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# OPEN VERSUS CLOSED EXPOSURE OF IMPACTED MAXILLARY CANINES

# ОТВОРЕНА НАСПРОТИ ЗАТВОРЕНА (ТЕХНИКА) НА ЕКСПОЗИЦИЈА НА ИМПАКТИРАНИ МАКСИЛАРНИ КАНИНИ

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## Abstract

This review aims to compare the effectiveness of two different canine exposure techniques (open vs. closed) regarding periodontal outcomes, duration of surgical treatment and canine's eruption, patient perception, aesthetics, and orthodontic treatment complications. The results indicate no significant difference between the two techniques in terms of periodontal outcomes and aesthetic appearance. However, the surgical procedure is shorter in the open exposure group, and the amount of postoperative pain during the first day is similar between the open and closed surgical exposure patients. **Keywords:** impacted maxillary canines, open surgical exposure, closed surgical exposure.

## Апстракт

Целта на овој преглед е да ја спореди ефикасноста на две различни техники за експонирање на канините(отворена и затворена) во однос на периодонталниот резултат, траењето на хируршкиот третман и ерупцијата на канините,перцепцијата на пациентот, естетскиот резултат и ортодонтските компликации од третманот. Резултатот е дека нема сигнификантна разлика помеѓу двете техники од аспект на пародонтолошки и естетски резултати. Меѓутоа, хируршката процедура е пократка кај отворената метода, а постоперативната болка во првиот постоперативен ден е слична помеѓу отворената и затворената метода. **Клучни зборови:** импактирани максиларни канини, отворено хируршко експонирање, затворено хируршко експонирање.

## Introduction

An impacted tooth can be defined as a tooth whose eruption is considerably delayed and for which there is clinical or radiographic evidence that further eruption may not take place[1].The incidence of canine impaction is 1.7%[2]. Impacted canines are palatally positioned in 85% of the cases[3].

Surgically assisted orthodontic intervention is often required to guide the canine into occlusion[4,5,6].

Surgical exposure and orthodontic alignment is indicated in patients beyond the age of interceptive treatment, in which the impacted canines are not severely ectopic, and the adjacent tooth shows no or mild resorption[7].

Accommodation of the canine within the arch can involve procedures of varying degrees of complexity, ranging from a simple interceptive treatment (removal of retained deciduous canine) or any impediments to exposure up to surgical reimplantation. A strategy that is commonly adopted is surgical exposure followed by orthodontic alignment. Two surgical methods for exposure are commonly used: open and closed. There is no general consensus about the choice of operative technique.

## Search method

A review of the literature was carried out using the following search methods: PubMed, MEDLINE, EMBASE, the Cochrane Central Register of Controlled Trials (CENTRAL), and the Cochrane Oral Health Group's Trials Register. The search was focused on various keywords including: 'open surgical exposure', and 'closed surgical exposure', as well as manual literature searches.

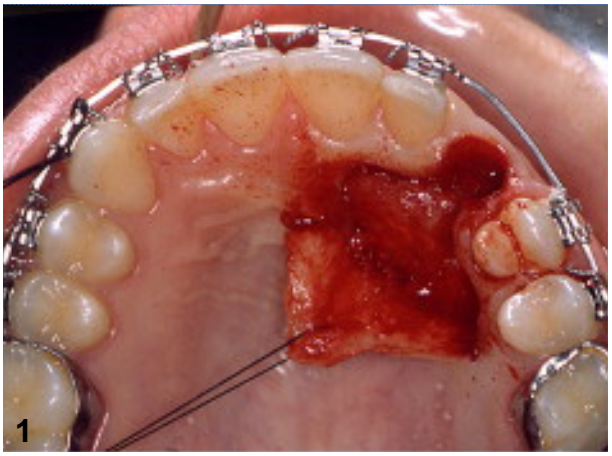
## Open and closed surgical exposure techniques

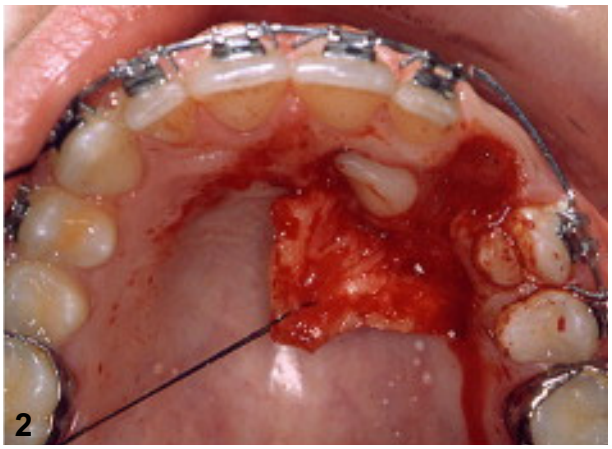
Open and closed surgical exposure techniques

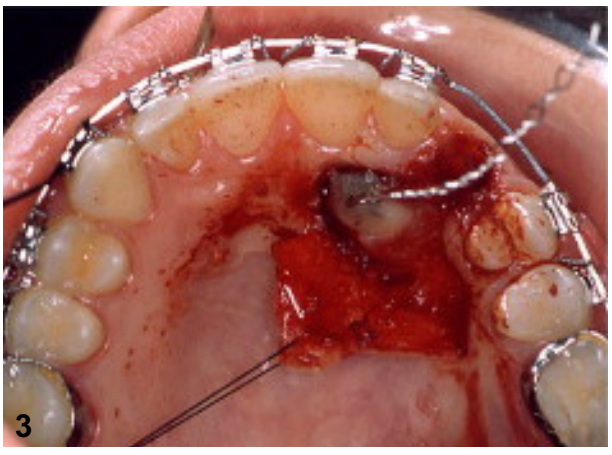
1. Closed exposure;
2. Open exposure;

## Closed Exposure

A full-thickness palatal mucoperiosteal flap is raised, the tissues overlying the canine crown are removed, and a low-profile orthodontic bracket with a gold chain attached is bonded to the canine crown[8]. The soft tissue covering the canine is not excised, and bonding is usually placed on the most accessible surface of the impacted tooth. Then, the gold chain is applied and passed through the incision. The free end of the chain can be retained with composite to an adjacent tooth, sutured to the mucosa, or attached to the archwire, if present (Figures1, 2, 3, and 4).





***Figures 1, 2, 3, and 4.*** *An example of closed exposure of palatally impacted canine. A full-thickness palatal mucoperiosteal flap with minimal bone removal (courtesy of Michele Nieri, Aldo Crescini, Robert Rotundo, Tiziano Baccetti, Pierpaolo Cortellini, and Giovan Paolo Pini Pratoe -28.08.2008 )cclusal carious lesions on tooth 85 and 84*

## Open Exposure

This procedure can be done either by excising the overlying mucosa or by elevating the full-thickness mucoperiosteal flap and removing enough bone to allow for the placement of an orthodontic attachment, followed by the repositioning of the flap with a hole (with or without dressing, depending on the vertical position of the canine). If the tooth does not erupt, surgical removal of any cicatricle tissue surrounding the crown is recommended.

There are two approaches to consider regarding the timing of the attachment placement and application of orthodontic traction, with or without traction.

### *Open Exposure Without Traction*

This involves the surgical exposure of the impacted canine in the late mixed dentition with no orthodontic traction[5,9]. This is done only when the tooth has a correct axial inclination assessed from the orthopantomogram[5,10]. Spontaneous attachment is placed on the tooth at the time of surgical exposure. The main advantage of this approach is that it avoids the delay in the application of orthodontic traction. Eruption can take up to 9 months postoperatively. The main advantage of this technique is that it allows for spontaneous eruption, thus reducing the time in active

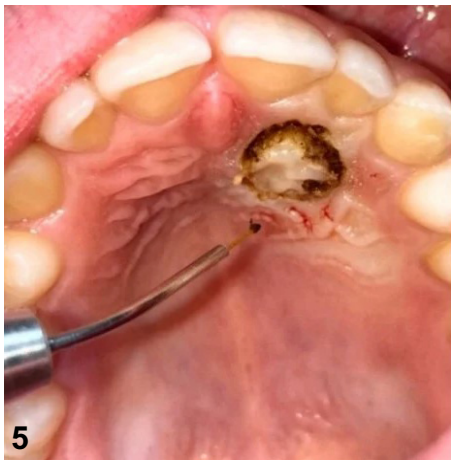




***Figure 5, Figure 6.*** *An example of open exposure of palatally impacted canine without traction wherespontaneous eruption of the impacted canine is allowed (courtesy of Alessandra Impellizzeri, Gaspare Palaia, Gerardo La Monaca, Daniele Pergolini, Antonella Polimeni, Umberto Romeo, Gabriella Galuccio - 23.02.2023)*

orthodontic treatment[9]. However, it should be noted that spontaneous eruption of the surgically exposed canine might take longer than active eruption[10] (Figures 5,6). The main disadvantage of leaving the exposed canine to erupt passively is gingival regrowth and the need for re-exposure.

## *Open Exposure With Traction*

Surgically exposed canines rarely erupt into a created space, without aid, if root formation is complete and the canine has unfavorable axial inclination, as determined from the orthopantomogram[5,10]. Therefore, after exposing the canine using the open technique, an attachment is bonded to the canine, and traction is applied. Bonding an eyelet was found to be more successful (94%) compared to an orthodontic bracket (75%), especially if it was bonded at the time of exposure[11].

Two options are suggested with regard to the timing of attachment placement[10]:

- Two-step approach: First, the canine is surgically exposed. Wound healing usually takes up to 8 weeks. At this point, an attachment is bonded to the crown of the impacted tooth[11,12]. This approach can be recommended when bleeding compromises attachment bonding during surgery.
- One-step approach: The attachment is placed on the tooth at the time of surgical exposure. The advantage of this approach is avoiding the delay in the application of orthodontic traction.

## Factors to consider when choosing open vs. closed technique

The main factors to consider when exposing using the open or closed surgical technique is gingival biotype and amount of keratinization. When the gingiva is attached,thick, and keratinized, we can do both techniques.

There are four important factors when selecting one exposure method over the other.

These factors are:

1. Presence of a dentigerous cyst;
2. Age of the patient;
3. The vertical level of impaction; and
4. Resorption of adjacent incisors.

### *Presence of dentigerous cyst*

When we want to preserve the tooth, and there is presence of a dentigerous cyst, we can enucleate the cyst and expose and bond the canine at the same visit.

After cyst enucleation, spontaneous eruption can be anticipated depending on canine eruption potential.

### *Age of the patient*

The root formation of maxillary canines is usually completed by the age of 13−15. If the impacted canine's root is not fully developed, spontaneous eruption using open exposure without traction might be anticipated. If the root apex is fully developed, there is little chance for the canine to erupt. Therefore, the tooth must be exposed (open or closed) with the application of active traction.

### *Resorption of adjacent tooth*

External root resorption of teeth (especially incisors) adjacent to the impacted is not uncommon[13]. The inci-

dence of root resorption of the adjacent lateral incisor caused by PICs was found in 68% of the cases when cone-beam computer tomography (CBCT) was used[14]. Therefore, CBCT should be considered in cases where the prognosis of the impacted canine and/or adjacent incisors is uncertain to justify whether exposure of the canine or removal of severely resorbed incisors is indicated[15]. If the impact is associated with severe resorption of the roots of incisors, then an open exposure method is contra-indicated since it might endanger the vitality of the incisors[14]. In this case, closed exposure is used to prevent the vitality of the impacted canine and incisor.

## *Vertical level of impaction*

The radiographic findings of the position of the impacted canine can determine the decision of which method is preferable. Taking the 'rule of thirds' into account, the closed exposure method is recommended for deeply impacted canines in vertical level III[16]. For canines positioned in level I or II, the open exposure method can be selected if the other three factors favor this method.

## *Outcomes of open versus closed exposure*

The advantages of the closed-exposure surgical technique are patient comfort during the healing process and better periodontal outcome. The advantages of the open exposure technique and spontaneous eruption of the canine are: the ability to observe the impacted tooth movement during treatment, no need for attachment bonding at the time of surgery, fewer failures, and less need to re-expose the impacted canine[17]. However, the latest Cochrane review concluded that there is a lack of high-quality evidence in this area, and further studies are needed in order to compare the outcomes of the two techniques[18].

It seems apparent that the evidence is equivocal, and these factors are less likely to influence the decision when selecting one exposure method over the other[17].

## *Patient comfort and perception of recovery*

The latest Cochrane review found a lack of high-quality evidence to support one technique over the other in terms of patient-reported outcomes[18]. Gharaibeh and Al-Nimri carried out a randomized prospective trial to compare patient perceptions of pain one week after having open exposure and closed exposure. It was found that clinically and statistically, there was no significant difference between the two methods. However, post-operative recovery seemed to be faster in the closed exposure group[19]. Londhe et al. suggested that the postoperative pain experienced by patients was similar, but the regression of pain was faster in the closed eruption technique[20]. The recovery period with the closed technique was significantly less than with the open technique. The perception of pain after surgical exposure of canines has been investigated in previous studies, which reported that there is no difference in the amount of pain between closed and open techniques. A moderate degree of discomfort was observed after the procedure, which disappeared a few days later[21,19]. A more recent multicenter randomized controlled trial reinforced the previous findings that there was no statistical difference between the two groups[21]. Chaushu et al. prospectively assessed patient perceptions of immediate postoperative recovery after the surgical exposure of impacted maxillary teeth with open exposure and closed exposure techniques. The comparison revealed that patients receiving an open exposure had a slightly longer recovery time[22]. However, no previous qualitative studies exploring patient perception and experiences with both techniques were found[17]. The postoperative recovery was longer after open eruption than the closed eruption technique. The mean recovery period was $72 \pm 4$ and $48 \pm 3.5$ h for open and closed eruption techniques, respectively ($P = 0.000$). Postoperative pain experienced by patients was similar, but regression of pain was faster in the closed eruption technique[20].

## *Periodontal health*

Parkin et al. carried out a multicenter, randomized controlled trial. Periodontal health was assessed three months after the removal of fixed appliances. More specifically, the level of attachment, crown height, bone support, and gingival recession were investigated in terms of comparisons of mean differences between previously impacted canines and their normal contra-laterals for closed and open eruption techniques. The results showed that there was no difference between canines exposed with open and closed surgical techniques[23]. The other trial involved palatally impacted canines exposed using open exposure without traction and closed exposure. A study found that there was no statistical difference in periodontal outcomes in terms of mean pocket depth, gingival recession, bone support, and width of keratinized gingiva between the closed and open exposure technique[24]. During the assessment of periodontal pocket depth, it was found that teeth that were treated with the closed technique had better periodontal health. The distal aspect of the erupted canine showed increased periodontal breakdown[20].

## Duration of the surgical exposure procedure

Gharaibeh, Al-Nimri, and Pearson et al. compared the operating times required to expose impacted canines surgically using the closed exposure method with the operating times required for the open exposure method. They reported that the closed exposure technique took longer to complete than the open exposure method[19,25]. Parkin et al. found the differences between the operating times not to be statistically significant[21]. The mean surgical time for the open eruption technique was 22.31±1.98 min, compared to 30.87 ± 2.38 min. for the closed eruption technique. The difference in time required for the two techniques was statically significant (P = 0.000)[20].

## Orthodontic treatment time

Two retrospective studies found that the duration of orthodontic treatment of impacted canines treated by the open exposure method or by the closed exposure technique was not significantly different between the groups[26,27]. The time needed for the canine's eruption, more specifically the duration from the surgical exposure of the canine until it was well positioned in the line of the arch, did not differ between the two exposure techniques[26]. On the other hand, it was reported that the eruption of the impacted canine was quicker for the patient group treated with the open technique. These researchers assessed the duration from surgery until a bracket can be bonded on the middle of the canine's labial surface[24]. The total duration of the orthodontic treatment depends on the level of impaction. Patients who had Level I impaction required guided eruption by orthodontic traction for an average period of 3±1.3 months, patients with Level II took an average of 5±1.4 months, while Level III impactions required 7±1.43 months to attain their proper position in the dental arch[20].

## Aesthetics

Parkin et al. recently carried out a multicenter randomized clinical trial to compare the aesthetic judgments of orthodontists and laypeople regarding the appearance of the impaction three months after treatment with either a closed or an open surgical exposure and orthodontic alignment[28]. The authors concluded that there is an aesthetic impact of aligning impacted canines, but it is mostly minor and unlikely to be detected by laypeople. Therefore, the aesthetic outcome is unlikely to affect the selection process of the exposure method. The results showed that there were no differences between the closed and open groups. The assessment of the inclination, shape, and color of the treated canines did not show any difference between the open and closed procedures[24].

## Re-exposure

Concerns exist about the frequency of repeat surgery with both the open and closed exposure techniques. If the closed method is used, failure of the bonded attachment usually means that repeat surgery is required to uncover the impacted canine so that a new bonded attachment can be placed. When the open exposure technique is used, overgrowth of the healing wound margins surrounding the surgical defect can necessitate further surgery to provide adequate access to the impacted canine[17]. Pearson et al. compared 52 consecutive cases treated by the open exposure technique with 52 patients treated by the closed exposure method[25]. His study found that 8 of the patients (15%) treated by open exposure required repeat surgery as a result of gingival overgrowth or failure to erupt. However, nearly one-third (31%) of the 52 patients treated by the closed exposure method required a second operative procedure. Six patients (12 %) needed repeat surgery as the result of the failure to erupt; bond failure occurred in 3 patients (6%), and in 7 patients (13 %), the wire ligature attached to the orthodontic bracket fractured. Although repeat surgery (re-exposure) can be required with both the open and closed exposure methods, the published evidence appears to indicate that this problem is more often associated with the closed eruption method[21].

## Ankylosis - related root resorption

Three main factors can cause trauma to the periodontal ligament or the cementum of the root of the impacted tooth and lead to ankylosis-related resorption:

1. The low-speed bur during exposure (both open and closed);
2. Chemical trauma to the periodontal ligament from the 35% phosphoric acid (this applies to open exposure as well as closed exposure);
3. Trauma to the periodontal ligament in the cervical region because of the direction or magnitude of the orthodontic force[17]. Thus, cervical root resorption can be a possible complication associated with both exposure techniques, especially if extensive bone removal is carried out beyond the cemento-enamel junction of the impacted canines[29].

## Conclusions

The surgical procedure was longer in the closed technique as compared to the open technique.Postoperative pain experienced by patients was similar, but the regression of pain was faster in the closed eruption technique. The recovery period with the closed technique was significantly less than with the open technique. The total duration of orthodontic treatment depends on the level of impaction; the deeper the impaction, the longer the duration of treatment. Canines managed with the closed method had better periodontal health compared to canines managed with the open method.

## Reference


1. Thilander B., Jakobsson SO. Local factors in impaction of maxillary canines; Acta Odontol Scand 1968; 26: 145−168;
2. Ericson S., Kurol J. Radiographic assessment of maxillary canine eruption in children with clinical signs of eruption disturbance; Eur J Orthod 1986; 8: 133−140;
3. Ericson S., Kurol J. Radiographic examination of ectopically erupting maxillary canines; Am J Orthod Dentofacial Orthop 1987; 91: 483−492;
4. Jacoby H. The etiology of maxillary canine impactions. Am J Orthod 1983; 84: 125−132;
5. Bishara SE. Impacted maxillary canines: Areview. Am J Orthod Dentofacial Orthop 1992; 101: 159−171;
6. Johnston WD. Treatment of PIC teeth; Am J Orthod 1969; 56: 589−596;
7. Husain J., Burden D., McSherry P., Morris D., Allen M. National clinical guidelines for management of the palatally ectopic maxillary canine; Br Dent J 2012; 213: 171−176;
8. Hunt NP. Direct traction applied to unerupted teeth using the acid-etch technique; Br J Orthod 1977; 4: 211−212;
9. Kokich VG. Surgical and orthodontic management of impacted maxillary canines; Am J Orthod Dentofacial Orthop 2004; 126: 278−283;
10. Bishara SE. Clinical management of impacted maxillary canines; Semin Orthod 1998; 4: 87−98;
11. Becker A., Shpack N., Shteyer A. Attachment bonding to impacted teeth at the time of surgical exposure; Eur J Orthod 1996; 18: 457−463;
12. Lewis PD. Pre-orthodontic surgery in the treatment of impacted canines; Am J Orthod 1971; 60: 382−397;
13. Ngan P., Hornbrook R., Weaver B. Early timely management of ectopically erupting maxillary canines; Sem Orthod 2005; 11: 152−163;
14. Walker L., Enciso R., Mah J. Three-dimensional localization of maxillary canines with cone-beam computed tomography; Am J Orthod Dentofacial Orthop 2005; 128: 418−423;
15. Becker A. Orthodontic Treatment of Impacted Teeth; Chichester, West Sussex: Wiley-Blackwell, 2012;
16. McSherry PF. The assessment of and treatment options for the buried maxillary canine; Dent Update 1996; 23: 7−10;
17. Alkadhimi AF., Ganesan K., Al-Awadhi EA. Orthodontic Update, 2017, № 3, p. 102-110;
18. Parkin N, Benson PE, Thind B, Shah A. Open versus closed surgical exposure of canine teeth that are displaced in the roofof the mouth; Cochrane Database Syst Rev 2008(4): CD006966;
19. Gharaibeh TM, Al-Nimri KS. Postoperative pain after surgical exposure of PICs: Closed-eruption versus open-eruption, a prospective randomized study; Oral Surg Oral Med Oral Pathol Oral RadiolEndod 2008; 106: 339−342;
20. Londhe SM, Roy ID, Kumar P. Management of Bilateral impacted maxillary Canines; Med J Armed Forces India 2009;65:190 2;
21. Parkin NA, Deery C, Smith AM, Tinsley D, Sandler J, Benson PE. No difference in surgical outcomes between open and closed exposure of palatally displaced maxillary canines; J Oral Maxillofac Surg 2012; 70: 2026−2034;
22. Chaushu S, Becker A, Zeltser R, Branski S, Vasker N, Chaushu G. Patients perception of recovery after exposure of impacted teeth: Acomparison of closed- versus open-eruption techniques; J Oral Maxillofac Surg 2005; 63: 323−329;
23. Parkin NA, Milner RS, Deery C, Tinsley D, Smith AM, Germain P et al. Periodontal health of palatally displaced canines treated with open or closed surgical technique: Amulticenter, randomized controlled trial; Am J Orthod Dentofacial Orthop 2013; 144: 176−184;
24. Smailiene D, Kavaliauskiene A, Pacauskiene I, Zasciurinskiene E, Bjerklin Kl. Palatally impacted maxillary canines: Choice of surgical-orthodontic treatment method does not influence post-treatment periodontal status. A controlled prospective study; Eur J Orthod 2013; 35: 803−810;
25. Pearson MH, Robinson SN, Reed R, Birnie DJ, Zaki GA. Management of palatally impacted canines: The findings of a collaborative study; Eur J Orthod 1997; 19: 511−515;
26. Iramaneerat S, Cunningham SJ, Horrocks EN. The effect of two alternative methods of canine exposure upon subsequent duration of orthodontic treatment; Int J Paediatr Dent 1998; 8: 123−129;
27. Fleming PS, Scott P, Heidari N, Dibiase AT. Influence of radiographic position of ectopic canines on the duration of orthodontic treatment; Angle Orthod 2009; 79: 442−446;
28. Parkin NA, Freeman JV, Deery C, Benson PE. Esthetic judgments of palatally displaced canines 3 months postdebond after surgical exposure with either a closed or an open technique; Am J Orthod Dentofacial Orthop 2015; 147: 173−181;
29. Koutzoglou SI, Kostaki A. Effect of surgical exposure technique, age, and grade of impaction on ankylosis of an impacted canine, and the effect of rapid palatal expansion on eruption: Aprospective clinical study; Am J Orthod Dentofacial Orthop 2013; 143: 342−352;

UDK: 616.314-77:615.464

# BONDING OF CERAMIC ORTHODONTIC BRACKETS TO FELDSPATHIC CERAMIC RESTORATIONS - ORIGINAL ARTICLE

# БОНДИРАЊЕ НА КЕРАМИЧКИ ОРТОДОНТСКИ БРЕКЕТИ НА ФЕЛДСПАТНИ КЕРАМИЧКИ РЕСТАВРАЦИИ

**Kuzmanovski S.[1]*, Bajraktarova Mishevska C.[2], Mijoska A[1], Stavreva N.[1], Andonovska M.[3], Jurhar R.[4], Petrovska Popovic S.[5], Bajraktarova Valjakova E.[1]**

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## Abstract

**Aim of the study:** To determine a conditioning protocol of feldspathic restorations in order bonding ceramic orthodontic brackets during fixed orthodontic treatment. **Material and method:** 45 ceramic specimens were obtained from feldspathic CAD/CAM blocks which were divided into five groups according to the performed conditioning method: 1. deglazing with a fine diamond bur (control group); 2. etching with 4% hydrofluoric acid (HF); 3. sandblasting with 29 μm alumina ($Al_2O_3$); 4. HF acid etching followed by conditioning with a universal primer - silanization (HF + S) and 5. alumina sandblasting followed by silanization ($Al_2O_3$ + S). A shear bond strength (SBS) test was performed after storing the samples in a water bath for 7 days. All of the fractured samples were analyzed with an optical microscope to determine the mode of fracture. **Results:** Etching with 4% hydrofluoric acid followed by silanization resulted in the highest bond strength - 9.68±1.19 MPa (95%CI 8.4-10.9), while alumina sandblasting followed by silanization – 6.62 MPa, which was non-significantly higher than HF acid etchingalone-5.62 MPa. Adhesive types of fractures were observed in the samples where only mechanical conditioning methods were used. In contrast, cohesive and mixed fractures were noted in samples treated with mechanical and chemical methods. **Conclusion:** Authors suggest that the optimal conditioning method when bonding ceramic brackets to restorations made of Mark II feldspathic ceramic is etching with 4% hydrofluoric acid, which ensures adequate bond strength during the fixed orthodontic treatment and prevents damage to the restoration during debonding of the brackets at the end of the orthodontic treatment. **Key words:** Ceramic brackets; Feldspathic ceramic; Conditioning methods; Hydrofluoric acid; Sandblasting; Silanization; Shear bond strength.

