase. This conservative approach successfully established controlled decompression while avoiding injury to important anatomical structures and reducing the overall surgical burden.

Postoperative follow-up: The patient was advised to attend regular follow-up visits for clinical and radiographic evaluation.

Discussion

There are various opinions in the literature regarding the management and recurrence potential of odontogenic keratocysts (OKCs). While some authors emphasize their aggressive behavior and high recurrence rates, others highlight that conservative approaches can achieve satisfactory long-term outcomes, particularly when the cyst is large or in close proximity to significant anatomical structures^{14,15}. Consequently, the choice of treatment is influenced by lesion size, bucco-lingual expansion, cortical perforation,

proximity to major anatomical structures, recurrence status, and patient-related considerations. Multiple treatment modalities are described, each with specific advantages and limitations regarding recurrence, morbidity, and preservation of surrounding tissues^{16,17}. A review of the available long-term studies demonstrates clear variability in recurrence rates among treatment modalities. The summarized tendencies are presented in the following table (Table 1).

In the present case, the lesion was managed through marsupialization, a conservative technique that offers several clinically relevant advantages^{18,19}. It allows gradual reduction in cyst volume, promotes progressive bone regeneration, and reduces the risk of damage to the inferior alveolar nerve—benefits particularly important in large or recurrent OKCs. Additionally, marsupialization is associated with lower postoperative morbidity, decreased surgical trauma during the secondary enucleation phase, and improved preservation of mandibular architecture³.

However, the technique presents certain limitations or **disadvantages**^{18,19}. Marsupialization requires a prolonged treatment period and demands strict patient compliance to maintain the patency of the decompression opening and

Table 1. Treatment modalities and recurrence rate 1

Treatment Modality	Follow-up Time / Study Context	Recurrence Rate	Notes
Enucleation only	Surgical management over long-term studies (20+ years) ¹²	Up to ~60% in some series (e.g. in long term study, enucleation alone had highest recurrence ~60%)	High risk especially for large/multilocular OKCs; minimal adjuncts used.
Enucleation + Peripheral Ostectomy	Retrospective case series, Hacettepe Univ (2001-2015), ~5 yrs follow-up	~14.8%	Lower morbidity; good option for posterior mandibular lesions.
Enucleation + Carnoy's Solution (or Modified Carnoy's)	Multiple studies including network meta-analysis, retrospective cohorts	Often around 10-15% recurrence; sometimes lower (~5-12.5%) depending on region, adjunct used, follow-up period.	Better control when used carefully; modified versions avoid chloroform in some countries.
Decompression / Marsupialization	Long-term experience in studies with >5 years follow-up	~11-25% depending on case and whether followed by definitive surgery	Usually used for large cysts to reduce size before definitive removal.
Resection	Systematic reviews & large cohort studies	Very low recurrence (often 0%)	But high morbidity; usually reserved for recurrent, aggressive, or syndromic cases.

prevent infection. Because the cystic lining is not fully removed during the initial stage, viable epithelial remnants may persist, meaning that recurrence potential remains until final enucleation is completed. These factors underscore the need for careful case selection and long-term follow-up^{20,16}.

Carnoy's solution—both the classic formulation containing chloroform and the modified formulation without chloroform—has been widely documented as an effective adjunct for reducing recurrence of OKCs. Its mechanism involves chemical fixation and coagulation of epithelial remnants within the peripheral bone, thereby decreasing the likelihood of residual islands that could lead to recurrence. The concern raised in recent decades relates primarily to the potential carcinogenicity of chloroform, prompting the development of modified Carnoy's solution, which retains efficacy but eliminates the controversial component¹⁹. In the present case, Carnoy's solution was not used because the surgical team opted for marsupialization as the initial stage of treatment, avoiding chemical adjuncts until definitive enucleation is performed.

Conclusion

Marsupialization resulted in a progressive reduction of the cystic cavity, confirmed clinically and radiographically throughout the follow-up period. The decompression window remained patent, soft-tissue healing was satisfactory and no episodes of infection or postoperative complications occurred. What was important is that the patient exhibited no neurosensory disturbances of the inferior alveolar nerve, despite its initial close proximity to the lesion. The gradual decrease in cyst size was accompanied by early bone apposition along the cavity margins, indicating a favorable regenerative response.

These findings represent the expected beneficial effects of marsupialization, demonstrating effective decompression, reduction of cystic volume, and preservation of surrounding anatomical structures. As is typical with staged management of large OKCs, the forthcoming definitive enucleation will build upon these improvements and facilitate complete lesion removal, contributing to long-term stability. Because the cystic lining remains partially intact during this phase, the current observations appropriately reflect intermediate—rather than final-treatment—outcomes.

In summary, marsupialization in this case generated highly favorable early clinical and radiographic results, including substantial lesion shrinkage and successful preservation of the important anatomical structures. These outcomes highlight the value of marsupialization as an initial therapeutic approach for extensive odontogenic keratocysts, as it reduces surgical morbidity, protects anatomy, and creates optimal conditions for a safer

and more conservative definitive procedure. The achieved decompression maintained nerve function, and ongoing bone regeneration collectively underscore the effectiveness of this technique in managing large lesions situated in anatomically sensitive regions.

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ENDOCROWNS - CONTEMPORARY APPROACH FOR RESTORATION OF ENDODONTICALLY TREATED TEETH – REVIEW ARTICLE

ЕНДОКОРОНКИ - СОВРЕМЕН ПРИСТАП ЗА РЕСТАВРАЦИЈА НА ЕНДОДОНТСКИ ТРЕТИРАНИ ЗАБИ: РЕВИЈАЛЕН ТРУД

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Abstract

Introduction: Restoration of the severely destructed endodontically treated teeth remains a challenge in everyday dental practice. The development of the modern adhesive dentistry enables a minimally invasive approach in restoring severely damaged teeth. Endocrowns are minimally invasive restorations that rely on macro-mechanical retention, achieved by anchoring the restoration within the pulp chambers' walls and to the cavity's margins, and micromechanical retention, achieved by adhesive cementation. **Material and method:** A comprehensive literature search was conducted using electronic databases, including PubMed, Scopus, Web of Science and Google Scholar. Articles published between 1995-2025 were considered to ensure the inclusion of both foundational and recent advancements in the field of endocrowns. In total, 48 articles were evaluated and all useful information was incorporated into this review article. **Results:** According to literature data, the most common indication for endocrown fabrication is severely damaged endodontically treated mandibular molars. Lithium disilicate ceramic is the most commonly used material, providing acceptable mechanical and aesthetic properties, as well as the ability for adhesive cementation. In general, endocrowns have a decay-oriented preparation design concept. There are a few important aspects to consider in endocrown preparation: occlusal walls preparation, axial walls preparation and ferrule effect and pulp chamber walls preparation. Resin cements are widely used for endocrown cementation due to their strong bonding ability, aesthetics, high mechanical properties and low solubility. **Conclusion:** Endocrowns represent minimally invasive prosthetic restorations and constitute an optimal therapeutic choice for the reconstruction of severely damaged endodontically treated teeth. **Key words:** endocrowns, endodontically treated teeth restorations, minimally invasive restorations, adhesive dentistry.

Апстракт

Вовед: Реставрација на силно деструирани ендодонтски третирани заби останува предизвик во секојдневната стоматолошка пракса. Развојот на современите техники во адхезивната стоматологија овозможува минимално инвазивен пристап при оваа постапка. Ендокоронките се минимално инвазивни реставрации што се темелат на макромеханичка ретенција постигната по пат на анкерирање за сидовите на пулпината комора и маргините на препарационите кавитети и микромеханичка ретенција постигната по пат на адхезивно цементирање. **Материјал и метод:** Опсежно литературно пребарување беше спроведено користејќи ги електронските бази на податоци вклучувајќи ги PubMed, Scopus, Web of Science и Google Scholar. Со цел обезбедување инклузивност на темелите но и современите достигнувања во полето на ендокоронките, во ревијалниот труд беа вклучени клучните информации од 48 трудови објавени во периодот помеѓу 1995-2025 година. **Резултати:** Според литературните податоци, најчестата индикација за изработка на ендокоронки се силно деструирани и ендодонтски третирани мандибуларни молари. Литиум дисиликатната керамика е најчесто користен материјал кој обезбедува прифатливи механички и естетски особини како и можност за адхезивно цементирање. Препарацијата за ендокоронките е насочена кон формирање на кавитет со минимално инвазивен пристап. Постојат неколку важни аспекти во однос на препарација за ендокоронките: препарација на оклузалните сидови, обезбедување ferrule ефект и препарација на сидовите на пулпината комора. Композитните цемента се најчесто користени за цементирање на ендокоронките поради нивната силна адхезивна моќ, естетика, ниска солубилност и високи механички особини. **Заклучок:** Ендокоронките претставуваат минимално инвазивни протетски реставрации и оптимален терапевтски избор за реставрација на силно деструирани ендодонтски третирани заби. **Клучни зборови:** Ендокоронки, ендодонтски третирани заби, минимално инвазивни реставрации, адхезивна стоматологија.