## Апстракт

**Цел на трудот:** Главната цел на трудот е одредување на протокол за кондиционирање на фелдспатни керамички реставрации пред бондирањето на керамички ортодонтски брекети во текот на фиксен ортодонтски третман. **Материјал и метод:** 45 керамички примероци добиени од фелдспатни CAD/CAM блокови беа поделени во пет групи според извршениот метод на кондиционирање на бондирачката површина: 1. Деглазирање со фин дијамантски борер (контролна група); 2. Нагризување со 4% флуороводородна киселина (HF); 3. Песочење со 29 μm алуминиум триоксидни зрна ($Al_2O_3$); 4. Нагризување со 4% HF киселина проследено со силинизација со универзален прајмер (HF + S); 5. Песочење со $Al_2O_3$ проследено со силанизација ($Al_2O_3$ + S). Тестот за одредување на силата на смолкнување (SBS) беше спроведен по складирање на примероците во водена бања (37°C) во траење од 7 дена. Сите бондирачки површини по дебондирањето на брекетите беа анализирани со оптички микроскоп со цел да се одреди типот на фрактура. **Резултати:** Нагризувањето со 4% флуороводородна киселина проследено со силанизација оствари највисока јачина на врзување (SBS) - 9,68±1,19 MPa (95%CI 8,4-10,9), додека песочењето проследено со силанизација - 6,62 MPa, што е несигнификантно повисоко од нагризувањето со HF киселина - 5,62 MPa. Атхезивниот тип на фрактура беше доминантен кај примероците каде кондиционирањето се спроведе користејќи исклучиво механички методи, додека зголемен процент на кохезивни и мешани фрактури беше забележан кај примероците каде што се користеа механички и хемиски методи за алтерирање на керамичките бондирачки површини. **Заклучок:** Авторите сугерираат дека оптималниот метод на кондиционирање на реставрации изработени од Mark II фелдспатна керамика при бондирање на керамички ортодонтски брекети, е нагризување со 4% флуороводородна киселина, што обезбедува соодветна јачина на бондирање од една страна и оневозможува оштетување на реставрацијата при дебондирање на брекетите на крајот од ортодонтскиот третман од друга страна. **Клучни зборови:** Керамички брекети; Фелдспатна керамика; Методи за кондиционирање; Флуороводородна киселина; Воздушна абразија; Силанизација; Сила на смолкнување.

## Introduction

With the increased number of adult orthodontic patients, clinicians often have to bond orthodontic brackets to teeth that have different types of restorations. One of the materials that have particularly presented problems to both the operative dentists and the orthodontists is ceramic due to its inert nature. Therefore, many attempts have been made to determine the conditioning method for altering the ceramic bonding surfaces, which will enable optimal bonding of orthodontic brackets[1]. There are different conditioning methods, which may be classified as mechanical, chemical, or mechanical-chemical methods.

In cases of natural teeth, the enamel surfaces on which the brackets will be bonded are etched using 37% phosphoric acid. However, in the presence of ceramic restorations, different protocols are required for etching the ceramic bonding surfaces due to their greater resistance to acids[2]. One of the mechanical methods for altering the ceramic surfaces is by etching with hydrofluoric acid. Clinicians should be very cautious when manipulating doing manipulations with this type of acid due to its corrosive and toxic effects on human tissues, including oral mucosa[3]. In addition, other conditioning methods can also be performed: sandblasting with 29 or 50 μm alumina particles, silicatization - sandblasting with silica-coated alumina particles.

Enhancing the bond between the ceramic brackets and ceramic restorations can be achieved by changing the nature of the bonding surface, using coupling agents such as ceramic primers or universal primers that contain silanes (chemical method). The silane contains two different functional groups: the hydrolyzable group that reacts with the inorganic ceramic, whereas its organofunctional group reacts with the resin, thus enhancing adhesion. Silanes are also known as adhesion promoters as they are adsorbed onto, altering the surface of a solid material (in this case ceramic) by either a chemical or physical process. The portion of the silane molecule that is not adsorbed presents a free surface that is wetted easily by adhesives. It is found that the silane coupler actually forms a chemical bond with both the resin and the porcelain, thus forming a bridge between the two materials[4]. In order to achieve a strong chemical bond with the adhesive resin, the process of silanization should be performed after altering the porcelain surfaces with mechanical conditioning methods[5].

The third method provides chemo-mechanical alteration of the ceramic bonding surfaces, which is performed with silica-coated alumina particles, known as silicatization.

The desired outcome of bonding the brackets to teeth previously restored with ceramic restorations is to provide an optimal bond that will be able to withstand the forces produced during the orthodontic treatment, as well as mastication, without displacement/debonding the brackets. On the other hand, the achieved bond strength should not be too strong so it can prevent any damage to the ceramic restoration during the debonding process of the brackets at the end of the orthodontic treatment when the detachment is preferred to occur at the bracket–adhesive interface[6]. The aim of this study was to determine a conditioning protocol of feldspathic restorations in order to bond ceramic orthodontic brackets during fixed orthodontic treatment.

## Material and method

Feldspathic CAD/CAM ceramic blocks Vita Mark II (VITA Zahnfabrik, Germany) (Fig. 1a) were cut by a precision cutting machine - Minitom (Struers, Denmark) using diamond blades, into 2 mm thick ceramic sections (Fig. 1b). Cutting was performed with permanent water cooling to prevent overheating of the ceramic material that may cause micro-cracks. The ceramic sections had rectangular shapes with a flat bonding surface, unlike ceramic restorations' vestibular surface designed with slight convexities imitating the morphology of the natural teeth. The anatomo-morphology of the restoration may influence the bond strength due to the unequal contact of the bracket and the bonding surface.

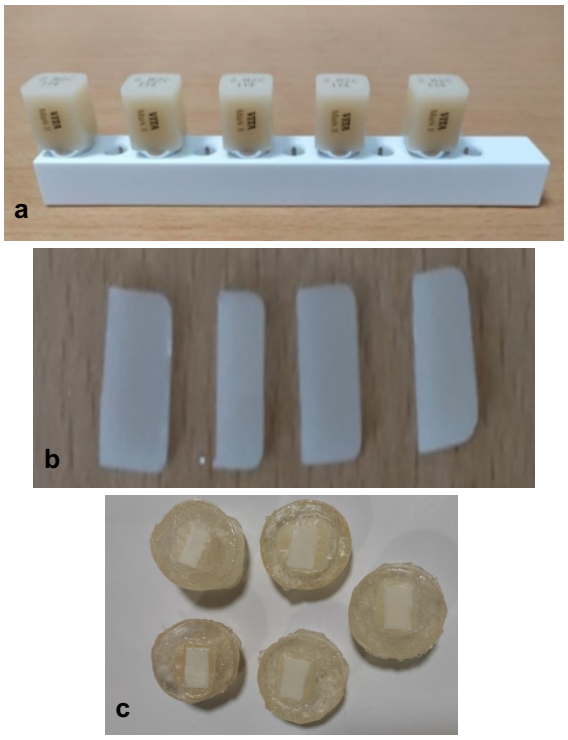


***Figure 1.*** *a) Feldspathic CAD/CAM ceramic blocks; b) Ceramic sections; c) Prepared acrylic molds with ceramic samples.*

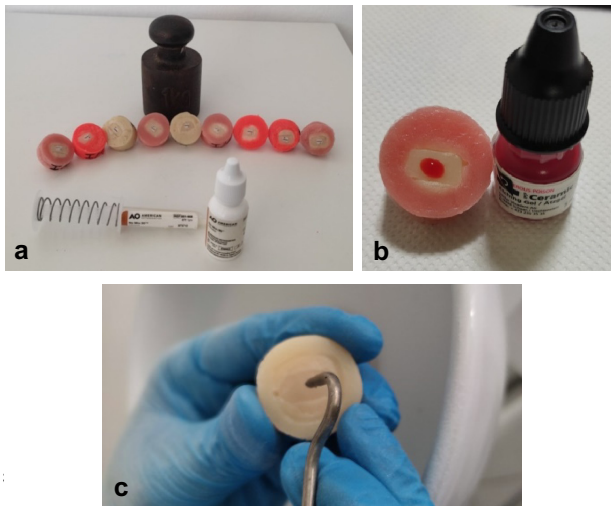

*Figure 2. a) Control group; b) Etching the samples with 4% hydrofluoric acid; c) Sandblasting.*

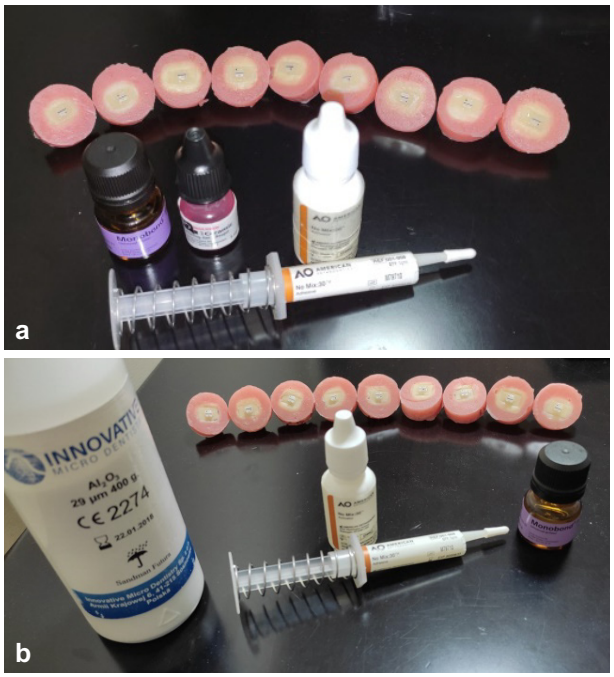

*Figure 3. a) Prepared samples - group 4; b) Prepared samples -group 5.*

Acrylic molds were prepared in the next step: the ceramic sections were immersed in the middle of the metal ring molds (d =30 mm) filled with freshly mixed auto-polymerizing acrylate – PoliTEMP (PoliDent, Slovenia), with an exposed ceramic surface that was used as a bonding surface for the ceramic brackets (Fig. 1c). Before the beginning of the conditioning treatments, the bonding surface of all samples was grinded using fine diamond burs. The prepared 45 samples were randomly divided into five groups:

1. **Control group** – no treatment (Fig. 2a).
2. **HF** - the ceramic samples were treated with 4% hydrofluoric acid - IPS Ceramic etching gel (Ivoclar Vivadent, Shaan Liechtenstein) for 60 seconds followed byrinsing for 60 seconds with copious water, and air dried with compressed air (Fig. 2b).
3. **$Al_2O_3$** - the bonding surfaces were sandblasted with 29-μm $Al_2O_3$ particles – Sandman (Innovative Micro Dentistry, Poland), perpendicular to the bonding surface, for 10 seconds, under a pressure of 1 bar and at 10 mm distance (Figure 2c). Surfaces were cleaned with air blowing for 5 sec.
4. **HF+S** - the bonding surfaces were etched with 4% hydrofluoric acid for 60 s, rinsed, and dried. A universal primer, Monobond Plus (IvoclarVivadent, Shaan Liechtenstein), was applied in a thin coat and left to react for 60 seconds (Fig. 3a).
5. **$Al_2O_3$+S** - the bonding surfaces were sandblasted with 29-μm $Al_2O_3$ particles using a blasting procedure as in Group 3. After that, a universal primer, Monobond Plus, was applied in a thin coat and left to react for 60 seconds (Figure 3b).

## *Bonding procedure*

Ceramic brackets for maxillary central incisors – Cosmetic 20/40 UR Central (American Orthodontics, USA) were bonded to treated surfaces using orthodontic composite luting cement (self-curing adhesive) No Mix:30TM One step Adhesive – (American Orthodontics, USA) with a constant vertical load of 1 kg, for 1 min. The samples were stored in distilled water at 37°C for 7 days – Biobase Water Tank WT-42 (Biobase Biodustry, Shandong, China), thus imitating the conditions in the oral cavity (moisture and temperature) (Fig. 4a).

## *Shear bond strength test*

The shear bond strength test (SBS) was performed using a universal testing machine – Shimadzu AGS-X (Shimadzu Co., Japan), at a speed of 0.5 mm/min until

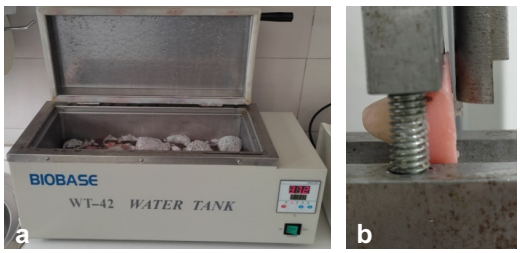


*Figure 4: a) Samples stored in a water bath, b) Performing of shear bond strength (SBS) test.*

fracturing occurred, to determine the bond strength between the orthodontic brackets and the ceramic surfaces (Figure 4b). The SBS was expressed in megapascals (MPa), derived by dividing the imposed force (N) at the time of fracture by the bonding area of the ceramic bracket (mm2) (MPa = N/mm$^2$).

### *Mode of fracture*

The mode of fracture (adhesive, cohesive in luting cement or ceramic bracket or mixed) for each specimen was determined using optical microscopy – Levenhuk Zeno Cash ZC6 (Levenhuk Inc., USA) at a magnification of 60x.

### *Statistical Analysis*

The categorical variables were analyzed by determining the coefficient of relationship, proportions, and rates. Continuous variables were analyzed using measures of central tendency (mean, median, minimum, and maximum values) and by measuring dispersion (standard deviation). Shapiro-Wilk W test was used to determine the normality of the frequency distribution of the studied variables. Pearson's chi-squared test was used to determine the association between certain attributive dichotomous features. The One-way ANOVA test was used to compare the Shear bond strength (SBS) values for multiple independent continuous variables with correct frequency distribution. In addition, Tukey post hoc (HSD) was used in order to determine the size of the effect of the determined significance between the variables.

## Results

The mean values of the shear bond strength (SBS) after the various treatments of the ceramic bonding surfaces are shown in Figure 5, and the percentage values of the mode of fracture after the debonding areshown in Table 1.

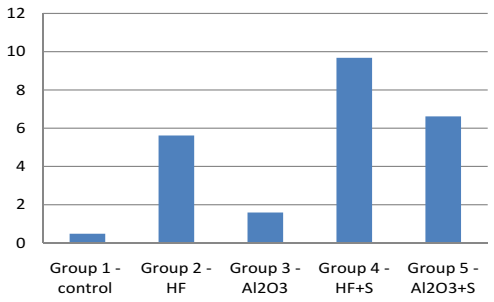


***Figure 5.*** *Mean SBS (MPa) after different conditioning treatments.*

**Table 1.** Mode of fracture after debonding.

| | Mode of fracture | | |
|---|---|---|---|
| | Adhesive (%) | Cohesive (%) | Mixed (%) |
| **Group 1** | 100 | / | / |
| **Group 2** | 77.7 | 11.1 | 11.1 |
| **Group 3** | 100 | / | / |
| **Group 4** | / | 85.7 | 14.3 |
| **Group 5** | 22.2 | 66.6 | 11.2 |

The highest mean SBS of 9.68±1.19 MPa (95%CI 8.4-10.9) with min/max values of 8.1/11.5 MPa was recorded in Group 4 (HF+S), which was significantly higher compared to all other groups. The mean SBS value of Group 5 (Al2O3+S) was 6.62 MPa,which shows a non-significantly higher value (p=0.6856) than Group 2 (HF) with a mean value of SBS of 5.62 MPa. Group 3 (Al2O3) provided a low mean SBS value of 1.59 MPa, which is not significantly higher (p=0.3629) compared to the control group.

An adhesive mode of fractures can be observed in the samples of the first three groups where only mechanical conditioning methods were used. An increased percentage of cohesive and mixed fractures is noted in Groups 4 and 5, where mechanical and chemical methods were performed to alter the ceramic bonding surfaces.

## Discussion

The aim of this study was to investigate the SBS between orthodontic ceramic brackets and monolithic CAD/CAM ceramic Vita Mark II after different conditioning methods of the feldspathic bonding surface and mode of fracture after debonding the brackets. High SBS values were achieved in the ceramic samples that were altered using mechanical and chemical methods (etching with hydrofluoric acid or alumina sandblasting, with the additional application of a universal primer) and in the ceramic samples that were etched with HF acid only. Lower SBS was observed when sandblasting was the only conditioning method without the application of a universal primer, while the lowest SBS values were found in the control group; that means that if the ceramic bonding surfaces are not altered and conditioned, then sufficient bond strength between the orthodontic brackets and the ceramic bonding surfaces cannot be expected.

When bonding orthodontic brackets to ceramic restorations, it is necessary to change the inert ceramic

surface to achieve clinically acceptable bond strength. The maximum bond strength that may be achieved is not usually required for orthodontic purposes. The ideal bond strength should be sufficiently strong to endure a course of orthodontic treatment and, at the same time, be sufficiently weak so not to cause any damage to the restoration during the debonding process when the orthodontic treatment is finished[7]. If the SBS exceeds 13 MPa, fracture of the ceramic surface can be expected. According to Schmage et al., the SBS value of 6 to 10 MPa is sufficient to ensure adequate bond strength between the orthodontic brackets and the ceramic surfaces[8].

The results of Türkkahraman's study show that the highest SBS values are detected when porcelain surfaces are treated with hydrofluoric acid followed by the application of a silane coupling agent. When ceramic materials are etched with 9.6% HFA, a double reaction occurs: primary - between the acid and the glassy phase, and secondary - between the acid and the crystalline phase, leaving the larger crystals intact. This creates an irregular surface with microscopic pores that enable the micromechanical retention of the adhesive resin[9]. There is a greater resistance of the ceramic to the acid etching when the crystalline phase is more present than the glassy phase in the composition of the ceramic material[2]. Ajouni et al. proved that etching with hydrofluoric acid and primer conditioning provided the strongest bond of orthodontic brackets to ceramic, but at the same time caused the greatest damage to the ceramic surfaces during debonding[1]. According to Bishara et al., the most reliable bonding procedure of orthodontic brackets to porcelain surfaces is micro-etching with hydrofluoric acid and conditioning with a silane coupler; this combination also produces the greatest damage to the porcelain surface[10].

Sandblasting as a method for mechanical alteration of the bonding surfaces of ceramic restorations causes an irregular surface required for micromechanical retention of the adhesive resin. On the other hand, sandblasting can cause irreversible damage to the ceramic restorations. Therefore, it is recommended that sandblasting should be performed under low pressure (1-2 bar), using aluminum oxide grains with a size smaller than 50 μm and at a distance of 10 mm from the surface being treated. In Türkkahraman's study, it was concluded that silane application to sandblasted ceramic provides poor results in vitro, and clinical trials are needed to determine its reliability for bonding ceramic brackets to ceramic crowns[9]. Also, Zachrisson reported that silane application to sandblasted ceramic did not provide clinically acceptable bond strength and suggested abandoning this technique[11].

The application of a silane coupling agent may produce such high bond strength with a tendency for cohesive fractures of ceramic surfaces during the debonding process, especially when the bonding surfaces have been acid-etched[12]. Newman reported that the bond strength between the resin and porcelain, achieved by using a silane, was sufficient to cause fracturing of the porcelain. Such an occurrence is undesirable when associated with the removal of orthodontic brackets from porcelain crowns on restored teeth[4]. On the other hand, literature data show that the use of a silane coupling agent as the only conditioning method of the ceramic surfaces does not provide long-term bond strength due to the susceptibility of the chemical bonds to hydrolysis[13].

Determining the optimal conditioning treatment for ceramic restorations is largely dependent on the analysis of fracture mode after debonding. The adhesive mode of fracture usually occurs when weaker bond strength is present between ceramic restorations and orthodontic brackets. During the optical microscopy analysis of the ceramic surfaces, no residue of the adhesive resin was observed on the bonding surfaces. The cohesive type of fracture, on the other hand, was often present in the samples that were treated with methods that achieved higher bond strength with the orthodontic brackets, whereby residue from the adhesive resin was observed on the ceramic surfaces. In some cases, parts of the fractured ceramic brackets that remained bonded to the ceramic surface could also be observed.

Despite the significance of this topic for the success of orthodontic treatment, there remains a noticeable gap in the existing literature. The limited number of studies addressing this issue highlights the need for further investigation to develop a more comprehensive understanding and guide future research, with an emphasis on clinical trials.

## Conclusions

The authors suggest that the optimal conditioning method when bonding ceramic brackets to teeth restored with Mark II feldspathic ceramic is etching with 4% hydrofluoric acid, which ensures adequate bond strength and most adhesive modes of fracture during the debonding process.

As an alternative conditioning method, the authors suggest the use of alumina sandblasting followed by chemical conditioning with a universal primer.

Additional clinical trials are needed to verify which suggested conditioning method offers an optimal bond.

## Acknowledgements

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## Reference

1. Raed A, Samir E. Bishara et al. The Effect of Porcelain Surface Conditioning on Bonding Orthodontic Brackets. Angle Orthodontist 2005, 75(5): 858-864.
2. Yucel MT, Aykent F, Akman S, Yondem I. Effect of surface treatment methods on the shear bond strength between resin cement and all-ceramic core materials. Journal of Non-Crystalline Solids 2012, 358(5): 925–930.
3. Bajraktarova-Valjakova E, Korunoska-Stevkovska V, Georgieva S. Hydrofluoric acid: burns and systemic toxicity, protective measures, immediate and hospital medical treatment. Open Access Macedonian Journal of Medical Sciences 2018, 6(11): 2257–2269.
4. Newman GV. Bonding to porcelain. Journal of Clinical Orthodontics 1983, 17:53-55.
5. Chen J, Matsumura H, Atsuta M. Effect of etchant, etching period, and silane priming on bond strength to porcelain of composite resin. Operative Dentistry 1998, 23: 250–257.
6. Alzainal HA, Shehab Majud A, Al-Ani MA, Mageet OA. Orthodontic bonding: Review of the literature. International Journal of Dentistry 2018, 2020:8874909.
7. Bourke, B. M., & Rock, W. P. Factors affecting the shear bond strength of orthodontic brackets to porcelain. British journal of orthodontics 1999, 26(4), 285–290.
8. Schmage P, Nergiz NV, Herrmann W, OzcanM, Nergiz I.Influence of various surface-conditioning methods on the bond strength of metal brackets to ceramic surfaces. American Journal of Orthodontics and Dentofacial Orthopedic 2003, 123(5): 540-546.
9. Türkkahraman H, Küçükesmen HC. Porcelain surface-conditioning techniques and the shear bond strength of ceramic brackets. European Journal of Orthodontics 2006, 28(5): 440-443.
10. Bishara, Samir E et al. Bonding orthodontic brackets to porcelain using different adhesives/enamel conditioners: a comparative study. World journal of orthodontics 2005, 6(1): 17-24.
11. Zachrisson B U. Orthodontic bonding to artificial tooth surfaces: Clinical versus laboratory findings. American Journal of Orthodontics and Dentofacial Orthopedics 2000, 117(5):592 – 594.
12. Lacy, A. M., LaLuz, J., Watanabe, B. S. and Dellinges, M.Effect of porcelain surface treatment on the bond to composite. Journal of Prosthetic Dentistry 1988, 60,288–291.
13. Yang B, Barloi A, Kern M. Influence of air-abrasion on zirconia ceramic bonding using an adhesive composite resin. Dental Materials2010, 26: 44–50.

UDK: 616.314-74:615.46

# COMPOSITE RESIN RESTORATION OF ENAMEL-DENTIN FRACTURE OF PERMANENT CENTRAL INCISOR - CASE REPORT

# КОМПОЗИТАНА РЕСТАВРАЦИЈА НА ЕМАЈЛОВО-ДЕНТИНСКА ФРАКТУРА КАЈ ТРАЕН МАКСИЛАРЕН ИНЦИЗИВ - ПРИКАЗ НА СЛУЧАЈ

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## Abstract

**Aim:** The aim of this study is to present the application of piezosurgery in the extraction of an impacted mandibular third molar in a patient with Parkinson's disease. The goal is to preserve insufficient bone tissue and maintain the integrity of the mandibular canal contents in a limited surgical field. **Material and Method:** A 67-year-old male patient with total toothlessness and Parkinson's disease visited the University Clinic for Oral Surgery and Implantology with signs of acute odontogenic infection in the lower left quadrant. A CBCT scan revealed the presence of an impacted left mandibular third molar, with close proximity to the apex of the tooth and the roof of the mandibular canal, which were separated from each other by a 1 mm bone wall. **Results:** The use of piezosurgery in the treatment of an impacted third molar in a patient with Parkinson's disease proved to be the most effective and predictable method, minimizing trauma to soft tissue and bone structures. **Keywords:** impacted mandibular third molar, piezosurgery, Parkinson's disease, surgical extraction.

## Апстракт

Композитната реставрацијата на забите софрактура на коронкатае конзервативно, навремено и економично решение при избор на третман. Современите адхезиви и композити им овозможуваат на стоматолозите да ги обноват фрактурираните дентални структури, враќајќи ја естетиката и функцијата на повредениот заб. Во оваа студија е прикажанаемајловодентинскатрауматска повреда на левиот максиларен централен инцизив. Пациентпт е на 7.5 годишна возраст чија повреда настанала при пад од стол во домашни услови. Опишана е целата процедура од приемот на пациентот во стоматолошка ординација до дефинитивно реконструктивно решение - реставрација со композитна смола. Реставрацијата со композитна смола на трајните заби со траума на коронката е едноставна процедура која треба да се планира и изведе запазувајќи ги анатомските и морфолошките карактеристики на фрактурираниотзаб, но исто така и повторно воспоставување на функцијата и естетиката на забот. **Клучни зборови:** фрактура на коронка, композитни реставрации, дентална траума.

## Introduction

Dental trauma injuries are the most common injuries in childhood and among schoolchildren. Tooth fractures mostly involve front teeth in the upper jaw because of their position in the oral cavity. However, they can also occur in the lower jaw and posterior teeth.

Boys are affected almost twice as often as girls in the primary and permanent dentition. Most of these injuries in both dentitions involve the anterior teeth, especially the maxillary central incisors. The injuries of the primary dentition most often happen between the ages of 2 and 4 because at this age, the child is learning to walk by itself, the coordination and judgement are incompletely developed, and the majority of injuries are due to falls in and around the home[1]. The injuries of permanent dentition are most often between the ages of 7 and 10, and they are caused by falls while playing and running some contact sports. However, bicycling and scooters are the common accessories of this age[2,3].

According to one research article, on a global scale, aprevalence of 22 % and 15 % has been observed for traumatic dental injuries in the primary and permanent dentition, respectively, along with an incidence rate of 28.2 cases per 1000 per year. Accidental falls, road traffic accidents, and some sports activities are reported as

the most frequent causes of dental injuries in children worldwide[4].

Trauma to the frontal teeth is one of the most disturbing conditions for children and parents. Treatment strategies for immature young teeth should aim to preserve pulp vitality for continuing tooth maturation and root development, especially in young patients with incomplete apexogenesis[5].

Dental trauma may result in esthetic, psychological, and functional problems. Also,it can make changes in speech and chewing and interfere with the child's normal development. Because of that, it is important that the missing parts of the teeth are reconstructed[6].

Over the past two decades, there has been a significant rise in the occurrence of traumatic dental injuries. It is likely to increase the incidence rate of traumatic dental injuries compared to dental caries and periodontitis in the future[7].

Children with lip competence coverage and children with obviously protruding incisors or increased overjet have a higher risk of injuries to the front teeth.

Dental trauma can be direct or indirect[11].

Direct dental trauma refers to an injury to the teeth and surrounding structures that occurs due to an external force or impact. This type of trauma typically involves physical damage to the teeth, gums, or jawbone and can happen due to various causes, such as falls, sports accidents, car accidents, or physical alterations. Types of direct dental trauma include chipped or fractured teeth, tooth displacement, avulsion, intrusion, or root fractures. Direct dental trauma causes fractures of front teeth, especially in the upper jaw[12].

Indirect dental trauma refers to injuries to the teeth and surrounding structures that occur due to forces transmitted through the jaw or other parts of the head rather than a direct impact to the teeth themselves. This type of trauma can occur when an external force such as a blow to the face, a fall, or a sudden jolt causes damage to the teeth, gums, or supporting structures indirectly, without direct contact with the tooth. Indirect dental trauma causes fractures of the premolars and molars[13].

Enamel-dentin fractures involve the upper central incisors, upper lateral incisors, or lower incisors. Patients with this type of fracture don't feel spontaneous pain. The tooth is just sensitive to temperature changes or chemical irritations, and the pain is present due to mastication. Early treatment of a fractured tooth gives the best chance for full recovery[8].

This paper reports a case of a permanent maxillary central incisor with crown fracture treated using composite resin restoration.

## Case Report

Parents with a 7.5-year-old male came to the Clinic for Pediatric and Preventive Dentistry at University Dental Clinical Center "St. Panteleimon", Skopje with a chief complaint of tooth enamel dentin fracture without pulp exposure one day after a fall in his house. The extraoral examination revealed no laceration or injury of the soft tissue. The surrounding soft tissue was uninjured.

The dental history revealed that he had a trauma as a result of a fall at home. The patient reported no treatment until that moment, and the crown fragment had been lost during the accident.

The patient had an Uncomplicated Crown Fracture (dentin and enamel): A coronal fracture confined to enamel and dentin without pulp exposure in teeth 21. The parents didn't find the missing tooth fragment. The surrounding soft tissue was not injured. The child and his parents were visibly upset, and we were not able to do an X-ray.

***Figure 1.*** *Coronal fracture of maxillary central incisors involving enamel and dentin.*

Clinical examination (Fig. 1) revealed a horizontal fracture with the leftmaxillary central incisor (21) involving enamel and dentin. An extraoral examination revealed no significant abnormalities. Soft tissue examination revealed lacerations of the upper lip. The tooth was tender on percussion and palpation. Periodontal probing depths were within the normal parameters. The tooth was grade I mobile and gave an early response to vitality tests.

The intraoralexamination showed that the injury had caused an uncomplicated crown fracture of the tooth (21) without pulp exposure (Figure 1). Clinical examination evidenced a fracture involving only the enamel aspect with no symptoms. Objective symptoms – there was missing part of the crown, and the pulp was not exposed.

In order to prevent pain and pulp infection, we made a temporary restoration with glass ionomer cement (GJC). The fractured incisor was just covered with calcium-hydroxide paste and glass ionomer cement becausethe child was anxious and didn't cooperate, and the restoration was scheduled for the next visit.

A check-up was scheduled two weeks after the day they came.During the second check-up, the child was uncooperative again, and we couldn't take any photos or x-rays.We just took the information from the parents that the boy did-

n't complain of any toothaches. We scheduled the next visit for two weeks later.

On the next visit, we checked the pulp vitality, and the pulp had a normal reaction.The glass ionomer cement was no longer there. The parents said that two days before the visit, they noticed that (Figure1). The boy didn't complain of any cold or hot sensations or during mastication. Then, the reconstruction of enamel-dentin injuries with composite resin (Tetric Evo Ceram Bulk Fill, Ivoclar Vivadent, Schaan, Liechtenstein) was done.

***Figure 2.*** *Build-up of the left central incisor.*

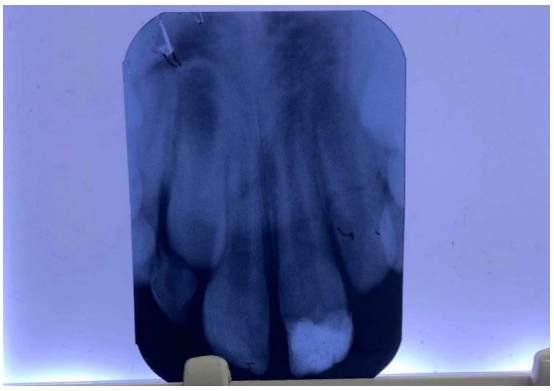

***Figure 3.*** *Radiographic follow-up after composite restavration*

***Figure 4a.*** *The restoration was then polished with FlexiDiscs and Astropol points*

***Figure 4b.*** *Frontal appearance of the restoration.*

The restoration was initiated with a small amount of composite from the palatal surface of the tooth. After that,we made the approximal surface using flexible matrices for anatomical anterior proximal restorations. Then, layer by layer, we reconstructed the labial surface of the fractured teeth (Figures 2). After that, we finished and polished the external enamel surface using abrasive disks, silicone points, and cups. Then, the occlusion should be carefully checked and adjusted to avoid a heavy occlusal load on the restoration. After the reconstruction, we took x-rays (Figure 3) and photos (Figures 4 a, b).

The advice given to the parents is regular visits to the dentist, during which the vitality of the restored teeth will be monitored. It is necessary to control the vitality of the pulp after 6-8 weeks, after 1 year, and as needed.

## Discussion

The restoration of the front teeth is more challenging in the practice of esthetic dentistry. Today, there are significant improvements in the esthetic materials and techniques. The changes in composite resins over the years have led to success in treatment with minimal loss of tooth structure, short operating time, and minimal cost for parents compared to veneers and porcelain crowns[12,18].

Enamel-dentin fractures are common dental injuries involving the hard outer enamel and the underlying dentin. These fractures typically occur as a result of traumatic impacts such as falls, accidents, or sports injuries. The severity and treatment of these fractures can vary depending on the extent of damage to the tooth structure, the location of the fracture, and the timing of treatment.

The upper central incisors are the most affected teeth by trauma because of their position on the dental arch. Also, they are the most visible in the smile. Because of this, it is important to reconstruct them with satisfactory esthetic. Dental trauma of the incisors is a very challenging emer-

gency situation, especially when the patient is a young child[9,10].

This situation requires immediate assessment, especially in young permanent teeth, where the apexogenesis is incomplete, like the one in this case.

Composite resins provide satisfactory treatments for young and adult patients.

Aesthetic and functional rehabilitation is the primary goal of the treatment of crown-fractured teeth. Actually, an alternative approach, which is becoming more attractive due to the technology of new dentin bonding agents, is fragment bonding; however, in cases of absence of the fragment, it becomes essential to preserve the remnant tooth structure with a composite resin restoration[11,12].

The current case offers a conservative, time-saving, inexpensive treatment option for a common type of esthetic problem following dental trauma. This case involves direct composite restoration using the layering technique. This technique is indicated for young patients because of the fewer clinical appointments, tooth preservation, and satisfying esthetic results[13].Composite resins provide satisfactory treatments for young and adult patients.

In the present case, the patient sustained a fracture to the maxillary incisor, with the involvement of both enamel and dentin. The fracture line extended through the enamel and into the dentin, leaving the pulp intact. This type of injury, known as enamel dentin fracture, represents a moderate level of damage that requires prompt intervention to prevent further complications such as pulp exposure or infection.For uncomplicated crown fractures, as in this case with enamel and dentin involvement without pulp involvement, direct adhesive restorations are the most common reconstructive treatment[14]. However,if the parents have the fractured fragment, that would be the first choice of treatment. The patient in this case did not have the fragment, so the reconstruction was planned with composite resin.

The composite resin restoration of permanent incisors with crown fractures is a simple procedure that should be planned and restored with attention to detail. Good results can be obtained by following a protocol aimed at preserving the pulp's vitality and restoring the injured tooth's functional and esthetic characteristics. The variation of some characteristics of the composite materials, like translucency and opacity of composite resins, requires the professional to know the different esthetic restorative materials and their optical behavior and may thus replace or correct color tones during the restorative procedure[15,16].

Several variables can affect the longevity of this type of restoration, including the extent of the crown fracture, the restoration size, the occlusion of the restored tooth, and the overall prognosis of the injured tooth[17,18]. The choice of resin should be focused on aspects related to strength and aesthetics. The present hybrid resins, due to their high percentage of inorganic filler and diversity of colors for enamel and dentin, allow satisfactory clinical results in terms of the longevity of the restoration.

## Conclusions

Enamel-dentin fractures are frequent clinical occurrences that can be successfully managed with timely and appropriate intervention. The careful assessment of fracture severity, coupled with the selection of suitable restorative materials, can significantly affect the long-term outcomes. The case underscores the importance of early diagnosis and intervention in minimizing complications and preserving the function and aesthetics of the affected tooth.

They must employ minimally invasive therapies, and an indirect composite resin restoration may be a suitable option with numerous advantages (i.e., reversibility, reparability, optimal esthetics, and more economical than ceramics) and may provide acceptable long-term success.

The composite resin restoration of permanent incisors with crown fractures is a simple procedure that should be planned and restored with attention to dental contours and convexities, facilitating the re-establishment of function and aesthetics.

## Reference


1. Ambarkova V, Tringo A, Fejzuli A, Krmzova T. Avulsion of primary teeth-case report. MicroMedicine 2021;9(2):37-41.
2. Welbury R, Whitworth JM, and Duggal MS. 12 Traumatic injuries to the teeth. https://pocketdentistry.com/12-traumatic-injuries-to-the-teeth/;
3. Milas A.Dentalnetraume u djecenapodručjugradaSplita u razdoblju od 2016. do 2021. Godine, 2021.view at: https://repozitorij.mefst.unist.hr/islandora/object/mefst:1219;
4. Patidar D, Sogi S, Patidar DC, Malhotra A. Traumatic Dental Injuries in Pediatric Patients: A Retrospective Analysis. Int J Clin Pediatr Dent. 2021 Jul-Aug;14(4):506–511. https://pmc.ncbi.nlm.nih.gov/articles/PMC8585915/#:~:text=This%20retrospective%20study%20aimed%20to%20analyze;
5. Thomas JM, Amutha Prabha Arumugam E, Harris A,Vimala Ravi V. Management of Traumatized Immature Vital Tooth: A Case Report. J Pharm Bioallied Sci 2019 May;11(Suppl 2): 481-484. https://pmc.ncbi.nlm.nih.gov/articles/PMC6555313/;
6. Costa Silva de OMENA AL, Aguiar Ferreira I, Lima Ramagem C, Maria Silva Moreira K. Severe trauma in young permanent tooth: Acase report.RGO, Rev GaúchOdontol 2020;68:1-5. https://www.scielo.br/j/rgo/a/4bbGN3YxpSJDx48zfcnWq4H/?lang=en;
7. Bellamkonda P, Akkaloori A, Koothati RK, Trinita H, Sharma M, Krishna V. Investigation of Anterior Teeth Fractures Among Students Aged Between 8 and 13 Years in Hyderabad, India.Cureus 2024;16(1):1-8. https://www.cureus.com/articles/222124-investigation-of-anterior-teeth-fractures-among-students-aged-between-8-and-13-years-in-hyderabad-india#!/;

8. Gjorgievska E., and sor. Detskastomatologija, Skopje: Ars Lamina, 2022.
9. Duran G. Esthetic Restoration of an Enamel-Dentin Fractured Single Maxillary Central Incisor with an Indirect Composite Resin A CASE REPORT, May 2020. https://www.researchgate.net/publication/341767710_Esthetic_Restoration_of_an_Enamel-Dentin_Fractured_Single_Maxillary_Central_Incisor_with_an_Indirect_Composite_Resin_A_CASE_REPORT#:~:text=Enamel-Dentin%20Fractured%20Single%20Maxillary%20Central%20Incisor;
10. Olsburgh S, Jacoby T, Krejci I. Crown fractures in the permanentdentition: pulpal andrestorative considerations. Dent Traumatol2002;18:103-15.https://onlinelibrary.wiley.com/doi/abs/10.1034/j.1600-9657.2002.00004.x;
11. Farik B, Munksgaard EC, Andreasen JO, Kreiborg S. Fractured teethbonded with dentin adhesives with and without unfilled resin. DentTraumatol 2002;18:66-9. https://onlinelibrary.wiley.com/doi/abs/10.1034/j.1600-9657.2002.180203.x;
12. Sakai VT, Anzai A, Silva SMB, Santos CF, Machado MAAM. Predictableesthetic treatment of fractured anterior teeth: A clinical report. DentTraumatol 2007;23:371-5.
13. Oliveira GM, Ritter AV. Composite resin restorations of permanentincisors with crown fractures. Pediatr Dent 2009;31:102-9.
14. Azzaldeen A, Mai A, Muhamad A. Fractured Anterior Tooth Using Direct Composite Restoration:A Case Report. IOSR Journal of Dental and Medical Sciences (IOSR-JDMS),2017;Volume 16(10): 01-12.
15. Skrinjaric I.Traumezuba u djeci. Globus/Zagreb, 1988.
16. Poojary P, Bhandary S, Srinivasan R, Nasreen F, Pramod J, Mahesh MC. Influence of restorative technique, bevelling and aging on composite bonding to sectioned incisal edges: A comparative in vitro study. J Conserv Dent 2013 Jan;16(1):28-31. https://pmc.ncbi.nlm.nih.gov/articles/PMC3548341/;
17. Pagadala S,Tadikonda DC. An overview of classification of dental trauma.Cureus 2024 Jul 14;16(7):e64524. https://www.iaimjournal.com/storage/2015/09/iaim_2015_0209_27.pdf IAIM. 2015;2:157–164. [Google Scholar];
18. Nayak UA, Khandelwal V, Nayak PA, Thakur JS. Restoration of fractured anterior permanent teeth using reference guide technique. BMJ Case Rep 2013:1-4. https://pmc.ncbi.nlm.nih.gov/articles/PMC3702879/;

UDK: 616.314.5-007.13-089.23

# SURGICAL EXTRACTION OF MANDIBULAR IMPACTED THIRD MOLAR USING PIEZO SURGERY – CASE REPORT

# ХИРУРШКА ЕКСТРАКЦИЈА НА ИМПАКТИРАН МАНДИБУЛАРЕН ТРЕТ МОЛАР СО КОРИСТЕЊЕ НА ПИЕЗОХИРУРГИЈА – ПРИКАЗ НА СЛУЧАЈ

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## Abstract

**Aim:** The aim of this study is to present the application of piezosurgery in the extraction of an impacted mandibular third molar in a patient with Parkinson's disease. The goal is to preserve insufficient bone tissue and maintain the integrity of the mandibular canal contents in a limited surgical field. **Material and Method:** A 67-year-old male patient with total toothlessness and Parkinson's disease visited the University Clinic for Oral Surgery and Implantology with signs of acute odontogenic infection in the lower left quadrant. A CBCT scan revealed the presence of an impacted left mandibular third molar, with close proximity to the apex of the tooth and the roof of the mandibular canal, which were separated from each other by a 1 mm bone wall. **Results:** The use of piezosurgery in the treatment of an impacted third molar in a patient with Parkinson's disease proved to be the most effective and predictable method, minimizing trauma to soft tissue and bone structures. **Keywords:** impacted mandibular third molar, piezosurgery, Parkinson's disease, surgical extraction.

## Апстракт

**Цел:** Целта на оваа студија е да се прикаже примената на пиезохирургијата при екстракција на импактиран мандибуларен трет моларкај пациент со Паркинсонова болест, со цел штедење на инсуфициентно коскено ткиво и зачувување на виталитетот на содржината од мандибуларниот канал, во услови на непрегледно работно поле. **Материјал и метод:** 67- годишен пациент, со тотална беззабост и Паркинсонова болест, ја посети Универзитетската клиника за орална хирургија и имплантологија со знаци на акутна одонтогена инфекција во долниот лев квадрант. На CBCT-скенот се детектирашеимпактиран мандибуларен трет молар кај кој апексот беше во непосредна близина со кровот на мандибуларниот канал одвоени меѓу себе со 1 мм коскен ѕид. Индицирана беше екстракција на забот со помош на пиезохируршки апарат. **Резултати:** Употребата на пиезихирургијата во третман на импактиран трет молар, кај пациент со Паркинсонова болест, се покажа како најефикасен и најпредвидлив метод, со минимизирање на траумата на меко-ткивните и коскени структури.
**Клучни зборови:** импактиран мандибуларен трет молар, пиезохирургија, Паркинсонова болест, хируршка екстракција.

## Introduction

Tooth impaction is a pathological condition in which a tooth fails to reach its normal, physiological position within the dental arch. The incidence of impaction is significantly higher in third molars compared to other teeth. Impacted mandibular third molars most commonly occur due to insufficient space between the distal surface of the second mandibular molar and the anterior border of the ascending ramus of the mandible[1,2,3].

Third molars are the most frequently associated teeth with various pathological conditions, making them one of the most studiedcases in oral surgery. According to the literature, the prevalence of impacted teeth ranges between 15.2% and 35%[4,5,6,7].

The surgical extraction of impacted mandibular third molars is one of the most common procedures in oral surgery. This intervention can prevent the occurrence of pericoronitis and painful conditions. However, it can also negatively impact the patient's quality of life due to postoperative complications such as pain, bleeding, swelling, trismus, alveolitis, and mastication difficulties[8,9].

As a recent innovation in dental technology, piezosurgery offers a novel approach to working with bone tis-

sue. Developed in the early 2000s, piezosurgery utilizes precisely controlled ultrasonic vibrations to minimize damage to surrounding soft tissues such as the mucosa, blood vessels, and nerves while precisely cutting hard structures like bone. The precision of piezosurgery allows for a more targeted and atraumatic surgical intervention compared to conventional burrs and drills, which can cause trauma to both soft and hard tissues. Due to these advantages, piezosurgery is increasingly being applied in oral surgery, including sinus membrane elevation, implant site preparation, and, more recently, surgical extractions with a risk of injury to adjacent anatomical structures.