Introduction

Restoration of the severely destructed endodontically treated teeth remains a challenge in everyday practice. After the root canal treatment (RCT), the tooth structures become weakened and susceptible to fractures due to the dehydration and excessive loss of dentin. Because of the considerable amount of hard tissue loss and complex microstructure modifications of the dentin, the mechanical properties and longevity of the endodontically treated teeth may be severely compromised¹.

The most common and widely accepted conventional approach for restoring extensively damaged endodontically treated teeth is to regain support for the final crown by postextension in the canal and a core build up².

Post and core is a well-established technique to restore endodontically treated teeth with significant coronal structural loss³. Metal and ceramic posts both have an elastic modulus that is much higher than that of the dentin, which could ultimately lead to root fracture when the tooth is overloaded. Fiber posts have been recommended for a more conservative approach, as their modulus of elasticity resembles that of natural dental tissues, and the utilization of adhesive luting agents ensures a more uniform distribution of occlusal stresses along the tooth structure⁴.

However, the primary role of the fiber-reinforced posts and traditional metal posts is to provide mechanical retention of the core buildup, not to increase the fracture resistance of the endodontically treated roots⁵. Keeping that in mind, a major limitation of the conventional method of restoration is the supplementary removal of the dental structure, particularly from the walls of the root canal walls, which causes a further decrease in mechanical resistance; increases the risk of root perforation during canal preparation; and creates uneven stress distribution due to differences in elastic modulus between the tooth structure and restorative materials⁶.

The development of the modern adhesive dentistry enables the minimally invasive approach in restoring severely damaged teeth, aimed at preserving a greater amount of healthy dental tissue. As a result, the necessity of using posts for mechanical retention in full-coverage crowns has been reconsidered. Endocrowns represent monolithic, conservative restorations introduced as an alternative to the conventional prosthodontic approach for severely compromised endodontically treated teeth⁷. Pissis developed the technique for endocrown restoration in 1995, but the term endocrown was coined by Bindl and Mormann in 1999. They described endocrowns as monolithic, single-piece restorations made of either full-composite or full-ceramic materials that partially or totally restore

the coronal portion of an endodontically treated tooth. These restorations rely on macromechanical retention, achieved by anchoring the restoration within the pulp chambers' walls and to the cavity's margins and micromechanical retention, achieved through adhesive cementation⁸.

The adhesive cementation technique used in endocrowns prevents marginal leakage and minimizes the penetration of microorganisms from the crown toward the root canals, thereby contributing to the success of the endodontic treatment⁹. Despite numerous advantages offered by endocrowns, there has been still an extensive debate in literature about the optimal approach for restoring the severely damaged teeth. Therefore, this review aims to offer a more comprehensive overview of endocrowns and assesses the influence of different materials and preparation designs on the mechanical properties, survival, and clinical success, as well as to compare conventional and modern approach for restoring endodontically treated teeth.

Material and method

A comprehensive literature search was conducted using electronic databases, including PubMed, Scopus, Web of Science and Google Scholar. Articles published between 1995-2025 were considered to ensure the inclusion of both foundational and recent advancements in the field of post-endodontic restoration. The following keywords were applied: "endocrown"; "monolithic restoration"; "restorations for endodontically treated teeth".

Studies were selected based on the following criteria:

► Inclusion Criteria:

- Peer-reviewed articles published in English.
- Studies evaluating the clinical performance, biomechanical properties, longevity, material selection, and adhesive techniques of endocrowns.
- In vitro, in vivo, and clinical studies focusing on endodontically treated posterior teeth restored with endocrowns.