Certain studies suggest that piezosurgery significantly reduces intraoperative bleeding, postoperative pain and swelling, as well as the risk of complications such as loss of periodontal tissue of adjacent teeth and alveolar bone[10].

## Aim

The aim of this case report is to present a piezosurgery-assisted extraction of an impacted mandibular third molar in a patient with Parkinson's disease to preserve the insufficient bone tissue and maintain the integrity of the mandibular canal contents while working in a limited surgical field.

## Case Report

A 67-year-old patient was admitted to the University Clinic for Oral Surgery and Implantology with signs of an acute odontogenic infection in the lower left quadrant. The patient's medical history indicated Parkinson's disease and controlled hypertension, both managed by a specialist internist and neurologist. The patient was classified as ASA III.

A2D panoramic radiograph revealed the presence of an impacted left mandibular third molar with a diffuse chronic lesion surrounding it (Figure 1). Due to the close proximity of the impacted tooth to the mandibular canal

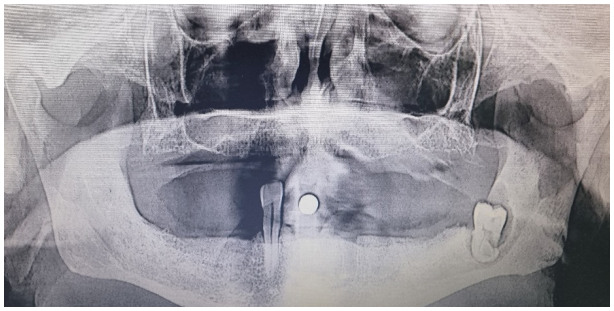

***Figure 1.*** *Position of the impacted left mandibular third molar on 2D Panoramic.*

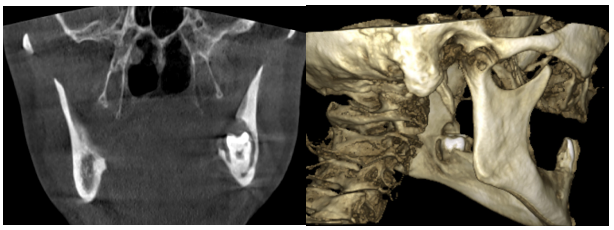

***Figure 2.*** *Position of the impacted left mandibular third molar on CBCT*

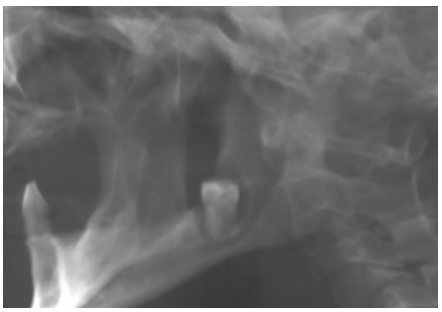

***Figure 3.*** *Position of the impacted left mandibular third molar (buccal view)*

***Figure 4.*** *Intraoral view of impacted left mandibular third molar*

and the limited vertical bone dimension from the tooth apex to the lower border of the mandible, a CBCT scan was performed to further plan the intervention. The scan confirmed a 1 mm bony separation between the tooth apex and the roof of the mandibular canal (Figures 2, 3).

The initial management of the acute odontogenic infection included incision and drainage of the abscess content, along with a five-day course of intramuscular antibiotic therapy (Amp. Neloren 600 mg and Amp. Dexamethasone 4 mg, for 2 days). Significant clinical improvement was noted at the first follow-up visit, and oral antibiotic therapy (Caps. Clindamycin 300 mg, 3x1) was prescribed for five days. Once the acute infection subsided, the patient was scheduled for surgical extraction of the causative tooth (Figure 4).

A mandibular nerve block was administered using a local anesthetic (Amp. Scandonest + epinephrine 2%), and


***Figure 5.*** *Piezo-surgical device*

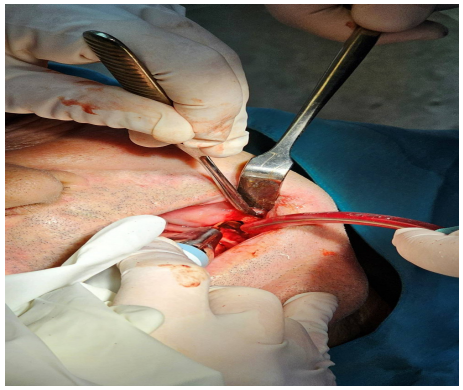

***Figure 6.*** *Extraction of the impacted left third mandibular molar with piezo-surgical device*

a mucoperiosteal triangular flap was elevated. After exposing the alveolar bone, an osteotomy was performed around the impacted third molar using a piezo-surgical device (Woodpecker Surgic Touch LED, Guilin Woodpecker Medical Instruments Co. Ltd., Guilin, Guangxi, P.R. China) (Figure 5,6). The tooth was extracted using lower root elevators and molar forceps. Following extraction, the chronic pathological lesion was excised from the post-extraction socket and

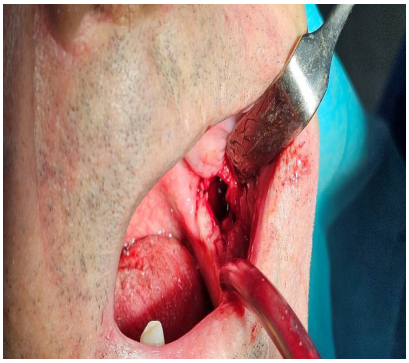

***Figure 7.*** *Post extraction wound*

***Figure 8.*** *Extracted third molar and extirpated distal pathological tissue*

МЕДИЦИНСКИ ФАКУЛТЕТ,
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Амб.број:
Прим./Зат.: 06.2.2025 - 20.3.2025

Клиничка дијагноза: Z00 K09.9 Отстранета патолошка формација при екстракција на импактиран
Вид на испратен материјал: Operative Material
Материјал опис :

ХИСТОПАТОЛОШКИ НАОД

INFLAMATIO CHRONICA GINGIVAE
K05.1 - K05.1

Макроскопски наод :
Доставен е неправилен мекоткивен фрагмент со светло розова пребоеност и средна конзистенција со димензии 2,6x2x0,3см. Фрагментот во дел е хеморагично имбибиран. Материјалот е земен целосно во три попречни пресека, вкалапени во 1 парафински блок и сечени полусериски во три нивоа.

Микроскопски наод:
Микроскопски видлив е површен истенчен, на места папиларно пролиферирам многуслоен плочест епител со правилна стратификација на слоевите, а субепително во едематозна строма има богат хроничен инфламаторен инфилтрат, доминантно сочинет од плазма клетки, а поретко лимфоцити и единечни неутрофили.
Направена е имунохистохемиска анализа за диференцираност и одредување на клоналност на плазма-клеточната популација при што се доби следниот имунопрофил: CD138 (+ дифузен), Kappa (+), Lambda (+), CK AE1/AE3 (- / + епител).
KI-67 покажа низок пролиферативен индекс на плазма клеточната популација кој на места достигнува до 10%.
Според опишаната морфологија и направена имунохистохемиска анализа, се работи за хроничен гингивитис со доминација на плазма-клеточна популација со поликлоналност на клетките и бенигни карактеристики.

Лекар:
д-р Ристовска Алексов Викторија

Раководител
Проф. д-р Костадинова-Куновска Славица
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Консултант

Патолог:
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Наодот е електронски авторизиран од Прим. д-р Илиевски Боро 738336

НАЛОМЕНА : Податални информации за акредитираните методи се наоѓаат во Прилогот кон сертификатот за акредитација бр. ЛТ-601 , објавен на ИАРМ. www.iarm.gov.mk

стр : 1/2

***Figure 9:*** *Histopathological findings*

sent for histopathological examination (Figure 7, 8). The histopathologica lexamination revealed chronic inflammation conformed with the immunohistochemical findings of plasma cell populations with specific immunoprofiles: CD138, Kappa (+), Lambda (+), and CK AE1/AE3(-/+ epithelium) (Figure 9). The mucoperiosteal flap was repositioned and sutured using 3-0 silk non-resorbable sutures.

Postoperative care instructions were given to the patient, and antibiotic therapy continued for an additional five days, supplemented with anti-inflammatoryand antiox-

***Figure 10:*** *Extracted third molar on 2D*

idant medicine (Chymoral 3x2). The sutures were removed after 14 days, and follow-up visits confirmed adequate bone and soft tissue healing without pain, swelling, infection, or damage to adjacent nerve structures. (Figure 10).

## Discussion

The extraction of mandibular third molars is frequently associated with temporary or permanent damage to the inferior alveolar and lingual nerve. The incidence of this complication is relatively low but increases when the nerve is in close proximity to the third molar roots.

Although osteotomy performed with conventional rotary instruments is faster, the risk of injury to surrounding soft tissues is higher, as is the occurrence of osteonecrosis due to thermal damage (overheating of the bone), which can impair tissue regeneration. Piezosurgery is widely used in oral surgery to minimize the risk of thermal damage, as it operates with lower pressure and continuous water cooling, creating a micro-protective effect.

Piezoelectric devices are also used in complex surgical procedures in anatomically challenging areas, such as the molar region of the mandible, where osteotomy lines are close to vital structures like nerves and blood vessels. Ultrasonic vibrations enable selective and precise cutting, offering greater accuracy and safety while reducing tissue trauma compared to conventional rotary instruments[11,12,13].

A study by Demirci A. et al. demonstrated that piezosurgery significantly improves patient quality of life by reducing postoperative swelling and trismus compared to conventional rotary methods. However, it is important to note that the overall operative time was longer with piezosurgery[14].

Similar findings were reported in the study by Tanaskovic N. and Lucic M., where significant differences were observed between conventional and piezosurgical techniques in the postoperative period regarding complications such as paresthesia, pain, and swelling. These complications were more pronounced in cases treated with conventional techniques. Although the duration of the intervention was longer with piezosurgery, postoperative complications were less severe. This is a crucial fact opposite the existing belief that prolonged surgical procedures are directly correlated with postoperative pain intensity[15].

Parkinson's disease primarily affects elderly patients and is characterized by involuntary body movements and muscle rigidity. The tremors associated with this condition pose a significant challenge for dentists, as patients struggle to keep their mouths open for extended periods, and anxiety during treatment can further exacerbate symptoms. Thus, managing these patients requires a calm, relaxed environment to maximize their comfort[16].

Performing a complex oral surgical procedure that demands high precision with rotary instruments is particularly challenging in patients who cannot maintain a stable and visible surgical field during the procedure. In such cases, the preferred method is using a piezosurgical device.

## Conclusions

In our case, surgical extraction of the mandibular left third molar proceeded without intraoral and extraoral complications. The use of piezo surgery in the treatment of impacted third molar in a patient with Parkinson's disease has proven to be the most effective and predictable method, minimizing trauma to soft tissue and bone structures.

## Reference


1. Santosh P. Impacted mandibular third molars: Review of literature and a proposal of a combined clinical and radiological classification. Ann Med Health Sci Res 2015;5(4): 229–234. DOI: 10.4103/2141-9248.160177
2. Matsuyama J, Kinoshita Kawano S, Hayashi Sakai S, Mitomi T, Sano Asahito T. Severe impaction of the primary mandibular second molar accompanied by displacement of the permanent second premolar. Case Rep Dent 2015:5(8):62-64.
3. Bouloux GF, Steed MB, Perciaccante VJ. Complications of third molar surgery. Oral Maxillofac Surg Clin North Am 2007;19:117 28.
4. Schersten E, Lysell L, Rohlin M. Prevalence of third molars in dental students. SWED DENT J 1989;13:7 13.
5. Ylipaavalniemi P, Turtola L, Murtomaa H, Rytomaa I. Evaluation of the need for third molar removals among 20- to 21- years old Finnish university students. PROC FINN DENT SOC 1985;81:222-5.
6. Hman M. Our third molar teeth: their eruption, presence and absence. Dental Cosmos 1936; 78:750-62.
7. Kramer RM, Williams, AC. The incidence of impacted teeth. ORAL SURG ORAL MED ORAL PATHOL 1970; 29:237-41
8. Dias.B.L.; Tonzar.T.T.;Santos.R.D. Salivary biomarkers of cellular damage and oxidative stress following of lower third molar surgical removalArch Health Invest (2020)9(1):11-17 http://dx.doi.org/10.21270/archi.v9i1.4865
9. Majid OW, Mahmood WK. Effect of submucosal and intramuscular

dexamethasone on postoperative sequelae after third molar surgery: Comparative study. Br J Oral Maxillofac Surg. 2011;49(8):647-52
10. Mancini, A.; Inchingolo, A.M.; Chirico, F.; Colella, G.; Piras, F.; Colonna, V.; Marotti, P.; Carone, C.; Inchingolo, A.D.; Inchingolo, F. et al. Piezosurgery in Third Molar Extractions: A Systematic Review. J. Pers. Med. 2024, 14, 1158. https://doi.org/10.3390/jpm14121158
11. Rullo R, Addabbo F, Papaccio G, D'Aquino R, Festa VM. Piezoelectric device vs. conventional rotative instruments in impacted third molar surgery: Relationships between surgical difficulty and postoperative pain with histological evaluations. J Craniomaxillofac Surg. 2013;41:e33–8. DOI: 10.1016/j.jcms.2012.07.007.
12. Barone A, Marconcini S, Giacomelli L, Rispoli L, Calvo JL, Covani U. A randomized clinical evaluation of ultrasound bone surgery versus traditional rotary instruments in lower third molar extraction. J Oral Maxillofac Surg. 2010;68:330–6. DOI: 10.1016/j.joms.2009.03.053.
13. Bhati B, Kukreja P, Kumar S, Rathi VC, Singh K, Bansal S. Piezosurgery versus Rotatory Osteotomy in Mandibular Impacted Third Molar Extraction. Ann Maxillofac Surg. 2017 Jan-Jun;7(1):5-10. DOI: 10.4103/ams.ams_38_16. PMID: 28713729; PMCID: PMC5502515.
14. Demirci A, Bayram F, Dergin G. Piezosurgery versus conventional rotary surgery for impacted third molars: A randomised, split-mouth, clinical pilot trial. Med Oral Patol Oral Cir Bucal. 2024 Jan 1;29(1):e1-e8. DOI: 10.4317/medoral.25929. PMID: 37992138; PMCID: PMC10765334.
15. Tanasković N. et Lučić M. The Use of Piezosurgery for Mandibular Third Molar Extraction, Serbian Dental Journal, Vol.61,N.4, 2014.
16. Fouad A. Al-Omari, MohammedM. AlMoaleem, Sulaiman S. Al-Qahtani, Abdullah S. Al Garni, Syed Sadatullah, andMaster Luqman. Oral Rehabilitation of Parkinson's Disease Patient:A Review and Case Report.Hindawi Publishing Corporation. Volume 2014, Article ID 432475, 4 pages. http://dx.doi.org/10.1155/2014/432475.

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# REMOVAL OF A FRACTURED INSTRUMENT FROM THE ROOT CANAL USING AN OPERATIVE MICROSCOPE – CASE REPORT

# ОТСТРАНУВАЊЕ НА ФРАКТУРИРАН ИНСТРУМЕНТ ОД КОРЕНСКИ КАНАЛ СО ПОМОШ НА ЕНДОДОНТСКИ МИКРОСКОП - ПРИКАЗ НА СЛУЧАЈ

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## Abstract

An instrument fracture during endodontic treatment is a common complication that can hinder proper cleaning and disinfection of the root canal, negatively affecting the treatment outcome. Removing fractured instruments presents a challenge due to their location, size, and the anatomy of the canal system. The aim of this study is to emphasize the significance of the operative microscope in the conservative removal of fractured instruments from the canal system and the possibility of subsequent successful endodontic treatment through case studies. In the presented cases, fractured instruments were removed from the root canal with minimal removal of the surrounding healthy dentin using ultrasonic tips under an operative microscope. **Keywords:** Operative microscope, ultrasonic tips, fractured instruments.

## Апстракт

Фрактурата на инструмент за време на ендодонтскиот третман е честа компликација што може да го попречи соодветното чистење и дезинфекција на коренскиот канал, што негативно влијае на исходот од третманот. Отстранувањето на скршените инструменти претставува предизвик поради нивната локација, големина и анатомијата на каналниот систем. Целта на овој труд ни беше преку приказ на случаи да го потенцираме значењето на оперативниот микроскоп при отстранување на фрактурирани инструменти од каналниот систем на конзервативен начин и можноста за последователен успешен ендодонтски третман. Во прикажаните случаи со помош на примена на ултразвучни продолжетоци и под оперативен микроскоп фрактурираните инструменти беа отстранети од коренскиот канал со минимално одземање на околниот здрав дентин. **Клучни зборови**: Оперативен микроскоп,ултразвучни продолжетоци, скршени инструменти.

## Introduction

One of the possible complications during endodontic treatment is the fracture of instruments inside the root canal[1].

This issue is significant both technically and clinically, as it can affect the treatment outcome, increase the risk of endodontic failure, and necessitate additional interventions.

Predisposing factors that may lead to instrument fracture include: the instrument's design, its usage dynamics, the manufacturing process, the canal configuration, the cleaning and sterilization process, and the frequency of use[2].

Additional factors may include complex tooth anatomy (e.g. curved, narrow canals) and possible iatrogenic errors. Proper coronal visualization is essential to enable thesuccessful removal of a fractured fragment from the canal system and to ensure the success of treatment methods.

The dental microscope is one of the key factors for successful endodontic treatment, especially in cases of fractured instruments in the root canal, as it can magnify the structure of an object from 0.2 mm to 0.006 mm (microns), improving visibility[4].

There is no standardized procedure for successfully removing a fractured instrument. Many techniques and

devices have been tested—mostly on fractured manual instruments. These techniques are time-consuming, have limited success,and pose a significant risk to narrow and curved canals[3]. One of the most commonly used techniques for removing fractured instruments from the root canal, both by endodontists and general dentists, is the use of specialized devices or ultrasonic techniques for the removal of fractured instruments[5].

The **aim** of this study is to highlight the importance of the operative microscope in removing fractured instruments from the canal system and the possibility of a subsequent successful endodontic treatment through case studies.

## Case Study

### *Case 1*

A 35-year-old patient presented with pain while chewing on the lower right molar (tooth 46). Intraoral examination revealed a large composite restoration with poor marginal adaptation. A periapical radiograph showed inadequate endodontic treatment and a fractured instrument in the mesiolingual canal.

After obtaining informed consent, a rubber dam was placed, and the patient was positioned for treatment using a dental microscope (Zumax OMS2350 with six magnification levels – 0.33x, 0.5x, 0.8x, 1.22x, 2x, and 3x). After removing the restoration, the root canal entry was widened using a Gates-Glidden Drill size 3 for better visualization of the coronal part of the instrument. Once the instrument was located (figure 1), ultrasonic tools (Dentsply Sirona Endo 1 and  Endo 5) were used to carefully remove 2-3 mm of dentin apically around the instrument without excessive canal enlargement, using 1.22 x magnification. The ultrasonic tip was positioned around the instrument, first loosening it from the inner wall to facilitate removal. During the ultrasonic procedure, continuous irrigation with 5% NaOCl and 17% EDTA was performed to prevent overheating of the root. After each irrigation, an endodontic probe was used to assess the degree of instrument loosening. Once the instrument was sufficiently loosened, it was successfully extracted using a Loop from the Cerkamed Endo Removal System (figure 2).

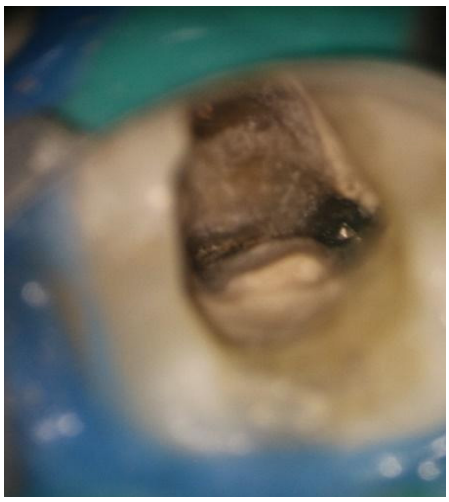

***Figure 1.*** *Examination of the cavity of tooth 46 using an operative microscope, visualizing the fractured instrument under 2x magnification*

***Figure 2.*** *Instrument for the removal of fractured instruments from the root canal (Loop, Cerkamed Endo Removal System).*

After the instrument removal, the working length of the root was determined using a K-file #8 (DiaDent) and an apex locator (Woodpecker Woodpex III). Retreatment of the remaining canals was performed by softening the gutta-percha with orange oil (Cerkamed), determining the working length of each root canal, and proceeding with final canal preparation using machine endodontic instruments (Soco – SC Niti File). The distal canal was prepared up to size 35/.04, the mesiobuccal canal up to size 25/.04, and the mesiolingual canal up to size 30/.04.

During the procedure, irrigation was performed using 5% NaOCl and 17% EDTA, followed by activation with an endo-activator (Woodpecker Endo 3 Ultrasonic Endo Activator). The irrigation protocol before obturation was as follows:

***Figure 3.*** *Visualization of activated 5% NaOCl under a microscope with 2x magnification.*

- 1-minute activation of 5% NaOCl per canal (5ml),
- 1-minute activation of 17% EDTA per canal (5ml),
- 1-minute activation of 5% NaOCl per canal (5ml) (figure 3), followed by rinsing with distilled water (5 ml).

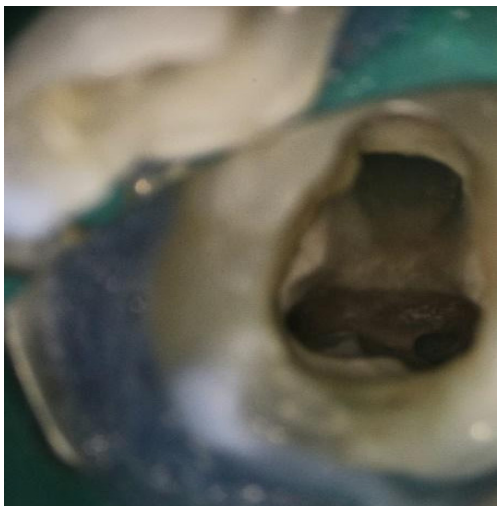

***Figure 4.*** *Examination of the cavity after the removal of the fractured instrument, showing the prepared three root canals under a microscope with 2x magnification.*

After the final preparation of all three root canals (figure 4), they were dried with paper points (DiaDent) and definitively obturated with gutta-percha cones corresponding to the prepared sizes (distal canal with a 35/.04 gutta-percha cone, mesiobuccal canal with a 25/.04 cone, and mesiolingual canal with a 30/.04 cone – DiaDent), using AH Plus (Dentsply Sirona) as the sealer and applying the single cone technique (Figure 5).

***Figure 5.*** *Radiographic view of tooth 46 before and after the final obturation.*

## *Case 2*

A 30-year-old female patient presented with pain in the maxillary left lateral incisor (tooth 22). A periapical radiograph (Figure 1a) revealed the presence of a fractured instrument in the root canal of the left lateral maxillary incisor, with a peri-apical lesion affecting the lateral incisor and the canine (teeth 22 and 23). Since the lateral incisor was also an abutment for a bridge construction, the intervention was performed through the crown with the aid of a dental microscope.

After obtaining informed consent from the patient, a rubber dam was placed,and a retreatment of the endodontic therapy was performed using a dental microscope (Zumax OMS2350) with six magnification levels: 0.33x, 0.5x, 0.8x, 1.22x, 2x, and 3x.