► Exclusion Criteria:

- Studies focusing solely on conventional crowns, post-and-core restorations, or non-endodontically treated teeth.
- Case reports, commentaries, editorials, or articles lacking sufficient methodological details.
- Duplicate studies or those with limited relevance to endocrown restorations.

Data Extraction and Analysis

Key information was extracted, including study design, sample size, type of teeth restored, restorative materials

used (e.g., lithium disilicate ceramic, zirconia, composite), adhesive strategies, and clinical outcomes such as survival rates, failure modes, and marginal adaptation. The selected studies were categorized based on common research themes, including:

- Material properties and selection criteria for endocrowns
- Bonding techniques and adhesive protocols
- Biomechanical behavior and fracture resistance
- Long-term clinical performance and failure analysis

A comparative analysis was performed to identify trends, advantages, limitations, and gaps in the existing research, highlighting areas for future investigation.

Quality Assessment

To ensure methodological rigor, selected studies were assessed based on sample size, study design, statistical analysis, and potential biases. Systematic review guidelines, such as PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), were followed where applicable (Table 1).

Table 1. Article categorization

In vitro studies
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13. He J, Zheng Z, Wu M, Zheng C, Zeng Y, Yan W. Influence of restorative material and cement on the stress distribution of endocrowns: 3D finite element analysis. *BMC Oral Health*. 2021, 21:495
14. Adel S, Abo-Madina MM, Abo-El Farag SA. Fracture strength of hybrid ceramic endocrown restoration with different preparation depths and designs. *IOSR J Dent Med Sci*. 2019, 18:17-23.
15. AL-Zomur S, Abo-Madina M, Hassouna M. Influence of different marginal preparation designs and materials on the marginal integrity and internal adaptation of endocrown restorations. *Egypt Dental J*. 2021, 67:3491- 500.
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14. Rocca GT, Krejci I. Crown and post-free adhesive restorations for endodontically treated posterior teeth: from direct composite to endocrowns. *Eur J Esthet Dent* 2013;8(2):156–179.
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Discussion

After evaluating the published articles, it was obvious that the majority of the studies were *in vitro* studies compared to only a few *in vivo* clinical studies. The primary focus of the studies was determination on the correlation between the different restorative materials used for fabrication of the endocrowns and the fracture resistance, the influence of the preparation design and the fracture resistance, as well as the advantages and disadvantages of the endocrowns compared to post and core restorations.

Indications and contraindications

Endocrowns are indicated in clinical cases when there is excessive coronal tooth structure loss and limited interocclusal space, which prevents achieving adequate ceramic thickness over the metal or the composite core¹⁰. According to the literature data, the most common indication for endocrown restorations is severely damaged mandibular molars. The classical approach for the

restoration of an endodontically treated molar with a post and core involves widening of the anatomically complex canal system, which in these teeth is often narrow, sometimes curved, and variable in angulation; such a restoration results in a 58.3% loss of tooth structure¹¹.

Endocrowns may be the solution to limitations regarding the use of intra-radicular posts, such as short or curved roots, calcified or narrow root canals and also fractured instruments in the root canals¹². Preexisting conditions for endocrown planning include: supragingival walls of 1 to 2 mm height and at least 2 mm thickness, and a pulp chamber of at least 3 mm depth¹². Also important is the presence of intact cervical enamel so that adhesive procedures can be more effective¹³.

Endocrowns are indicated for all molars, particularly those with clinically short crowns, calcified root canals, or narrow canals¹⁴. They are not recommended if adhesion cannot be assured, if the pulpal chamber depth is less than 3 mm deep, or if the cervical margin width less than 2 mm wide for most of its circumference¹². Furthermore, endocrown restoration is indicated for cases where it is

difficult to achieve an adequate ferrule, such as in teeth with short clinical crowns and extensive destruction of the tooth structure¹⁵.

Endocrowns have been proven as effective in molar restorations, but there is ongoing debate regarding their use in premolars and anterior teeth⁷. In premolars, several researchers have reported a higher failure rate for endocrowns compared to molars⁹. This is attributed to the smaller pulp chamber dimensions, resulting in a reduced bonding surface area¹⁵. Additionally, the greater ratio of preparation-to- the overall crown-height in premolars creates a greater leverage effect, which decreases fracture resistance, particularly under non-axial forces¹⁵.