The canal access was widened with a Gates-Glidden Drill #2 to improve visibility and access to the instrument. In the next phase, removal of the instrument was initiated

***Figure 1.*** *Radiograph of teeth 22 and 23 before the start of the intervention.*

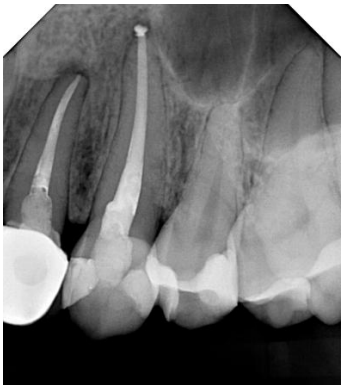

***Figure 2.*** *Radiograph of teeth 22 and 23 after 3 months.*

***Figure 3.*** *Radiograph of teeth 22 and 23 after 6 years.*

using an ultrasonic instrument (Dentsply Sirona Endo 1 and Endo 5). The working protocol was the same as in the previous case. Once the fractured instrument was successfully removed, final canal preparation was performed.

After determining the canal length with an apex locator (Woodpecker Woodpex III) and a K-file #10 (DiaDent), the canal was prepared using machine-driven expanders (Soco – SC Niti File) up to size 35/.04.

Final irrigation was performed according to the established protocol:

- 1-minute activation of 5% NaOCl (5ml),
- 1-minute activation of 17% EDTA (5ml),
- 1-minute activation of 5% NaOCl (5ml), followed by rinsing with distilled water (5ml).

After thorough cleaning and preparation, the canal system was dried with paper points (35/.04 – DiaDent) and definitively obturated with gutta-percha cones (35/.04 – DiaDent) and AH Plus (Dentsply Sirona) as a sealer using the single-cone technique.

During the same visit, an endodontic treatment of the upper left canine (tooth 23) was also performed. After forming an access cavity and entering the root canal, the working length was determined using a K-file #10 (DiaDent) and an apex locator (Woodpecker Woodpex III). The canal system was instrumented using machine-driven expanders (Soco – SC Niti File 35/.04) and an endo-motor (Dentsply X-Smart Plus Endo Motor). Irrigation followed the pre-established protocol, with activation performed using an ultrasonic activator (Woodpecker Endo 3 Ultrasonic Endo Activator).

After the canal preparation and cleaning, the system was dried with paper points (DiaDent 35/.04) and definitively obturated with gutta-percha cones (DiaDent 35/.04) and AH Plus (Dentsply Sirona) as a sealer using the single-cone technique (Figure 2).

## Discussion

Instrument separation is a frustrating and undesirable complication in endodontics[6]. Most stainless-steel instruments fracture due to repeated use[7]. Fractures can also occur due to aggressive movements, such as rushing through the canal or applying excessive force to the instrument beyond its intended working length or around sharp curvatures[7].

The ability to safely remove a fractured fragment depends on the complexity of the canal anatomy, including the thickness of the root dentin, its curvature, and the dimension and location of the fragment within the canal.8

Managing a case with a fractured instrument may involve either an orthograde or a surgical approach. The three orthograde approaches are:

(a) attempting to remove the instrument,

(b) attempting to bypass the instrument, and

(c) preparing and obturating up to the fractured segment.

Successful retreatment can be performed when these instruments can be removed. If the instrument can be removed or bypassed, and the canal can be properly cleaned and filled, the non-surgical endodontic procedure is the more conservative approach. While many fractured instruments can be removed from the root canal, there are cases where removal is not possible due to limited access, especially when the fracture occurs around a curvature. The fractured instrument typically obstructs access to the root apex, which may impair the operator's ability to properly prepare, disinfect, and obturate the entire root canal system[9].

The use of ultrasound under magnification is one of the most conservative techniques for instrument removal compared to alternative methods.1 However, ultrasonic techniques are much simpler and less invasive[10].

Ultrasonic tips can be used in deeper parts of the canal due to their contra-angle design and have shown a success rate of 55%-79%[11].

The introduction of the dental microscope has truly revolutionized endodontic practice. The microscope improves theaccuracy of identifying anatomical features of the root canal, which is crucial for successful treatment and long-term outcomes.

With the microscope’s magnification and illumination, clinicians can better observe the coronal aspects of fractured instruments and remove them without causing perforation[12]

According to Fors and Berg, the location of the instrument plays a crucial role in managing fractured instruments. Objects fractured in the coronal third of the canal can be removed using an instrument extractor or small forceps, whereas instruments fractured in the middle third of the canal should ideally be bypassed to prevent excessive removal of surrounding dentin and weakening of the tooth root[13].

Research by Fu et al. has shown that the ultrasonic removal of instruments from the middle third of the canal significantly increases canal volume and may lead to the formation of micro cracks, reducing resistance to vertical root fracture. Therefore, even though the success rate of instrument removal from the middle third of the canal is reportedly high, clinicians should make efforts to minimize the amount of dentin removed around the instrument to improve the tooth's long-term prognosis[14].

In the first case presented in this study, since the fractured instrument was located deeper in the middle third of the root canal, the use of a dental microscope was particularly significant. The combination of ultrasonic tips and an operative microscope allowed for controlled dentin removal around the fractured instrument, loosening it, and ultimately extracting it using an instrument extractor.

In the second case, the instrument fracture was in the coronal third of the root canal, which led us to opt for its removal from the canal. The removal of the instrument enabled proper canal preparation, disinfection, and obturation, creating favorable conditions for adequate healing and repair of the surrounding periapical tissues.

## Conclusions

Based on the presented cases, we can conclude that the use of ultrasonic instruments in combination with an operative microscope allows for the successful removal of fractured instruments from the root canal, whether the fracture occurs in the coronal or middle third of the canal while maintaining a controlled removal of surrounding dentin. However, in cases of fractured instruments in the middle third, special attention should be given to avoid excessive removal of root dentin and weakening of the tooth root.

## Reference


1. Ungerechts C., Bardsen A., Fristad I. Instrument fracture in root canals–where, why, when, and what? A study from a student clinic. International Endodontic Journal. 2014;47:183–190. DOI: 10.1111/iej.12131.
2. Al-Zahrani MS, Al-Nazhan S. Retrieval of separated instruments using a combined method with a modifiedVista dental tip. Saudi Endodontic Journal. 2012;2:41–5.
3. Ward JR, Parashos P, Messer HH. Evaluation of an Ultrasonic Technique to Remove-Fractured Rotary Nickel-Titanium Endodontic Instruments from Root Canals: Clinical Cases. Journal of Endodontics. 2003 Nov;29(11):756-63. DOI: 10.1097/00004770-200311000-00017.
4. Hakobyan G, Yessayan L, Khudaverdyan M and Kiyamova T. The Use of Operating Microscope for Removal of Broken Instruments from the Canal in Endodontic Treatment. IJCMCR. 2020; 3(5): 002 DOI: 10.46998/IJCMCR.2020.03.000072
5. Souter NJ, Messer HH. Complications associated with fractured file removal using an ultrasonic technique. Journal of Endodontics. 2005;31(6):450–452. DOI: 10.1097/01.don.0000148148.98255.15. [DOI] [PubMed] [Google Scholar]
6. Lakshmaiah D, Kumar JR, Sakthi N, Karunakaran J, Vishwanath S. The Management of Fractured Dental Instruments: A Case Series.Cureus. 2023; 20;15(11):e49132. DOI: 10.7759
7. Parashos P, Messer HH. Rotary NiTi instrument fracture and its consequences. Journal of Endodontics. 2006;32:1031-43. DOI: 10.1016/j.joen.2006.06.008.
8. Alomairy KH. Evaluating two techniques on removal of fractured rotary nickel-titanium endodontic instruments from root canals: An in vitro study. Journal of Endodontics. 2009;35:559-62. DOI: 10.1016/j.joen.2008.12.019.
9. Ward JR, Parashos P, Messer HH. Evaluation of an Ultrasonic Technique to Remove Fractured Rotary Nickel-Titanium Endodontic Instruments from Root Canals: Clinical Cases. Journal of Endodontics. Vol. 29, No. 11, November 2003.
10. Plotino G, Pameijer CH, Grande NM, Somma F. Ultrasonics in endodontics: Areview of the literature. Journal of Endodontics. 2007;33:81-95. DOI: 10.1016/j.joen.2006.10.008.
11. Shen Y, Peng B, Cheung GS. Factors associated with the removal of fractured NiTi instruments from root canal systems. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2004;98:605-10.
12. Gurleen Kaura, Gunmeen Sadanam, Rashu Grovera, Sunil Guptaa, Teena Gupta, and Manjul Mehra. Magnification in Dentistry: Literature Review. Asian Journal of Dental Sciences.2023; 6 (1):232-39. https://journalajds.com/index.php/AJDS/article/view/152.
13. Fors UGH, Berg JO. Endodontic treatment of root canals obstructed by foreign objects. International Endodontic Journal. 1986;19:2–10.
14. Mei Fu , Xiaoxiang Huang , Kunya Zhang , Benxiang Hou. Effects of Ultrasonic Removal of Fractured Files from the Middle Third of Root Canals on the Resistance to Vertical Root Fracture. J Endod. 2019 Nov;45(11):1365-1370. DOI: 10.1016/j.joen.2019.08.009

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# THE IMPACT OF ARTIFICIAL SWEETENERS AND SUGARS AS A POSSIBLE RISK FACTOR FOR INCREASED DMFT INDEX IN CHILDREN WITH MIXED DENTITION

# ВЛИЈАНИЕТО НА ВЕШТАЧКИТЕ ЗАСЛАДУВАЧИ И ШЕЌЕРИ КАКО МОЖЕН РИЗИК ФАКТОР ЗА ЗГОЛЕМЕН КЕП ИНДЕКС КАЈ ДЕЦА СО МЕШОВИТА ДЕНТИЦИЈА

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## Abstract

**Introduction:** A diet rich in sugars and artificial sweeteners has always been the subject of research in determining the factors that directly influence the occurrence of caries from a young age, mainly due to the connection with increased acid production in the mouth as a result of prolonged presence of sugars that directly affect the demineralization of tooth enamel. **Aim:** The aim of this study is to determine the state of oral health by determining sugars as a possible risk factor for the occurrence of caries. **Material and methods:** The research included a total of 80 children, aged 9, randomly selected from two primary schools in Skopje, Municipality of Centar (Primary Schools "KiroGligorov" and "Kocho Racin"), of which 37 were girls and 43 were boys. **Results:** The results we obtained regarding DMFT in deciduous dentition were 2.6, which, according to WHO, is in the medium DMFT index in relation to the results of the use of products enriched with artificial sweeteners. t Start=7.9356 and p<0.01 confirms sugar as a possible risk factor for the occurrence of an increased DMFT index. The results we obtained for the DMFT in permanent dentition are 0.58, which, according to WHO, is considered a low DMFT index in relation to artificial sweeteners t Start=0.62131 and p<0.01. The result shows that the short-term presence of permanent dentition and the duration of exposure to carbohydrates represent a reduced risk for an increased DMFT index in the stomatognathic system. **Conclusion:** Daily education of children in order to improve their oral hygiene habits and proper and balanced nutrition would contribute to better results in the dmft/DMFT values. Health education and motivation as a multidisciplinary approach among dentists, teachers, children, and parents should be a basic imperative as the most important preventive measure. Introducing appropriate controls for the availability of sugars and similar sweeteners in any form near schools will significantly reduce the risk factor - sugar and caries incidence. **Keywords:** sugar, dental caries, dmft/DMFT index.

## Апстракт

**Вовед:** Исхраната богата со шеќери и вештачки засладувачи од секогаш била предмет на истражување во областа на детерминирање на факторите кои директно влијаат на појавата на кариес од најмала возраст. Особено поради поврзаноста на зголемена продукција на киселини во устата поради подолгото присуство на шеќерите кои непосредно влијаат на деминерализација на забната глеѓ. **Цел:** Целта на оваа студија е утврдување на состојбата на оралното здравје преку детерминирње на шеќерите како можен ризик фактор за појава на кариес. **Материјал и методи:** Во истражувањето беа вклучени вкупно 80 деца, на возраст од 9 години по случаен избор од две основни училишта во Скопје, општина Центар (о.у. Киро Глигоров и о.у.Кочо Рацин), од кои 37 се девојчиња и 43 момчиња. **Резултати:** Резултатите кои ги добивме во однос на кеп кај млечна дентиција изнесуваше 2,6 што според СЗО влегува во среден кеп индекс во соооднос со резултатите на употребата на производи збогатени со вештачки засладувачи t Start=7.9356 и p<0.01 ни го потврдува шеќерот како можен ризик фактор за појава на зголемен КЕП индекс. Резултатите кои пак ги добивме за КЕП кај трајна дентиција изнесуваа 0.58, што според СЗО влегува во низок КЕП индекс во сооднос со вештачките засладувачи t Start=0.62131и p<0,01. Резултатот ни покажува дека краткотрајното присуство на трајната дентиција и времетраењето на изложеност на јаглехидрати претставува намален ризик за зголемен КЕП индекс во стоматогнатниот систем. **Заклучок:** Секојдневната едукација на децата во насока на подобрување на навиките за подобра орална хигиена и правилна и балансирана исхрана би придонеле за

подобри резултати на КЕП вредностите. Здравствената едукација и мотивација како мултидисциплинарен пристап мегу стоматолозите, наставниците, децата и родителите треба да биде основен императив како најважна превентивна мерка. Воведување на соодветни контроли за достапност на шекерите и слични засладувачи во било каква форма во близина на училиштата значително ќе го намали ризик факторот-шеќер и кариес инциденцата. **Клучни зборови:** шеќер, забен кариес, КЕП индекс

## Introduction

According to the World Health Organization (WHO), caries is a localized process of exogenous origin, i.e., a multifactorial disease with a progressive course that occurs through the interaction of primary (causal) and secondary (conditional) factors.

The modern way of life, the rapid progress of food technology, and the wide range of refined food choices are the reasons for the emergence of an increasing number of chronic diseases. Since ancient times, the saying that health enters through the mouth speaks of the importance of dietary choices. The increase in the production and implementation of sugars (carbohydrates) in numerous food products is proportional to the increasing incidence of dental caries as a chronic disease from a very young age in developing countries. The disruption of the balance, i.e., the increase in the dietary-bacterial balance on one hand and the host on the other, leads us to the terminal phase of this chronic disease - the carious lesion.

A diet rich in sugars and artificial sweeteners has always been the subject of research in determining the factors that directly influence the occurrence of caries from a young age. Mainly due to the connection with increased production of acids in the mouth that directly affect the demineralization of tooth enamel, it was a reason to conduct this research and confirm these factors as possible risk factors for an increased dmft/DMFT index in children.

The primary factor is the host, i.e., the tooth substance with the cariogenic microorganisms (oral microflora) found on the dental surfaces and the substrate of sugars that provide the energy and nutritional needs of the cariogenic bacteria. However, dental caries occurs only if all three primary factors are present simultaneously over a long period, which is why the time factor is also included among the basic factors.

Secondary factors related to the dietary substrate are the physical and chemical properties of the food, the frequency of sugar intake, the clearance of food, and oral hygiene habits. Streptococcus mutans is potentially the most cariogenic bacteria. It is the main initiator of the carious process because it has a high selectivity for sucrose, which firmly adheres to the tooth enamel, causing caries in correlation with poor oral hygiene and improper diet. It forms a water-resistant glucan responsible for creating dental plaque, which immediately after consuming sugars has a pH value of less than 5.5, resulting in demineralization of the enamel. In addition, Lactobacillus are cariogenic microorganisms that are most abundant in saliva, plaque, and dental caries and are responsible for the further course of the carious process.

Secondary factors are directly related to the primary factors and influence the intensity and speed of progression of the pathological process. Thus, secondary factors related to the host factor include: the anatomical and morphological characteristics of the teeth and their placement in the dental arch, heredity, gender, pregnancy and breastfeeding, hormones and various general diseases. Secondary factors influencing the causative agents themselves are: the composition and properties of the oral microflora, the quality and composition of saliva, and the presence of fluorides. On the other hand, secondary factors related to the suitable substrate where the metabolism of cariogenic microorganisms takes place are: the physicochemical properties of food, the frequency of meals, the clearance of food from the oral cavity, and oral hygiene habits.

## Aim

The aim of this study is to determine the state of oral health by identifying sugars as a possible risk factor for the occurrence of caries.

In order to achieve the set goal, a total of 80 respondents, children aged 9, were included in the research. For all respondents, we individually determined:

- The ratio between the values of the dmft/DMFT index and the values obtained from the questionnaire regarding the diet and oral hygiene of each child individually;
- The value of the DMFT index compared to the dmft of the deciduous dentition and the DMFT of the permanent dentition in all respondents.

## Material and methods

The research included a total of 80 children, aged 9, randomly selected from two primary schools in Skopje, Municipality of Centar (Primary Schools “Kiro Gligorov” and “Kocho Racin”), of which 37 were girls and 43 were boys.

These examinations were conducted at the Polyclinic.

All respondents were provided with:

- Clinical trials,
- Patient questionnaire
- Statistical processing of the obtained results.

The children were examined with appropriate instruments (probe and dental mirror) to determine the condition of the oral cavity, which was recorded individually in a chart using the new marking method in accordance with the new WHO criteria. dmft/DMFT index was determined individually for each child using the Klein-Palmer system. The DMFT index is the average number of decayed, missing, and filled permanent teeth per student.

dmft/DMF = total number of decayed teeth+total number of missing teeth+total number of filled teeth/examined x100

The data was collected by filling out a questionnaire regarding the amount and form of sugar, fat, and protein intake, as well as the way the child maintains their oral hygiene. The respondents entered them into a questionnaire specially designed for that purpose. In this way, we attempted to obtain data on the state of dental health and determine possible risk factors.

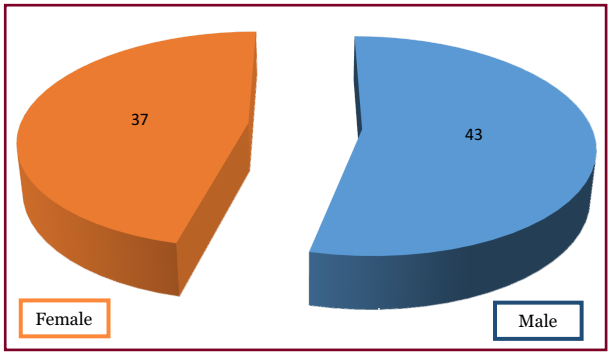
The questions were asked in a dental office individually in the presence of a parent, followed by a clinical dental examination by a preventive team.

For the statistical processing of the obtained data, a student's t-test was used to compare numerical data between corresponding groups, with $p<0.01$ being considered significant.

## Results

The research included 80 respondents, children aged 9from two primary schools in Skopje.

Graph no.1 shows the ratio of male and female respondents, i.e., out of a total of 80 respondents in the survey, 43 were male respondents, and 37 were female respondents.




***Graph 1:*** *Display of respondents by gender*

**Table 1.** Presentation of DMFT in permanent teeth and dmftin deciduous teeth separated by gender.

| | DMFT | dmft | DMFT Index | Dmft Index |
|---|---|---|---|---|
| **Male** | 25 | 123 | 0.58139 | 2.86046 |
| **Female** | 22 | 89 | 0.59459 | 2.40540 |
| **Total** | 47 | 212 | 0.5875 | 2.63293 |

According to the formula for calculating the DMFT index, i.e., number of decayed teeth + total number of missing teeth + total number of filled teeth divided by the number of respondents, the following values were obtained (Table 1).

dmft in the primary dentition was 2.6, which according to WHO is included in the medium DMFT index, while DMFT in the permanent dentition was 0.58, which is included in the low DMFT index according to WHO.

The results of the analysis of dmft by gender show that dmft in boys is 2.86 and dmft in girls is 2.4, which is in favor of a better dmft index in girls in the primary dentition.

The DMFT index of the permanent dentition in boys was 0.58. In girls, the DMFT was 0.59, with no statistically significant difference in the values of DMFT in the permanent dentition in relation to gender.

**Table 2.** Student's t-test: on two samples representing unequal variances of the dmft index in deciduous teeth in relation to the type of food consumed by the respondents.

| | dmft/cookies | dmft/gummy candies | dmft/ lollipops | Overall average value |
|---|---|---|---|---|
| **t Stat** | 4.8568444 | 9.25404209 | 9.696212 | 7.935699 |
| **p** | 0.0000014 | 0.0000000 | 0.0000000 | 0.0000004 |
| **t Critical** | 1.6545549 | 1.65455488 | 1.654555 | 1.65455492 |

According to the Student's t-test,the difference between the DMFT of permanent teeth and the dmft of deciduous teeth is statistically significant, t-Stat=7.37203, and p<0.01.

Regarding nutrition, according to the Student's t-test (Table 2), there is a statistically significant difference between the DMFT index and the different types of food, where the alpha value was set to α=0.05 and p<0.01.

There is a statistically significant difference between the dmft index in deciduous teeth and the intake of cookies, t Stat =4.856 and p<0.01. There is a significant difference between the dmft index in deciduous teeth and the intake of gummy candies, t Stat =9.254 and p<0.01.

There is a statistically significant difference between the dmft index in deciduous teeth and the intake of lollipops, t Stat=9.696 and p<0.01.

If all the obtained values are summed up in relation to the use of sugars and artificial sweeteners, the mean value of t Stat=7.9356 and p<0.01 will be obtained. This value, in correlation with the dmft index in the deciduous dentition, which is 2.6, points to artificial sugars as one of the risk factors that increase the dmft/DMFT index in the stomatognathic system.

According to the Analysis of Variance (ANOVA), Table 3a, there is a statistical difference between the different types of food (healthy and cariogenic) consumed by the respondents in relation to the present dmft index of the deciduous teeth, F=74.34806 and p<0.01.

**Table 3.** View of Analysis of Variance - ANOVA between the dmft index in deciduous teeth in relation to the type of food (healthy and cariogenic) consumed by the respondents.

| SUMMARY | | | | |
|---|---|---|---|---|
| ***Groups*** | ***Count*** | ***Sum*** | ***Average*** | ***Variance*** |
| **proteins** | 80 | 123 | 1.5375 | 0.251741 |
| **fast food** | 80 | 171 | 2.1375 | 0.196044 |
| **fruit** | 80 | 97 | 1.2125 | 0.194778 |
| **cookies** | 80 | 115 | 1.4375 | 0.274525 |
| **gummy candies** | 80 | 28 | 0.35 | 0.23038 |
| **lollipops** | 80 | 20 | 0.25 | 0.189873 |
| **chocolate** | 80 | 78 | 0.975 | 0.024684 |
| **sweetened drinks** | 80 | 45 | 0.5625 | 0.249209 |
| **dmft** | 80 | 212 | 2.65 | 4.711392 |

**Table 3a.** Display of analysis between different types of food

| **ANOVA** | | | | | | |
|---|---|---|---|---|---|---|
| ***Source of Variation*** | ***SS*** | ***df*** | ***MS*** | ***F*** | ***P-value*** | ***F crit*** |
| **Between Groups** | 417.8444 | 8 | 52.23056 | 74.34806 | 0.00000000 | 1.951408 |
| **Within Groups** | 499.4875 | 711 | 0.702514 | | | |
| | | | | | | |
| **Total** | 917.3319 | 719 | | | | |

**Table 4.** Student's t-test: two samples representing unequal variances of the DMFT index in permanent teeth in relation to the type of food (healthy or cariogenic) consumed by the respondents..

| | **DMFT/Cookies** | **DMFT / Gummy candies** | **DMFT / Lollipops** | **Overall average value** |
|---|---|---|---|---|
| **t Stat** | 6.042159828 | -1.71229 | -2.465922 | 0.6213159 |
| **p** | 0.00000001 | 0.044402 | 0.007367 | 0.0172563 |
| **t Critical** | 1.654554876 | 1.654555 | 1.654555 | 1.654554 |

Regarding nutrition, according to the Student's t-test (Table no. 4), there is a statistically significant difference between the DMFT index and the different types of food, where the alpha value was set to $\alpha=0.05$, and $p<0.01$. There is a statistically significant difference between the DMFT index in permanent teeth and the intake of cookies, t Stat=6.04215 and $p<0.01$, which is not the case with the use of gummy candies and lollipops. If all the obtained values are summed up in relation to the use of sugars and artificial sweeteners, the average value of t Stat=0.62131 and $p<0.01$ will be obtained. This value in correlation with the DMFT index in permanent dentition, which is 0.58, which falls into low DMFT, is another confirmation that the connection between the use of artificial sweeteners is closely correlated with the values of the DMFT index.