In case of severe dental tissue loss, where after preparation the endcrown finish line is completely below the cementenamel junction, the use of an endcrown may not be appropriate due to the increased risk of tooth fracture and the decreased restoration retention. Hence, in this case, restoring the endodontically treated tooth using the conventional method would be more appropriate¹³.

Furthermore, when there is evidence of increased functional and lateral stresses, as seen in steep occlusal anatomy, wear facets, or parafunction, a full-coverage crown with or without post is the treatment of choice¹⁶. Similarly to premolars, incisors and canines receive higher non-axial forces compared to the more axially oriented forces on posterior teeth, which explains the limited number of studies conducted on this group of teeth¹⁷.

Materials

Several materials, such as lithium disilicate glass-ceramic, zirconia-reinforced lithium silicate glass-ceramic, zirconia, and resin composites, have been used to fabricate endocrowns¹⁸.

The choice of material can impact the mechanical properties and the performance of the endcrown¹⁹.

It has been shown that endocrowns made of lithium disilicate-based ceramics are considered among the most commonly used restorative materials because of their adhesive properties²⁰.

An *in vitro* study conducted by Gresnigt et al. evaluated the effect of axial and lateral forces on the strength of endocrowns made of lithium disilicate glass ceramic and multiphase resin composite.

It has been concluded that under axial loading, both lithium disilicate glass ceramic and multiphase resin composite used as endcrown materials presented similar fracture strength, but under lateral forces, the latter exhibited significantly lower results²⁰.

In 2018, Tribst et al. evaluated the influence of restorative material type on the biomechanical behavior of endcrown restorations and concluded that leucite

ceramic presents a better stress distribution and can be a promising alternative to lithium disilicate ceramic for the manufacturing of endocrown restorations²¹.

Resin composite materials have been introduced for endocrown fabrication as an alternative to ceramic materials, primarily because of their low elastic modulus, which is similar to dentin¹⁹.

This characteristic enables appropriate stress distribution, resulting in more favorable modes of failure²².

Additionally, unlike ceramics, resin composites can be adjusted and repaired intraorally²³.

Furthermore, some researchers have reported that resin composites exhibit the highest fracture resistance compared to other materials¹⁸.

However, it is worth noting that these materials tend to have a higher degree of marginal leakage. Zoidis et al. proposed polyetheretherketone (PEEK) as an alternative framework material for endocrown restorations. They demonstrated that the elastic modulus of the polyetheretherketone framework (4 GPa) veneered with indirect composite resin, could absorb the occlusal forces, protecting tooth structures better than ceramic materials, but further long-term clinical evidence is required²⁴.

Zirconia-reinforced lithium silicate glass-ceramic is a glass-based ceramic material that incorporates zirconia particles into its matrix to enhance its mechanical and physical properties²⁵.

However, although the addition of zirconia particles increases the material's strength and resistance to deformation, it also reduces the bond strength between the restoration and tooth structure.

Additionally, the high modulus of elasticity of this material leads to stress concentration at the weakest points, potentially leading to catastrophic tooth failure²⁶.

Zirconia, a polycrystalline ceramic material devoid of a glass phase, is widely used because of its excellent mechanical properties²⁷.

However, zirconia lacks the ability to be etched using routine methods, which can result in reduced bond strength and potential restoration debonding²⁸.

Furthermore, it has exhibited the highest rate of catastrophic failures compared with other materials²⁷.

Dejak et al. reported that zirconia endocrowns exhibited the highest fracture strength in a finite element analysis of stress distribution²⁹.

Also, zirconia was shown to have a higher stress concentration than lithium disilicate ceramic restorations regardless of the occlusal thickness of the endcrown in finite element analysis evaluating stress distribution³⁰.

However, in their studies, Dartora et al. concluded that despite their increased fracture resistance, monolithic zirconia endocrowns also presented the highest nonrestorable failure patterns³¹.

Taha et al. compared fracture strength of resin nanoceramic endocrowns with lithium disilicate, polymer-infiltrated ceramic, and zirconia-reinforced lithium disilicate endocrowns in mandibular molars and found that the resin nanoceramic and lithium disilicate groups showed the highest fracture strength³².