**Table 5.** View of Analysis of Variance – ANOVA between the DMFT index in permanent teeth in relation to the type of food (healthy and cariogenic) consumed by the respondents.

| SUMMARY | | | | |
|---|---|---|---|---|
| ***Groups*** | ***Count*** | ***Sum*** | ***Average*** | ***Variance*** |
| **DMFT** | 80 | 47 | 0.5875 | 1.308703 |
| **proteins** | 80 | 123 | 1.5375 | 0.251741 |
| **fast food** | 80 | 171 | 2.1375 | 0.196044 |
| **fruit** | 80 | 97 | 1.2125 | 0.194778 |
| **cookies** | 80 | 115 | 1.4375 | 0.274525 |
| **gummy candies** | 80 | 28 | 0.35 | 0.23038 |
| **lollipops** | 80 | 20 | 0.25 | 0.189873 |
| **chocolate** | 80 | 78 | 0.975 | 0.024684 |
| **sweetened drinks** | 80 | 45 | 0.5625 | 0.249209 |

According to the Analysis of Variance (ANOVA), there is a statistical difference between the different types of food (healthy and cariogenic) consumed by our respondents in relation to the present DMFT index of permanent teeth, F=97.59308 and $p<0.01$.

## Discussion

Artificial sweeteners and sugars, as the most commonly used products by the food industry, are increasingly posing a risk factor for the occurrence of caries in people, especially young children.

All this has been an area of investigation in many countries and studies in which direct correlations were made between the DMFT index in children and the frequent use of foods and beverages with enriched sweeteners[1,2]. Knowing the chronology of pH disturbance in the oral environment,as a result of these artificial sweeteners and sugars, research was conducted in a Belgian study that included children from 7 years of age, which proved that those who were exposed to the consumption of artificial sweeteners had a lower pH value and represented a suitable environment for the development of cariogenic bacteria, compared to children who did not consume artificial sweeteners[3,4].

A study conducted in England among children aged 12-15 found that children who consumed foods and drinks enriched with artificial sweeteners were more likely to develop dental caries. However, if these children who consumed foods enriched with artificial sweeteners were to increase the frequency of drinking water in fluoridated areas, there was a greater possibility of reducing the percentage of dental caries. This study demonstrated a direct connection between the occurrence of dental caries and the consumption of artificial sugars[5].

Wang YC, Bleich SN, Gortmaker in a study examining the intake of 100% fruit juices enriched with artifi-

**Table 5a.** Display of analysis between different types of food

| SUMMARY | | | | | | |
|---|---|---|---|---|---|---|
| ***Source of Variation*** | ***SS*** | ***df*** | ***MS*** | ***F*** | ***P-value*** | ***F crit*** |
| **Between Groups** | 253.3028 | 8 | 31.66285 | 97.59308 | 0.00000000 | 1.951408 |
| **Within Groups** | 230.675 | 711 | 0.324437 | | | |
| | | | | | | |
| **Total** | 483.9778 | 719 | | | | |

cial sweeteners in children and adolescents found that children and adolescents in today's modern society receive 10 to 15% of their total calories from sugar-sweetened beverages and 100% fruit juice. This analysis indicates an increased consumption of these supplements across all age groups. Schools are places where children are most exposed to the intake of beverages enriched with artificial sweeteners, which would be an incentive to implement an initiative to limit the sale and availability of these beverages in and near schools.

In this process, the advice and dedication of pediatricians who can educate parents of children from a young age that increased sugar intake can have a very harmful effect on the overall health of children, including the stomatognathic system[6], are of great importance. These are more frequent examinations and proven impacts on the overall health of children with their exposure to all kinds of artificial sweeteners that daily affect the increasing prevalence of dental caries in children, WHO has implemented special guides that help dentists and pedodontistsprovide appropriate guidelines for prevention and early care for excessive consumption of artificial sweeteners in everyday practice[7].

Infants, especially those living in poor socioeconomic conditions, are at high risk for early childhood caries. The most influential factor in this uncontrolled process of caries development is the prolonged use of baby bottles, during the day or night, containing highly fermentable sugars (e.g., fruit juice and other sweetened beverages) and pacifiers dipped in sweet additives (such as sugar, honey, or syrups). Therefore, during this period of development, the word of pediatricians is of great importancein encouraging mothers in a traditional way to wean their infants from a bottle with a pacifier to a cup as soon as their first birthday. However, frequent exposure to sweet liquids, even in a cup, can also increase the risk of caries. Therefore, drinks (other than milk or water) in a bottle or cup should be limited and given mainly during main meals[8].

Another study conducted to determine the frequency of sugar consumption in everyday life showed that most preschool children consumed sweets daily - an average of 9.7±6.2 times per week.The most popular were cookies, gummy bears, and chocolate. Sweets consumption did not show a significant correlation with sociodemographic factors such as age and gender but was associated with cultural and contextual factors such as the origin of the respondents, parental education, and specific levels of knowledge about nutrition and oral hygiene. The identified consumption patterns are the result of high availability and parental influence (factors such as parental knowledge level, interest, and habits regarding their child's diet)[9].

According to a study with saliva samples from three different types of carbohydrates (banana, chocolate and white bread), it has been proven that the clearance of other sugars from the teeth (fructose, sucrose and maltose) is significantly higher in chocolate and banana compared to white bread, which requires more time due to the breakdown of starch under the action of amylase. Foods with a high concentration of starch (chips, donuts, and cakes) remain in the mouth longer and have less self-cleaning by saliva compared to foods with less starch (milk chocolate, jelly candies, and caramels). Donuts and potato chips processed at the highest temperature have the highest starch concentration compared to the other test products because starch in the mouth breaks down (into maltose and maltotriose) and has the highest cariogenic potential[10].

The daily intake of sugars per person should be 30g per day for preschool children and 60g per day for school children and teenagers[11].

According to the study on restriction of sugar intake, i.e. quantity and frequency[12], it has been proven that after sugar intake, a drop in pH in the mouth occurs that lasts for 30 minutes, which would mean that additional intake after these 30 minutes is less harmful than in the first 30 minutes.

According to Woodward and Walker[13], who analyzed data from the WHO database from a total of 90 countries, there is a correlation between carbohydrate intake and caries in 29 developed and 61 developing countries, with 23 out of 29 countries having 12-year-old children consuming less than 50 g of carbohydrates per day, the DMFT value being less than 3.0, and in more than 78% of countries with lower carbohydrate consumption, around 10 kg per year, the DMFT is less than 2.0.

The National Strategy for Oral Health Prevention in children up to 14 was adopted in 2008[14]. The aim is timely education and motivation, raising awareness of the oral health of the individual by incorporating effective methods of fissure sealing in school children as well as implementing fluoride prophylaxis and training in proper oral hygiene from an early age, thus enabling the improvement of overall oral health and reducing the percentage of caries in children. This strategy is a step closer to approaching the standards for quality of life offered by the WHO worldwide, and with its implementation we would get a complete picture of the proper growth and development of the orofacial system as well as success in reducing caries incidence by controlling the intake of sugars as one of the main determinants of caries.

The analyses conducted according to the survey questionnaire and the statistical processing of the tables and their parallel analysis proved there is a direct connection between the use of artificial sweeteners in the

daily diet of children and that it represents a high risk factor for the occurrence of a higher DMFT index in the analyses. Of course, in everyday practice, it is necessary to conduct additional parallel analyses, especially in children with only deciduous dentition, and separately in children with permanent dentition, to establish age as a possible risk factor in relation to the control of dmft/DMFT compared to the intake of sugars, where greater self-awareness of older children could be expected, primarily due to the greater availability of information about sugars and their harmful effects on teeth.

The results we obtained in terms of dmft in the deciduous dentition were 2.6, which according to the WHO is included in the medium DMFT index in relation to the results of the use of products enriched with artificial sweeteners t Stat=7.9356 and $p<0.01$, which confirms sugar as a major risk factor, while DMFT index in the permanent dentition was 0.58, which is included in the low DMFT index in relation to artificial sweeteners t Stat=0.62131 and $p<0.01$, which clearly shows that the reduced intake of sugars represents a reduced risk for an increased DMFT index in the stomatognathic system. The data obtained in this way results from the age of the students who are in the period of mixed dentition, which makes the need for visiting a dentist and providing dental interventions greater. At the same time, the higher socio-economic status, primarily the education of the parents, the culture, and the way of life of this group of students impact the provision of preventive measures.

## Conclusions

From the results obtained, we concluded that educating children and parents about the daily routine habits that families have inside and outside the home regarding nutrition should be a priority for all communities and societies, in order to influence the reduction of the occurrence of caries in children from the youngest age. Numerous epidemiological studies conducted at the population level indicate a direct correlation between the form, quantity, and frequency of carbohydrate consumption and the development of caries.

Consuming sugars or artificial sweeteners in any form more than four times a day increases the risk of dental caries by more than 50%. The recommended daily intake should be no more than 60 grams per day for teenagers and adults, and for preschoolers and young children, the intake should be no more than 30 grams per day.

Daily education of children in order to improve their oral hygiene habits and proper and balanced nutrition would contribute to better results for the DMFT values. Health education and motivation as a multidisciplinary approach among dentists, teachers, children, and parents should be a basic imperative as the most important preventive measure. Considering the causes that lead to the occurrence of caries on a global level, one of the most effective measures is fluoride prophylaxis and its implementation at an early age. Introducing appropriate controls for the availability of sugars and similar sweeteners in any form near schools will significantly reduce the risk factor - sugar and caries incidence. These strategic measures aim to preserve overall oral health in the most vulnerable age to ensure proper growth and development of the stomatognathic system.

## Reference


1. Burt BA, Pai S. Sugar consumption and caries risk: a systematic review. J Dent Educ. 2001; 65:1017-1023view at: https://pubmed.ncbi.nlm.nih.gov/11699972/
2. Ismail AI, Burt BA, Eklund SA. The cariogenicity of soft drinks in the United States.J Am Dent Assoc. 1984; 109:24-1 245 View at:https://pubmed.ncbi.nlm.nih.gov/6590604/;
3. Mwalili SM, Lesaffre E, Declerck D. The zero-inflated negative binomial regression model with correction for misclassification: an example in caries research. Stat Methods Med Res. 2008;17:123-139. View at: https://journals.sagepub.com/doi/10.1177/0962280206071840;
4. Burt BA, Eklund SA, Morgan KJ, et al. The effects of sugars intake and frequency of ingestion on dental caries increment in a three-year longitudinal study. J Dent Res. 1988; 67:1422- 1429. View at: https://pubmed.ncbi.nlm.nih.gov/3053822/;
5. Hong, J, Whelton, H, Douglas, G orcid.org/0000-0002-0531-3909 et al. (1 more author) (2018) Consumption frequency of added sugars and UK children's dental caries. Community Dentistry and Oral Epidemiology, 46 (5). pp. 457-464. ISSN 0301-5661 Viewat:https://eprints.whiterose.ac.uk/133561/1/Consumption%20frequency%20of%20added%20sugars.pdf;
6. Wang YC, Bleich SN, Gortmaker SL. Increasing caloric contribution from sugar-sweetened beverages and 100% fruit juices among US children and adolescents, 1988ñ2004. Pediatrics. 2008; 121: e1604-e1614. View at: https: //publications.aap.org /pediatrics/article-abstract/121/6/e1604/72757/;
7. Guideline: Sugars intake for adults and children. Geneva: World Health Organization; 2015. view at:https://www.who.int/publications/i/item/9789241549028;
8. Tang J, Altman DS, Robertson D, O'Sullivan DM, Douglass JM, Tinanoff N. Dental caries prevalence and treatment levels in Arizona preschool children. Public Health Reports 1997;112: 319-29. View at: https://pmc.ncbi.nlm.nih.gov/articles/PMC1381972/#supplementary-material1;
9. Sven Schneider, Moran Jerusalem, Johannes Mente & Freia De Bock -Sweets consumption of preschool children—extent, context, and consumption patterns. https://link.springer.com/article/10.1007/s00784-012-0813-;
10. Riva Touger-Decker, Cor van Loveren. Sugars and dental caries October 2003 Pages view at: The American Journal of Clinical Nutrition, Volume 78, Issue 4Sugars and dental caries - PubMedhttps://doi.org/10.1093/ajcn/78.4.881S881S-892S;
11. Sheiham A. Dietary effects on dental diseases 2001 Apr; Public Health Nutri; View at https://pubmed.ncbi.nlm.nih.gov/ 11683551/;
12. Cor van Loveren . Sugar Restriction for Caries Prevention: Amount

and Frequency. Which Is More Important? - PubMed12 View at:https://pubmed.ncbi.nlm.nih.gov/30089285/;
13. Woodward M, Walker Arp. Sugar and dental caries: The evidence from 90 countries. British dental Journal 1994;Apr.23;176(8):297-302 View at: https://pubmed.ncbi.nlm.nih.gov/8186040/;
14. Министерство за здравство на Р. Македонија-Прирачник за спроведување на национална стратегија за превенција на орални за болувања кај деца од 0-14 години, Скопје, 2008 година, View at https://zdravstvo.gov.mk/wp-content/uploads/2020/06/F_NACRT-PRIRACNIK-NACIONALNA-STRATEGIJA-ZA-PREVENCIJA-NA-ORALNI-ZABOLUVANJA-2019-1.pdf

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# EFFECT OF MYOBRACE APPLIANCES IN MALOCCLUSION CLASS II DIVISION 1 PATIENTS – CASE REPORT

# ЕФЕКТИ НА MYOBRACE АПАРАТИ КАЈ ПАЦИЕНТИ СО МАЛОКЛУЗИЈА КЛАСА II ОДДЕЛЕНИЕ 1 – ПРИКАЗ НА СЛУЧАЈ

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## Abstract

**Aim:** The aim of this study is to show the effect of the myofunctional appliance in the treatment of Class II division 1 malocclusion. **Material and Method:** Eight-year-old twin boys S.G. and J.G. with Class II division 1 malocclusion came to our Department of Orthodontics, and clinical, functional, radiographic, and gnatometric examinations were performed. Impressions were taken for studio casts to perform a gnatometric analysis, before and after treatment with myofunctional devices. The patients were treated with Myobrace K1 step 1 medium and K2 step 2 medium myofunctional appliance. **Results:** After the treatment, the gnathometric analysis showed correction of the crowding, a reduction of the overbite and overjet, significant correction of irregular functions of swallowing and breathing, and improvement of the facial profile. **Conclusion:** The use of myofunctional appliances Myobrace K1 and K2 in early mixed dentition greatly contributes to the timely correction of the dentoalveolar anomaly. **Keywords:** Class II division 1 malocclusion, early mixed dentition, myobrace.

## Апстракт

**Цел:** Целта на овој труд е да се прикаже ефектот од примената на миофункционалните апарати во третман на малоклузија Класа II/1. **Материјал и Метод:** На клиниката за Ортодонција извршено е клиничко, функционално, рентгенграфско и гнатометриско испитување на пациенти С.Г. и Ј.Г., близнаци, 8 годишни момчиња со малоклузија Класа II одделение 1. Земени се отпечатоци за студиомодели за гнатометриска анализа пред и после третманот со миофункционални апарати. Пациентите се третирани со миофункционален апарат Myobrace K1 step 1 medium и K2 step 2 medium. **Резултати:** По спроведениот третман гнатометриската анализа покажа значителна корекција на збиеноста, намалување на вертикалниот инцизивен преклоп и хоризонталната инцизална стапалка и корекција на неправилните функции на голтање и дишење и подобрување на лицевиот профил. **Заклучок:** Употребата на миофункционалните апарати во рана мешовита дентиција во голема мера допринесуваат во навремено корегирање на дентоалвеоларната аномалија. **Клучни зборови:** Малоклузија Класа II/1, рана мешовита дентиција, myobrace.

## Introduction

The great challenge for orthodontics is the treatment of Class II malocclusions in children. Developing class II malocclusion is one of the biggest problems in the mixed dentition stage. Early detection and treatment lead to decreasing the severity of the malocclusion and the time and complexity of the orthodontic treatment[1].

The main component of Class II division 1 malocclusion is mandibular retrusion, resulting in excessive overjet, protruded upper incisors, and a shorter upper lip. The main cause of the development were parafunctional habits such as thumb/lip sucking and tongue thrusting[2]. Class II dentoskeletal disharmony cannot correct itself with growth if not treated and can even worsen with time[3].The aim of the treatment of skeletal Class II division 1 is to correct the dental arch relationship and improve the facial profile by promoting favorable mandibular growth[4].

Part of the orthodontics treatment is the use of functional appliances. They are the first-order choice for early treatment of Class II Division 1 malocclusion for many orthodontists. Functional/myofunctional appliances use muscle action to adjust skeletal and dentoalveolar growth to normal occlusion. In pediatric dentistry, Oral Myofunctional Therapy (OMT) is used to treat malocclusion. Its structure has components built to positively stim-

ulate the masticatory and tongue muscles activity, changing the posture of the mandible to a forward position, correcting orofacial habits (chewing and swallowing), and improving nasal breathing[5,6,7].

One of the functional appliances that is used to correct malocclusions and bad habits in children is the Myobrace appliance. It is an intraoral appliance system used in interceptive orthodontics, and its design is adjusted to treat malocclusions in the mixed dentition stage (8-12 years). Adult patients can also use Myobrace but the indication is limited only for non-extractive cases and mild or moderate malocclusions. The usage of this appliance tends to correct the balance of the facial muscles and the chewing. It can also improve tongue posture[8]. To sum up, the main goals of the treatment using Myobrace are1) restoring nasal breathing from mouth breathing, 2) correcting tongue posture, 3) correctingswallowing, 4) aligning the teeth and jaw to correct position, and 5) unhindered craniofacial development[9,10,11].

The Myobrace appliance can be classified into six groups: Myobrace for juniors (aged3-6), for children (aged 6-10), for teens (aged 10-15), for adults (Aged>15), and the Myobrace Interceptive Class III, and permanent dentition Class III.

Myobrace for children (aged 6-10) is a three-stage appliance system designed to correct poor oral habits while treating upper and lower jaw development problems. The peak effect can be reached after the child's permanent front teeth have come through and before all the permanent teeth have erupted. It is available in three sizes *(K1-K3)*[5,12,13,14].

The *K1* is made of soft and flexible silicone, which offers easy adaptation to any dental arch form and malocclusion. It has small breathing holes to establish continuous nasal breathing and myofunctional features to promote correct habits. Because of the manufacturing material used, this appliance can be used at night and induces great retention. Patients can move to the *K2* when the *K1* is staying in overnight and nasal breathing has been established.

The *K2* provides dental arch development and continuing habit correction and it is ideal for kids aged between 5 and 10. It features a revolutionary *Dynamicore*™ with Frankel grid ideal for jaw enlargement and development and further improvement of habit correction. Patients can move to the *K3* when the *K2* has corrected the arch form, breathing and myofunctional habits.

The *K3* focuses on the final alignment of the teeth while retaining the dental arch form, breathing, and myofunctional habits. It is the firmest appliance in the series, made of polyurethane, and designed to provide the best retention of dental arch form and bad habits. By this stage of treatment, patients' teeth will be mostly aligned and, therefore, the *K3* can be used to finalize any remaining mildmalocclusion. Patients can move to the Myobrace® for Teens series if further treatment or retention is required in the developing permanent dentition[15,16].

In order to achieve the best results, the appliance must be worn regularly for 1-2 hours daily and overnight while sleeping. If it is not used every day, it is not going to work. Patients need instruction how to swallow correctly and to position the tongue in the correct place in the mouth. It is also of great significance to keep their mouth closed when not speaking or eating[17].

Myobrace myofunctional devices are advantageous because of greater patient cooperation. Due to the two-material technology, once it is removed, the tongue and lips can align due to the unique reeducation features[18] of Myobrace. Any disadvantages of using this appliance have not been documented in the literature[19],

## Case Report

Eight-year-old boys S.G. and J.G., twins, came to our Department of Orthodontics complaining of protruding upper incisors and crowding.


***Figure 1.*** *Pretreatment facial photography, S.G.: A) Front; B) Profile*

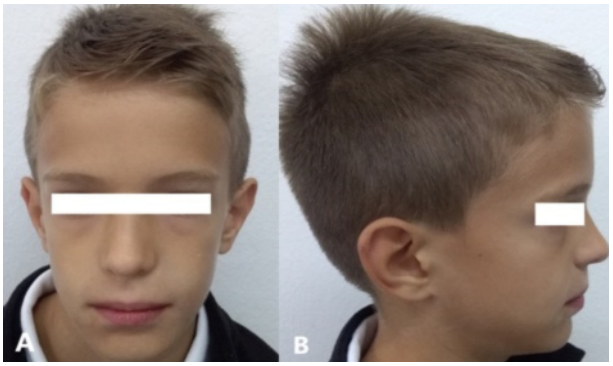


***Figure 2.*** *Pretreatment facial photography, J.G.: A) Front; B) Profile*

Extraoral clinical examination showed that they both had leptoprosopic and symmetricalfaces, convex profiles with a protrusive maxilla, retrusive mandible, an increased lower anterior facial height, and deep labiomental fold. The lips were incompetent and protrusive (figure 1 and figure 2).

Intraoral clinical examination showed that:

S.G. had Angle's class II molar relationship bilaterally and class II canine relationship bilaterally. Protrusion in the maxillary frontal teeth, crowding in the mandibular dental arch, irregular swallowing, and oronasal breathing were found. Increased overjet up to 5mm and overbite of 3 mm were present (Figure 3).

***Figure 3.*** *Pretreatment intraoral photography S.G.*

J.G. had Angle's class II molar and canine relationship bilaterally with a protrusion in the maxillary frontal teeth and crowding in the mandibular dental arch. Irregular swallowing and oronasal type of breathing were found. Increased overjet up to 7 mm and overbite of 5mm were present (Figure 4).

***Figure 4.*** *Pretreatment intraoral photography J.G.*

The panoramic radiograph showed that they both had the presence of all permanent teeth and no pathology.

## Treatment Plan

Our treatment plan was based on the patient's symptoms, extraoral and intraoral examination, and roentgenographic and gnatometric analysis, and it included two phases:

1. The patients were instructed to wear the Myobrace K1 appliance for 2 hours each day and overnight while sleeping for a period of 6 months. The K1 contributed to initial myofunctional improvement. It focuses on establishing nasal breathing and the initial correction of myofunctional disorders in the mixed dentition.

2. After Stage K1, we moved to Stage K2, when the patients were instructed to wear the Myobrace K2 appliance for 2 hours each day, plus overnight while sleeping. The design features of the K2 are suited to promote arch development while correcting breathing and myofunctional habits in the mixed dentition.

## Results and Discussion

The Schwarz model analysis after 12 months of therapy showed that:

1. S.G. had an increase in anterior and posterior widths (anterior upper width from 32 to 38 anterior lower width from 32 to 39 mm; posterior upper width from 40 to 48 mm, posterior lower width from 41 to 47 mm) (table 1).