In another study, El Ghouli et al. found that lithium disilicate endocrowns exhibited higher fracture strength when compared to zirconia-reinforced lithium disilicate ceramic and resin nanoceramic for both endocrowns and crowns²⁶.

Also, Güngör et al. when comparing resin nanoceramic and lithium disilicate endocrowns and crowns, found that lithium disilicate endocrowns had the highest fracture strength³³.

According to Zheng et al., resin composite may also represent an effective alternative for endocrowns compared to lithium disilicate, polymer infiltrated ceramic, resin nanoceramic, zirconia-reinforced glass ceramic and hybrid nanoceramic, as it showed a more uniform stress distribution and higher fracture resistance³⁴.

Preparation designs

The primary goal of endocrown preparation is to preserve as much sound dental tissue as possible.

With respect to the endocrown length, a design that utilizes only the pulp chamber-without extension into the root canal-provides superior stress distribution compared to designs involving intraradicular extensions¹⁸.

In general, endocrowns follow a decay-oriented preparation design concept¹⁰.

Several key aspects must be considered in endocrown preparation, including the preparation of the occlusal walls, preparation of axial walls, the ferrule effect, and the configuration of the pulp chamber walls.

Endocrown restorations achieve macromechanical retention through anchorage to the pulp chamber walls and cavity margins.

The amount of occlusal reduction depends primarily on the selected restorative material. Rocca and Krejci recommended an occlusal reduction of 1–1.5 mm when resin composite is selected, taking advantage of the material's elastic modulus and stress-absorbing properties, which are similar to dentin³⁵.

Conversely, Fages et al. suggested at least 2 mm of occlusal reduction when monolithic ceramic materials are used¹².

The overall thickness of the ceramic restoration, measured from the axial wall margin to the highest occlusal point, typically ranges between 3 and 7 mm, with several studies reporting increased fracture resistance associated with greater thickness^{15,36,17}.

A butt-joint margin refers to a 90° circumferential band, 1–2 mm wide, located between the pulp chamber and the

axial walls of the tooth. It is formed during cuspal reduction and serves to enhance adhesive bonding while providing a stable surface capable of withstanding compressive forces³⁷.

Endocrown preparations typically exclude the use of a ferrule¹⁷.

However, an alternative design has been proposed that incorporates a ferrule effect along with a shoulder finish line^{7,38,39}.

The ferrule effect refers to a 360° encircling collar along the axial walls above the preparation's shoulder finish line³⁶.

In this design, a 90° shoulder margin, 1 mm wide and located in sound enamel, is added to the butt-joint configuration³⁹.

This modification aims to create short axial walls that resist shear stresses and improve marginal load distribution in the pulpal floor area³⁸.

When comparing the butt-joint design to the shoulder-with-ferrule design, the former is less complex and demonstrates superior marginal integrity and internal adaptation^{36,38}.

Nonetheless, studies evaluating the impact of the ferrule effect have reported conflicting results^{18,9}.

Some researchers have suggested that the shoulder design with a ferrule provides greater fracture resistance and reduces the incidence of catastrophic failures compared to the butt joint design^{18,36,38,9}.

Others, however, have reported no significant differences in stress distribution or fracture resistance between the two designs¹⁸.

According to Einhorn et al., incorporating a ferrule into endocrown preparation necessitates excessive dentin removal, thereby weakening the tooth-restoration complex⁴⁰.

Moreover, areas with reduced dentin wall thickness may lead to intaglio surface overmilling during CAD/CAM fabrication due to limitations in milling bur diameter.

Axial wall enamel reduction during preparation for the ferrule effect can also negatively affect adhesive cementation.

For optimal outcomes, all margins should remain supragingival, and any undermined enamel should be removed³⁶.

Preparation of the pulp chamber involves eliminating undercuts in the endodontic access cavity using a cylindrical-conical diamond bur with an approximately 7° occlusal taper, ensuring continuity between the access cavity and pulp chamber⁴¹.

The bur should be aligned parallel to the long axis of the tooth and used with minimal pressure to avoid unnecessary thinning of the chamber walls³⁶.

Regarding pulp chamber depth, several studies have reported that increasing the chamber depth does not enhance fracture resistance, but may instead lead to more catastrophic failures^{18,39,9}.