**Table 1.** Dental cast measurements before, during treatment, and after treatment, according to Shwartz (patient S.G.)

| **Maxillary arch S.I=7+9+9+7=32mm** | | | |
|---|---|---|---|
| | Anterior width | Posterior width | Dental arch height |
| Before treatment | 32mm | 40mm | 21mm |
| During treatment | 35mm | 45mm | 22mm |
| End of treatment | 38mm | 48mm | 20mm |
| **Mandibular arch S.I=7+9+9+7=32mm** | | | |
| Before treatment | 32mm | 41mm | 19mm |
| During treatment | 39mm | 44mm | 21mm |
| End of treatment | 39mm | 47mm | 19mm |

2. J.G. had an increase in anterior and posterior width (table 2), (anterior upper width from 34 to 43mm, anterior lower width from35 to 42mm; posterior upper width from 44 to 52mm, posterior lower width from 44 to 53mm).

**Table 2.** Dental cast measurements before, during treatment, and after treatment, according to Shwartz (patient J.G.)

| **Maxillary arch S.I=8+10+10+8=36mm** | | | |
|---|---|---|---|
| | Anterior width | Posterior width | Dental arch height |
| Before treatment | 34 mm | 44 mm | 23 mm |
| During treatment | 36 mm | 48 mm | 21mm |
| End of treatment | 43 mm | 52 mm | 22 mm |
| **Mandibular arch S.I=8+10+10+8=36mm** | | | |
| Before treatment | 35 mm | 44 mm | 18 mm |
| During treatment | 38 mm | 48 mm | 21mm |
| End of treatment | 42 mm | 53 mm | 20 mm |

After stage K2, both had correction in occlusion (figure 5 and figure 6), (canine and molar relationship) and reduction in overjet (S.G. from 5 to 3mm, J.G from 7 to 3) and overbite (S.G. from 3 to 1mm, J.G. from. 5 to 2mm).


***Picture 5.*** *After treatment intraoral photography A) S.G.*


***Picture 6.*** *After treatment intraoral photography B) J.G.*

**Table 3.** Dental cast measurements according to Moyers.

| **Patient S.G. (8 years old)** | | | | |
|---|---|---|---|---|
| DSI=7+6+6+7=26 mm | | | | |
| | Leeway space | Leeway space | Leeway space | Leeway space |
| | Maxillary arch right | Maxillary arch left | Mandibular arch right | Mandibular arch left |
| Measuredspace 3+4+5 | 22 mm | 23 mm | 23 mm | 21 mm |
| 3+4+5 | 24.3 mm | 24.3 mm | 24 mm | 24 mm |
| Difference | -2.3 mm | -1.3 mm | -1 mm | -3 mm |
| **Patient J.G. (8 years old)** | | | | |
| DSI=6+6+6+6=24mm | | | | |
| | Leeway space | Leeway space | Leeway space | Leeway space |
| | Maxillary arch right | Maxillary arch left | Mandibular arch right | Mandibular arch left |
| Measuredspace 3+4+5 | 22 mm | 22 mm | 20 mm | 23 mm |
| 3+4+5 | 23.1 mm | 23.1 mm | 22.8 mm | 22.8 mm |
| Difference | -1.1 mm | -1.1 mm | -2.8 mm | -1.8 mm |

**Table 4.** Dental cast measurements according to Lundstrom at the end of the treatment.

| **Patient S.G. (8 years old)** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Maxillary dental arch** | | | | | | | | | | | | |
| Tooth | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 |
| Width (mm) | 11 | 7 | 8 | 9 | 7.5 | 9.5 | 10 | 7.5 | 9.5 | 7.5 | 7 | 10 |
| Segment | S1 | | S2 | | S3 | | S4 | | S5 | | S6 | |
| Required space (mm) | 17 | | 17 | | 17 | | 17.5 | | 17 | | 17 | |
| Available space (mm) | 17.5 | | 17 | | 17 | | 17 | | 16.5 | | 17 | |
| Difference (mm) | -0.5 | | 0 | | 0 | | +0.5 | | +0.5 | | 0 | |
| **Mandibular dental arch** | | | | | | | | | | | | |
| Tooth | 36 | 35 | 34 | 33 | 32 | 31 | 41 | 42 | 43 | 44 | 45 | 46 |
| Width (mm) | 12 | 8 | 8 | 8 | 7 | 5.5 | 6 | 7 | 8 | 8 | 8 | 11 |
| Segment | S1 | | S2 | | S3 | | S4 | | S5 | | S6 | |
| Required space (mm) | 20 | | 16 | | 12.5 | | 13 | | 16 | | 19 | |
| Available space (mm) | 19 | | 16 | | 12 | | 12.5 | | 16 | | 19 | |
| Difference (mm) | +1 | | 0 | | +0.5 | | +0.5 | | 0 | | 0 | |
| **Patient S.G. (8 years old)** | | | | | | | | | | | | |
| **Maxillary dental arch** | | | | | | | | | | | | |
| Tooth | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 |
| Width (mm) | 11 | 7.5 | 9 | 8 | 8 | 9.5 | 10 | 7.5 | 8.5 | 8 | 8 | 11.5 |
| Segment | S1 | | S2 | | S3 | | S4 | | S5 | | S6 | |
| Required space (mm) | 18.5 | | 17 | | 17.5 | | 17.5 | | 16.5 | | 19.5 | |
| Available space (mm) | 18 | | 16 | | 18 | | 18 | | 16 | | 19 | |
| Difference (mm) | +0.5 | | +1 | | -0.5 | | -0.5 | | +0.5 | | +0.5 | |
| **Mandibular dental arch** | | | | | | | | | | | | |
| Tooth | 36 | 35 | 34 | 33 | 32 | 31 | 41 | 42 | 43 | 44 | 45 | 46 |
| Width (mm) | 11 | 8.5 | 8.5 | 8 | 7 | 5.5 | 6 | 7 | 8 | 8.5 | 8 | 11 |
| Segment | S1 | | S2 | | S3 | | S4 | | S5 | | S6 | |
| Required space (mm) | 19.5 | | 16.5 | | 12.5 | | 13 | | 16.5 | | 19 | |
| Available space (mm) | 19.5 | | 16 | | 13 | | 13 | | 16 | | 20 | |
| Difference (mm) | 0 | | +0.5 | | -0.5 | | 0 | | +0.5 | | -1 | |

Results from Moyer's analysis in mixed dentition at the start of the treatment (tab.3) show that the upper maxillary arch and lower mandibular arch have moderate crowding (<8), which means that there is not enough space for placing the permanent teeth in the dental arch.

***Picture 7.*** *Dental cast before treatment S.G.*

***Picture 8.*** *Dental cast before treatment J.G.*

A Lundstrom analysis at the end of the treatment (tab.4) shows that by wearing K1 and K2 appliances in each segment, we provided enough space (positive value) for placing the teeth.

According to the results from this case report, there is an indication that myofunctional devices, when used in growing patients with mixed dentition and mild-to-moderate sagittal issues, can improve partial or complete resolution of Class II division 1 malocclusion. We have also reviewed other articles where myofunctional devices have been used and have shown positive results when treating growing patients.

In our case, with the use of two Class II correction appliances, K1 and K2, significant differences were documented. The upper anterior teeth were retroclined, and the overjet was reduced. The overbite was slightly reduced. There was a slight increase in the width of both dental arches, suggesting that myofunctional treatment played a role in promoting the transversal development of the dental arches.

***Picture 9.*** *S.G. dental cast at end of the treatment*

***Picture 10.*** *J.G. dental cast at end of the treatment*

In a study from Rongo et al. (2019) has been reported efficient results from the use of myofunctional treatment for correcting Class II malocclusion. In this study, the cephalometric analysis showed larger maxillary dimensions for the contemporary group (CG) than the historical group (HG), while no differences were shown between the growth rate and direction of the two groups[20].

Antonorakis et al. (2019) analyzed fifteen growing children with Class II division 1 malocclusion. Results have been obtained using dynamic 3D recordings of facial expressions priorto and 12 months after using myofunctional devices. It was concluded that myofunctional appliance treatment has improved the condition of kids with Class II malocclusion by reducing the overjet[21].

The incorrect myofunctional habits such as mouth breathing, tongue thrusting, reverse swallowing, and thumb sucking are the real causes of malocclusion according to a study of Sander FG et al. (2001). Considering the results from the last 20 years, myofunctional research has developed orthodontic appliances to improve the dental and facial development of children from 5 to 15, with the usage of myofunctional orthodontic techniques instead of traditional orthodontics. This technique straightens teeth and also treats the incorrect jaw development[17].

Habashy e tal. (2020) compared the dentoalveolar effects of the myofunctional trainer T4KTM versus twin

block in children with class II division I malocclusion. The overjet showed a higher significant decrease in the twin block group compared to T4K ($p = 0.03$). The mean values of the overbite were significantly decreased in twin block than in T4k ($p < 0.0001$). Both groups showed significant dentoalveolar improvements toward class I occlusion. However, the twin block showed significantly better results than the T4K appliance[22].

## Conclusions

The use of myofunctional appliances, such as myobrace K1 and K2, in early mixed dentition greatly contributes to the timely correction of the dentoalveolar anomaly by establishing correct orofacial functions of breathing, swallowing, and mastication, as well as improving the facial profile of the patients. Widening of the upper and lower anterior and posterior width of the arches results with relief of crowding.Moyers' analysis at the start of treatment (table 3 and figure 7 and 8) and Lundstrom's analysis at the end of treatment (table 4 and figure 9 and 10) showed that treatment with Myobrace K1 and K2 appliances helped in correcting crowding and provided space for all teeth in the dental arch.

## Reference


1. Moyers RE, Riolo ML, Guire KE, Wainright RL, Bookstein FL. Different diagnosis of Class II malocclusions: Part 1. Facial types associated with Class II malocclusions. Am. J. Orthod.1980;78:477-494.
2. Tallgren A, Christiansen RL, Ash Jr M, Miller RL. Effects of a myofunctional appliance on orofacial muscle activity and structures. Angle Orthod 1998;68(3):249-58.
3. Stahl F, Baccetti T, Franchi L, et al. Longitudinal growth change in untreated subjects with class II division 1 malocclusion. Am J Orthod Dentofac Orthop 2008;134(1):125-137.
4. Basciftci FA, Uysal T, Büyükerkmen A, Sari Z. The effects of activator treatment on the craniofacial structure of Class II division 1 patients. Eur J Orthod. 2003;25:87-93.
5. Usumez S, Uysal T, Sari Z, Bascifti FA, Karaman AI, Guray E. The effects of early preorthodontic trainer treatment on class II, division 1 patients. Angle Orthod 2004;74(5):605-9.
6. Quadrelli C, Gheorgiu M, Marcheti C, Ghiglione V. Early myofunctional approach to skeletal class II. Mondo Ortod 2002;27:109-22.
7. Ramirez-Yañez G, Professor A, Fluter J, Ramirez-Yañez GO. Dimensional changes in dental arches after treatment with a prefabricated functional appliance. J Clin Pediatr Dent 2007;31(314):279-83.
8. Yanez GR, Farrell C. Guiding Craniofacial growth and development with the myobrace system. 1st Ed. Australian dental practice 2020. P.40.
9. Farrel C.(2016) Achieving lifelong results with myofunctional treatment- Benefitting patient and dentist, Australasian Dent Prac:72.
10. Cirgić E, Kjellberg H, Hansen K, Lepp M. Adolescents' experiences of using removable functional appliances. Orthodontics and Craniofacial Research ,2015;18:166 .
11. Cirgic E, Kjellberg H, Petzold M, Hansen K. A cost-minimization analysis of large overjet reduction with two removable functional appliances based on a randomized controlled trial. European Journal of Orthodontics, 2018;40:439.
12. Harun A, Nurul A. Management of Malocclusion in Chlidren using Myobrace Appliance: A Systematic Review Hasanuddin University Indonesia, 2021;2120-2136.
13. Ramirez-Yañez GO, Faria P. Early treatment of a Class II, division 2 malocclusion with the Trainer for Kids (T4K): a case report.J Clin Pediatr Dent Summer;2008;32(4):325-330.
14. Achmad H, Areni IS, Ramadany S, Agustin R, Ardiansya R. Reduction of excessive overjet in pediatric malocclusion using myofunctional therapy accompanied by electromyography activity evaluation in orofacial muscles. JIDMR, 2022;15(2), 656–668.
15. Pompeia LE, Rossetti RM, Faria PR, Ortolani CLF, Faltin Jr K. Tratamento de mordida aberta anterior com terapia miofuncional – relato de caso. Orthod Sci Pract. 2017;10: 75-81.
16. Faria PR. The use of Myofunctional Orthodontics in the treatment of children and teenagers. Ortho Sci Orthod sci pract.2014;7: 401-406.
17. Sander FG. Functional processes when wearing the SII appliance during the day. J Orofac Orthop 2001;62:264-274.
18. Myofunctional Research CO (2020) Myobrace para crianças pequenas- dentição decídua.
19. Tomita NE, Bijella VT, Franco LJ. Relação entre hábitos bucais e má oclusão em pré-escolares. Rev. Saúde. 2000;34: 299-303.
20. Rongo R, Martina S, Bucci R, Valetta R, Anto VD, Martina R. Differences in craniofacial growth of class II individuals from different decades:A retrospective study.Orthodontic and craniofacial. Research. 2019;22(4).
21. Antonarakis B, Kiliaridis S. Class II functional appliance treatment and dynamic three-dimensional mimic muscle evaluation. J. Oral Rehabil. 2019;46(9):813–819.
22. Habashy LME. Elhamouly, el housseiny, IsIn developing class II division 1 malocclusion, a randomized comparative clinical experiment compared the use of myofunctional trainers and twin blocks. Dent J. 2020;8(2):44.

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# STRESS DISTRIBUTION OF IMPLANT-RETAINED OVERDENTURE WITH DIFFERENT ATTACHMENT SYSTEMS: A FINITE ELEMENT ANALYSIS

# ДИСТРИБУЦИЈА НА НАПРЕГАЊЕТО КАЈ ИМПЛАНТ - РЕТИНИРАНА ПОКРОВНА ПРОТЕЗА СО РАЗЛИЧНИ СИСТЕМИ ЗА РЕТЕНЦИЈА: АНАЛИЗА СО МЕТОД НА КОНЕЧНИ ЕЛЕМЕНТИ

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## Abstract

**Objective:** The aim of this paper is to analyze the force transmission and stress distribution of an implant-retained overdenture and to assess the influence of the overdenture retention system in the implants, peri-implant bone, and the posterior regions of the residual alveolar ridge. **Material and method:** A CBCT scan of the edentulous mandible was used to create a model. The tests were conducted on two models of a mandibular edentulous jaw, on which two implants were positioned in the interforaminal space. Different retention systems (ball, locator) and an acrylic removable prosthesis were placed in each model. The models were tested under axial loads of 150N, unilaterally and bilaterally, at the level of the first molar. These models were analyzed by finite element software (SOFIFTIK software package) using Von Mises stress analysis. **Results:** The highest stress values were observed at the implant necks and abutments in both models. Regarding the peri-implant bone and the posterior regions of RAG, the highest stress values were observed in the model with a locator attachment. **Conclusion:** According to the results of this study, we can conclude that ball attachments provide a more homogeneous distribution of load forces compared to locator attachments. **Keywords:** implants, overdenture, FEM (finite element method), biomechanics, attachments.

## Апстракт

**Цел:** Целта на овој труд е да го анализира преносот на сила и дистрибуцијата на напрегање на имплант ретинирана покровна протеза, и да се процени влијанието на ретенцискиот систем на покровната протеза, во имплатите, пери-имплантната коска и постериорниот дел на резидуалниот алвеоларен гребен. **Материјал и метод:** Користено е CBCT скенирање на беззабната мандибула за создавање на модел. Испитувањата се спроведени на два модели на мандибуларна тотално беззабна вилица, на која во интерфораминалниот простор се позиционирани два импланти. Кај секој од моделите се поставени различни ретенциски системи(топка, локатор) и акрилатна мобилна протеза. Моделите беа тестирани под оптоварување со аксиални сили од 150N унилатерлно и билатерално на ниво на првиот молар. Овие модели беа анализирани од софтверот за конечни елементи (SOFIFTIK софтверскиот пакет) користејќи анализа на Von Mises стрес. **Резултати:** Највисоки вредности на напрегање беа забележани на вратот на имплантите и на абатментите во двата модела. Во однос на пери-имплантна коска и постериорниот дел на РАГ највисоки вредности на напрегања беа забележани кај модел со локатор атечмен. **Заклучоци:** Според резултатите од ова истражување, можеме да заклучиме дека, топка атечмените обезбедуваат, порамномерна дистрибуција на силите на оптоварување во спордба со локатор атечмените. **Клучни зборови:** импланти, покровна протеза, МКЕ (метод на конечни елементи), биомеханика, атечмени.

## Introduction

For over a century, conventional dentures have been a non-invasive treatment option for complete tooth loss, also known as edentulism. However, in many cases, this rehabilitation does not meet patient expectations1. Edentulous patients often complain about the functionality of conventional dentures, particularly those made for the lower jaw (mandibular dentures). The resorption of the alveolar ridge is a crucial factor associated with the loss of stability and

retention of the lower denture due to the reduction of the supporting tissue beneath the complete denture[2]. Overdentures (ODs) are a recognized method for prosthetic treatment of mandibular edentulism. Relatively affordable cost, simple clinical management, and significant improvements in retention and stability make this type of restoration an attractive treatment option for patients and dentists[3]. Following the McGill and York consensus, overdentures supported by two implants have become the preferred treatment for mandibular complete edentulism due to the favorable outcomes in improving orofacial function and patient satisfaction[4]. Implant-retained overdentures are usually retained on attachments, which allows for better retention and stabilization of the prosthesis. Various attachment-retention systems are used in implant-supported overdentures. Attachments are rigid or resilient connectors that absorb and orientate occlusal forces. Their function is to protect and preserve soft tissue and bones, provide retention, counteract forces that can dislodge the denture, and participate in transferring occlusal forces from the denture to the peri-implant tissue in an axial direction while distributing shear forces. If these forces are of high intensity or persist for long durations without compensation, exceeding the adaptive capacity of the affected tissue, they lead to morphological and functional changes in the least resistant tissues[5]. The ideal retention system for an implant-supported overdenture should be hygienic, easy to use, and ensure uniform and atraumatic transmission of occlusal loads to the bone[6]. Clinically, it is still impossible to assess stress distribution in the bone tissue caused by implant-retained overdentures. Bioengineering studies can evaluate the biomechanical characteristics of implants and dentures. Simulation-based methods, such as the finite element method (FEM), can be used to assess and quantify stresses on implants, peri-implant bone, and deformations of prosthetic components[7].

## Objective

The **aim** of this study is to analyze force transmission and stress distribution in an implant-retained overdenture and assess the impact of the retention system on the overdenture, implants, peri-implant bone, and the posterior part of the residual alveolar ridge in conditions where a narrow mandibular ridge prevents the placement of standard-diameter implants.

## Materials and methods

In accordance with the study's stated objective, numerical tests were conducted using a 3D model of a completely edentulous mandible analyzed through the finite element method (FEM). The 3D model was created based on CBCT (Cone Beam Computed Tomography) scans of an edentulous mandible. The study used a CBCT scan from a patient at the Clinic for Mobile Prosthetics at the Public Health Institution University Dental Clinical Center "St. Panteleimon" in Skopje. After obtaining written consent, the CBCT scan was performed at the University Clinic for

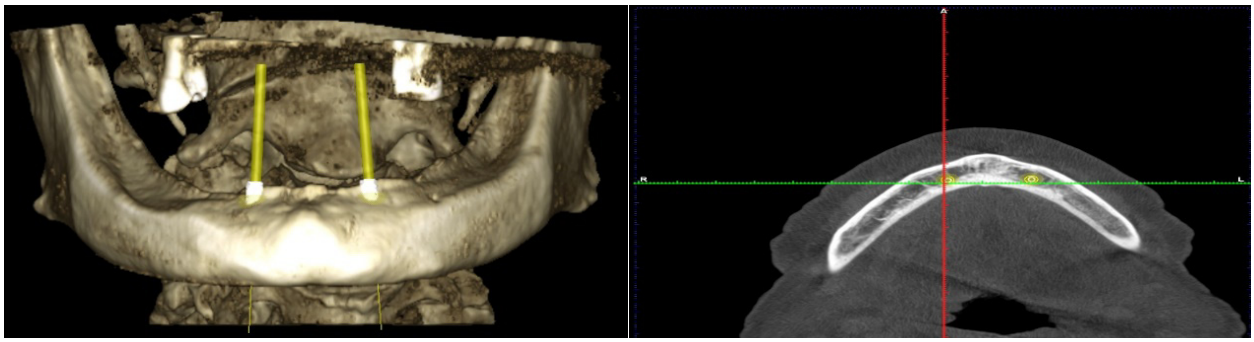

***Figure 1.*** *CBCT radiographic images of an edentulous mandible with virtually positioned implants.*

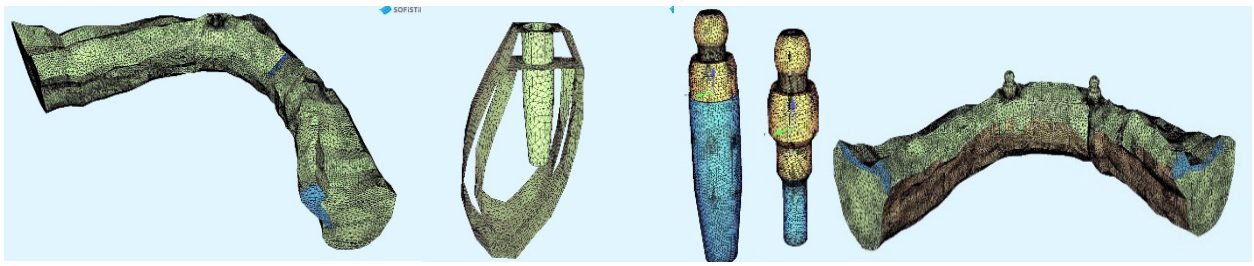

***Figure 2.*** *3D finite element model of a mandible with implants and ball attachments*

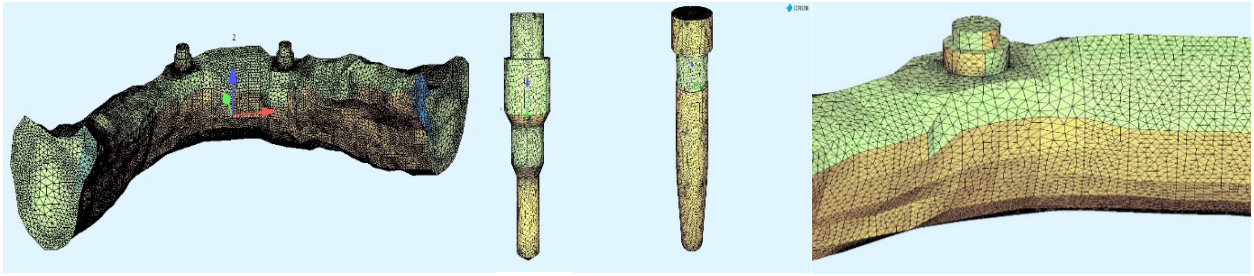

*Figure 3. 3D finite element model of a mandible with implants and locator attachments.*

Maxillofacial Surgery in Skopje. Using the Romexis Planmeca software database, appropriate implants were positioned in the interforaminal space of the edentulous mandible.

The data obtained from the 3D radiography were used to generate a finite element mesh using the SOFISTIK software package. The boundary between cortical and cancellous bone was contoured.The contour data of the profiles were transformed into $x$, $y$, and $z$ coordinate points. Tests were conducted on models of a completely edentulous mandible with two narrow-diameter implants (3.3 mm) placed in the interforaminal region.Each of the models has different retention systems, acrylic resin overdenture, and acrylic teeth

- **Model 1:** Two implants in the canine region with ball attachments
- **Model 2:** Two implants in the canine region with locator attachments

## Material characteristics of the model

To perform finite element analysis, all model components must have precisely defined material properties. Most dental materials analyzed are assumed to be homogeneous, isotropic, and linearly elastic. The input parameters for all modeled objects include the modulus of elasticity (E) and Poisson's ratio (ν), derived from literature sources (Table 1).