For the chamber floor, it is recommended to remove gutta-percha to a depth of approximately 2 mm to create a saddle-shaped anatomy, which enhances stability⁴². According to Alqarni et al., the availability of sufficient intracoronal space allows endocrowns with only a 2 mm intracoronal extension to achieve maximum fracture resistance.

In cases where the remaining tooth structure is short, endocrowns without intracoronal extensions may still represent a clinically acceptable alternative, offering a reduced risk of catastrophic failure⁴³.

However, extension into root canals has been associated with reduced stress distribution efficiency and decreased marginal and internal adaptation^{18,9}.

Since achieving reliable adhesion to dentin remains a clinical challenge, the use of immediate dentin sealing (IDS) is strongly recommended to improve dentin bonding and minimize microleakage⁴⁴.

In some cases, irregularities in the pulp chamber walls may need to be corrected with resin composite material to eliminate undercuts that could hinder the passive seating of the restoration³⁹.

The fundamental requirement for an ideal endocrown preparation is that all cavity surfaces-including walls and the chamber floor-should be visible from a single occlusal viewpoint, with no undercuts or divergent areas.

Summary of Key Recommendations for Endocrown Preparation:

- **Cuspal reduction:** 2–3 mm with 90° circumferential butt-joint margins (1–2 mm wide).
- **Cervical margins:** Positioned as supragingivally as possible.
- **Pulp chamber divergence:** 5–7° to ensure a continuous transition between the pulp chamber and endodontic access cavity.
- **Gutta-percha removal:** Up to 2 mm depth to maintain a saddle-shaped cavity floor.
- **Internal design:** Smooth internal transitions, a relatively flat chamber floor, and sealed radicular spaces.

Adhesive cementation

Adhesive cement plays a crucial role in the performance and longevity of endocrowns by providing micromechanical retention. Effective adhesion facilitates optimal stress distribution, thereby enhancing fracture resistance. However, failure of the adhesive interface may lead to complications such as microleakage, secondary caries and periodontal problems⁴⁵.

Resin cements are the material of choice for endocrown cementation due to their strong bonding potential, aesthetic properties, high mechanical strength, and low solubility. They are generally classified as conventional resin cements or self-adhesive resin cements. Conventional resin cements require multiple bonding steps, including surface conditioning of both the tooth and the restoration with etchants and bonding agents. Although these steps enhance adhesion, they also increase the procedure time and risk of contamination, making the technique more sensitive. To simplify the clinical protocol and eliminate the need for pretreatment, self-adhesive resin cements were introduced. However, several studies have reported that their bond strength is comparatively lower than that of conventional resin cements⁴⁶.

Resin cements can also be categorized according to their polymerization mode: self-cured, light-cured or dual-cured.

Self-cured resin cements have limited clinical applications because of their inferior mechanical and aesthetic properties and shorter working time.

Light-cured resin cements provide extended working time, but their effectiveness is limited to shallow preparations, as light penetration in deeper areas may be inadequate, increasing the risk of adhesive failure.

Dual-cured resin cements, combining both self-curing and light-curing mechanisms, are therefore considered ideal for deep cavities, offering excellent mechanical performance and adequate working time⁴⁷.

Polymerization of resin cement may be negatively affected by residual eugenol-containing root canal sealers; this issue can be mitigated by thorough cleaning and acid etching of the cavity walls before cementation.

After placement, it is essential to remove all excess cement, especially from subgingival margins, to avoid biological complications.

Radiographic verification may be performed to ensure that no residual cement remains⁴⁸.

Conclusion

Based on the reviewed literature, it can be concluded that endocrowns represent a reliable and minimally invasive prosthetic alternative for the restoration of severely damaged endodontically treated teeth. They are most commonly indicated for mandibular molars, particularly those with complex root canal anatomies-such as curved, narrow or calcified canals-where conventional post-and-core restorations are more challenging. Among the available materials, lithium disilicate ceramics remain the most frequently used, owing to their excellent adhesive bonding capabilities and favorable mechanical and aesthetic properties.

Endocrowns have demonstrated comparable or superior fracture resistance under both axial and lateral loading compared to traditional post-and-core systems.

Consequently, they are regarded as an optimal therapeutic solution for the functional and aesthetic reconstruction of extensively compromised endodontically treated teeth.

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