## *Material characteristics of the model*

The occlusal load was simulated with an axial force of 150 N, applied unilaterally and bilaterally to the first molar region. The study did not consider time as a factor in force application, meaning only short-term forces were analyzed. The study examined the impact of occlusal forces on the implants, peri-implant bone, and the posterior part of the alveolar ridge.

## Results

The stress analysis conducted using the SOFISTIK software package provided results in the form of von Mises stress distribution maps with color-coded bands. These colors represent different levels of stress distribution, with red followed by orange, yellow, light green, green, light blue, blue, and dark blue, indicating the highest stress levels. With these different colors, the stress distribution pattern can be analyzed in different models. The stress values corresponding to each color are provided in the images.

**Table 1.** Input parameters of oral tissues and prosthetic materials.

| Material | Elastic Modulus (MPa) | Poisson's Ratio (v) |
|---|---|---|
| Implants/Attachments (Ti-6Al-4V)(21) | 135,000 | 0.3 |
| Cortical Bone (21) | 13,700 | 0.3 |
| Cancellous Bone(21) | 1,370 | 0.3 |
| Acrylic Resin(20) | 3,000 | 0.35 |
| Mucosa (20) | 1 | 0.37 |
| Nylon Cap (12) | 350 | 0.40 |
| Stainless Steel | 19,000 | 0.31 |

**Unilateral axial load of 150 N**

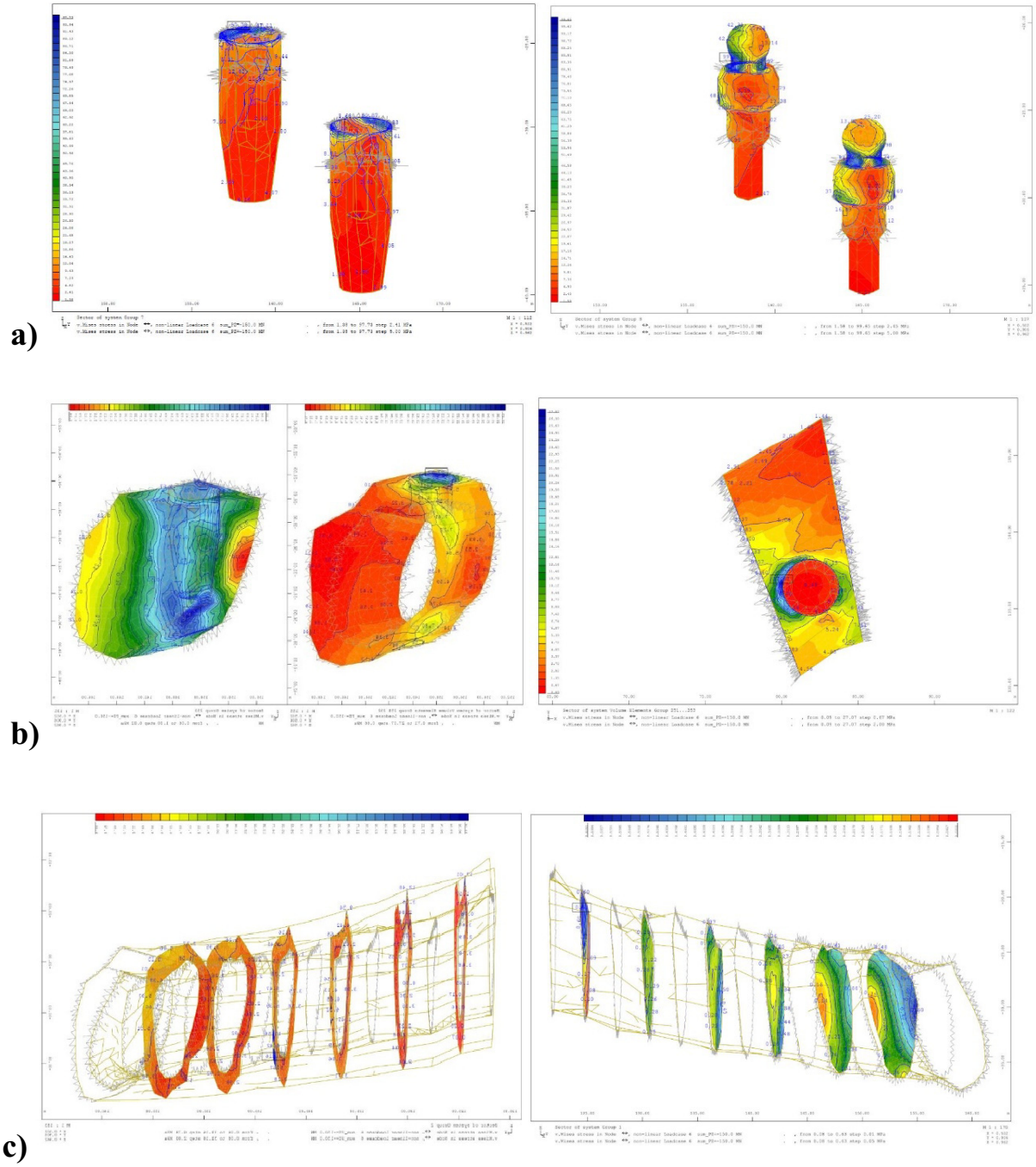


***Figure 5.*** *Von Mises stress (MPa) results for ball attachment, (a) implant, (b) peri-implant bone, and (c) posterior part of the RAG.*

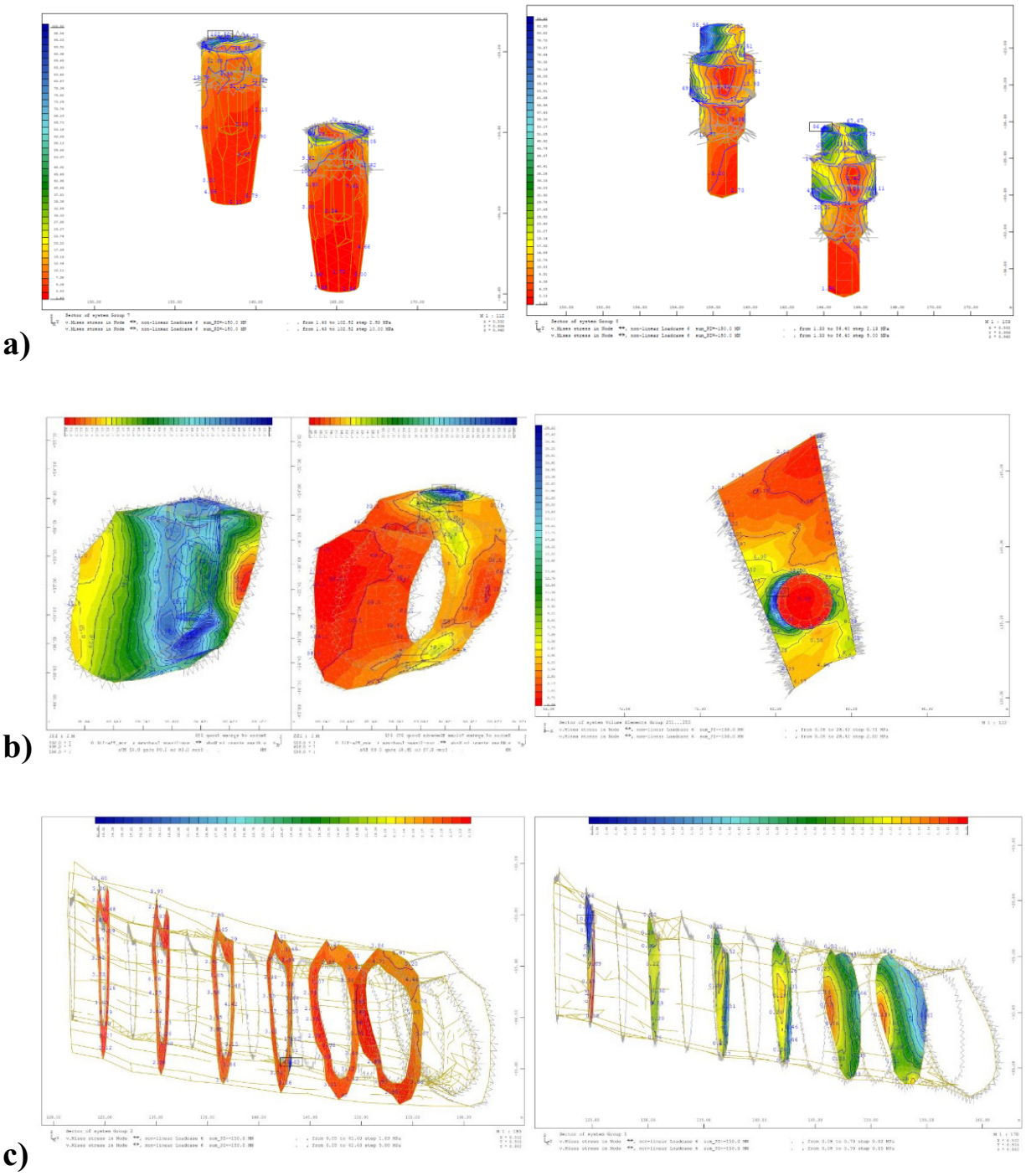


***Figure 6.*** *Von Mises stress (MPa) results for Locator attachment (a) implant, (b) peri-implant bone, and (c) posterior part of the RAG.*

## Bilateral axial load of 150 N

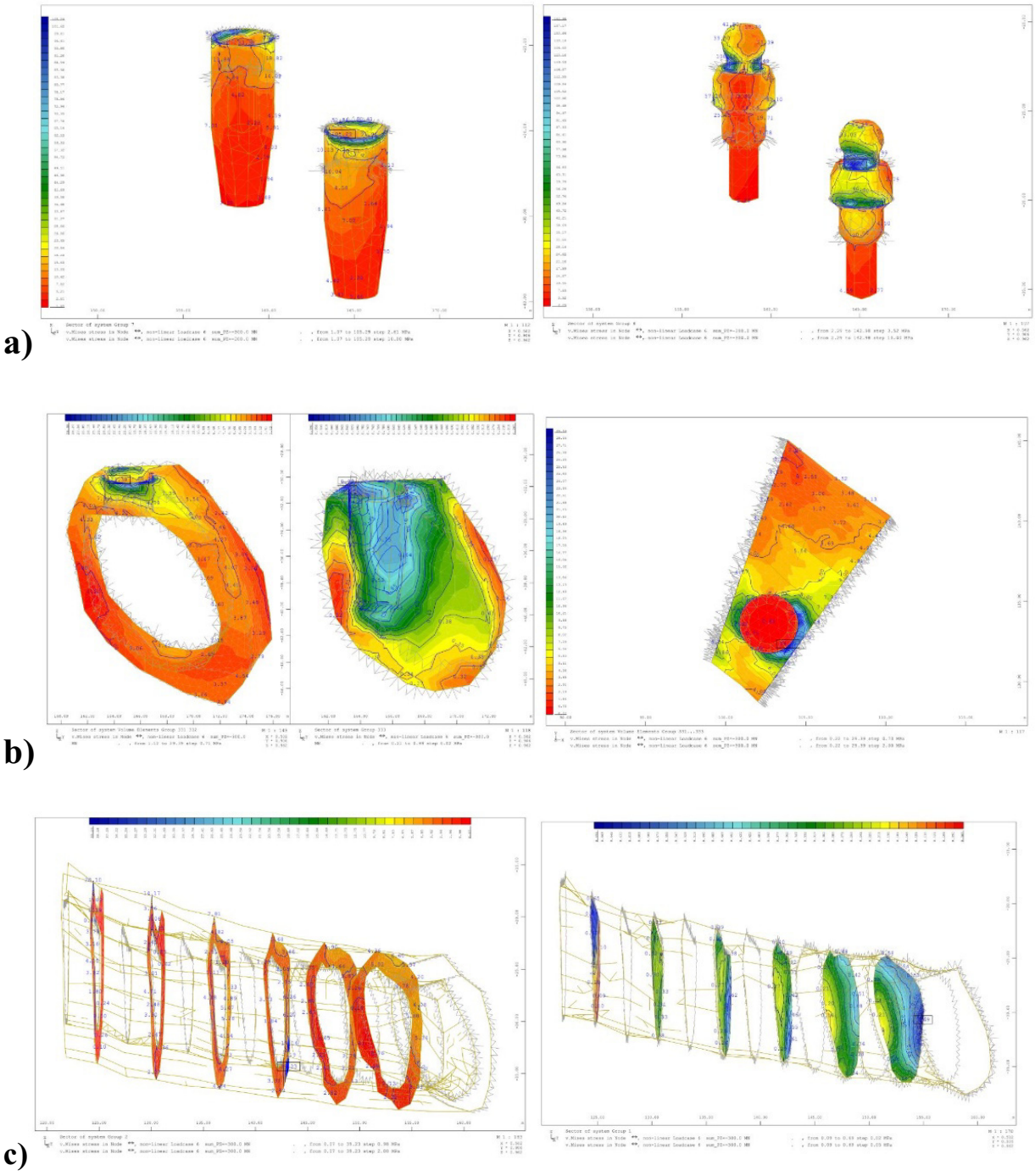


***Figure 8.*** *Von Mises stress (MPa) results for ball attachment, (a) implant, (b) peri-implant bone, and (c) posterior part of the RAG*

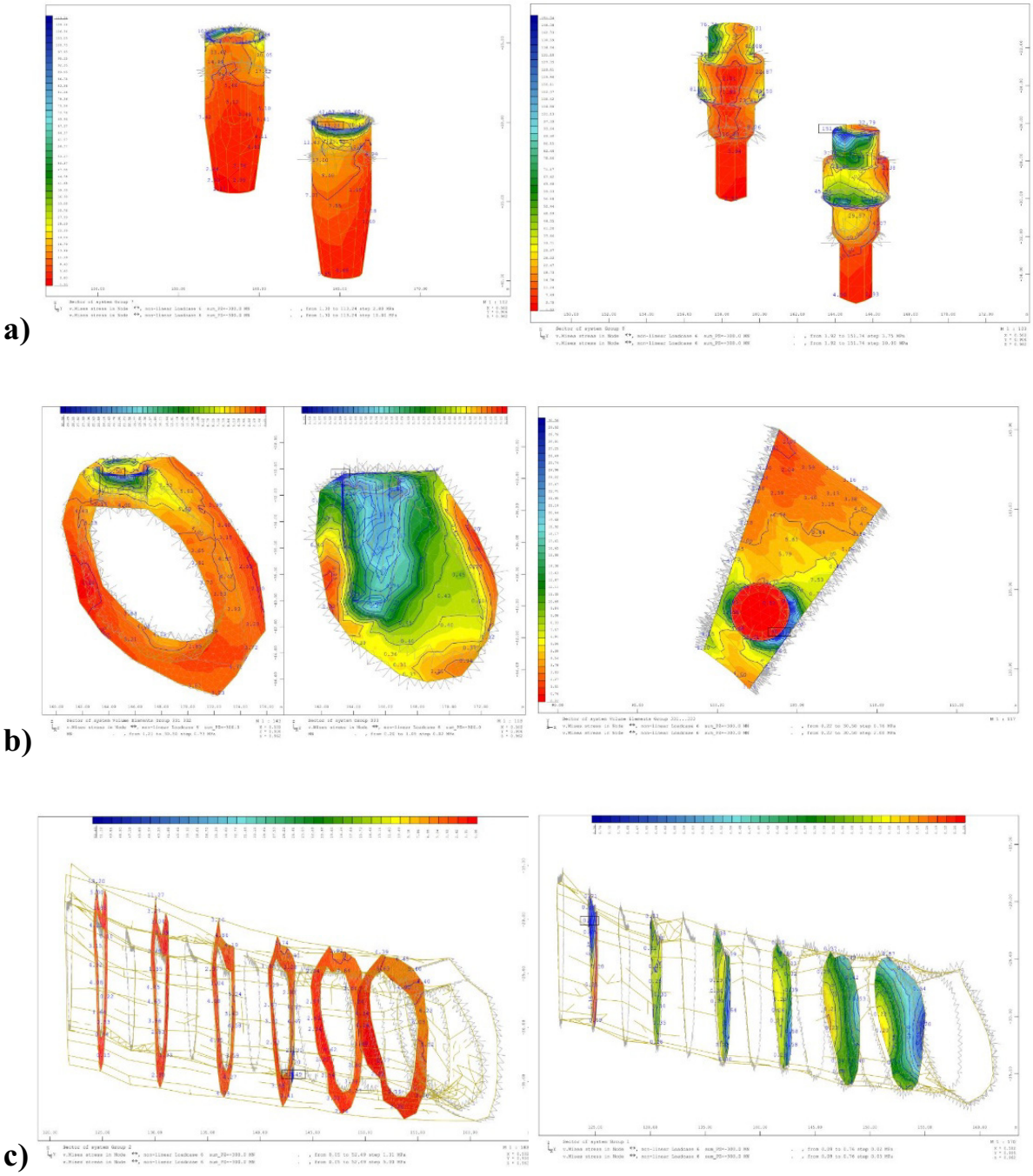


***Figure 9.*** *Von Mises stress (MPa) results for Locator attachment, (a) implant, (b) peri-implant bone, and (c) posterior part of the RAG*

## Tabular presentation of Von Mises stress values (MPa)

**Table 2:** Comparison of stress distribution for ball and locator under axial loading forces of 150 N, unilaterally.

| Model | Implant | | Peri-implant bone | | Posterior region of RAG | |
|---|---|---|---|---|---|---|
| | body | abutment | cortical | cancellous | cortical | cancellous |
| **Model-1 ball** | 97.73 | 99.65 | 27.07 | 1.00 | 31.60 | 0.62 |
| **Model-2 Locator** | 102.52 | 86.60 | 28.42 | 1.04 | 41.40 | 0.70 |

**Table 2:** Comparison of stress distribution for ball and locator under axial loading forces of 150 N, bilaterally.

| Model | Implant | | Peri-implant bone | | Posterior region of RAG | |
|---|---|---|---|---|---|---|
| | body | abutment | cortical | cancellous | cortical | cancellous |
| **Model-1 ball** | 105.29 | 142.98 | 29.39 | 0.99 | 39.23 | 0.69 |
| **Model-2 Locator** | 113.24 | 151.74 | 30.50 | 1.05 | 52.49 | 0.76 |

## Graphical representation of Von Mises stress results (MPa)

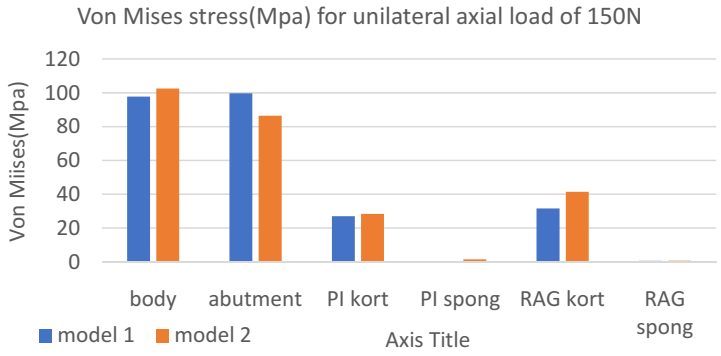


*Figure 10. Comparison of stress distribution between the ball and locator attachment under a unilateral load of 150 N.*

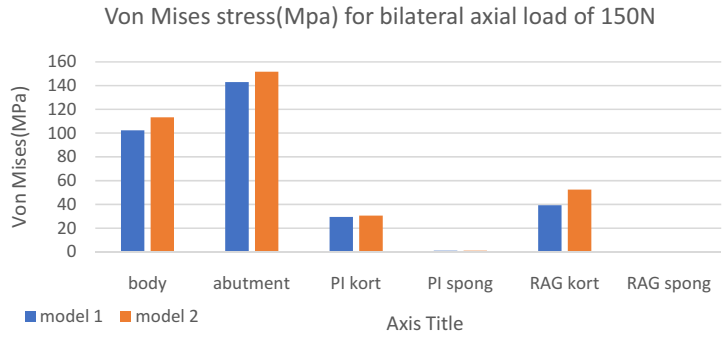


*Figure 11. Comparison of stress distribution between the ball and the locator attachment under a bilateral load of 150 N.*

## Discussion

Despite a high survival rate of dental implants documented in various clinical studies, early or late failures of implant therapy remain unpredictable[6,19,20]. Structural problems and failures are often observed after prosthetic treatment. Due to the complexity of the masticatory system, numerous in vitro biomechanical studies on implant-supported restorations cannot fully clarify the mechanisms of osseointegration loss or implant fracture. This study aims to minimize the risk of clinical failures due to occlusal loading in the prosthetic treatment of completely edentulous mandibles by using FEM analysis, which accurately simulates conditions in the patient's mouth.The finite element method is a crucial tool in implant dentistry for studying stress distribution in bone tissue, biomechanics of dental implants and bones, implant-bone interfaces, and implant fatigue analysis. FEM is increasingly used by researchers due to advancements in virtual engineering that enable computer simulations under precise and stable conditions, reducing errors found in experimental studies[8]. Various factors influence stress distribution in implant-retained overdentures, including implant design, attachment type, loading conditions, and material properties of the implants, prosthesis, and bone[9]. This study investigates the effect of these factors on stress distribution to properly understand the biomechanics of stress transfer from the prosthesis to the attachments, implant, and surrounding bone in a two-implant overdenture. Data from related literature suggest that implants withstand axial forces better than horizontal and oblique forces, which, over time, may lead to bone loss, loosening, and potential implant failure. In this study, models were tested under an axial load of 150 N, as the literature indicates that the maximum chewing force for implant-supported overdenture patients is 150-170 N[10].One of the factors influencing the amount of force transmitted to the implant is the choice of the attachment system used for overdenture retention. The type of attachment used for retaining an implant-retained overdenture (IROD) is considered a crucial factor for implant success regarding the stresses occurring in the implant during function. Bhattacharjee et al. highlight the impact of the type of attachment on stress in the peri-implant bone as a conclusion from their analysis of literature data on this topic[11]. According to El-Taftazani et al., whenever the retention system is resilient, the stress in the bone around the implant is subsequently reduced, and some of the stress is transferred to the posterior part of the alveolar ridge. This results in better stress distribution, thereby reducing the maximum stress levels. Ball attachments are more resilient than locator attachments and, therefore, transmit less force. According to the authors, the resilience of these two attachments is closely related to the nylon caps used in the attachments. Since the volume of the nylon cap in the ball attachment is larger than that in the locator attachment, and because the ball attachment has a single retention mechanism while the locator has a dual retention mechanism, the ball attachment is more resilient and transmits less stress than the locator attachment[12]. This study confirms the same findings. The stress distribution in the model with ball attachments is more uniform, and lower Von Mises stress values appear in the implant, peri-implant bone, and the posterior part of the residual alveolar ridge (RAR).

### *Stress Distribution in the Implant*

It is suggested that narrow-diameter implants have lower resistance to mechanical forces compared to standard-diameter implants. On the other hand, Morneburg et al. did not report any implant fractures over six years and two years of follow-up. According to the authors, implant fractures were avoided due to proper loading protocols, implant placement in the anterior part of the mandible, and the use of short attachments[13,14].This study showed that implants experience the highest stress when under load. Under an axial load, the highest stresses are observed at the neck of the implant body and the abutments in both models. The highest Von Mises stress values in the implant are observed in models with locator attachments. A recent finite element method study by Varela-Jimenez et al. determined that complications associated with narrow implants can be minimized by the mechanical advantages provided by a bar attachment. Connecting narrow implants with a bar would protect the implants from excessive loading and prevent fractures at the implant/abutment junction. Implant connections are made to increase the stability of the structure as a whole, achieve better stress distribution, and increase the total surface area receiving the load[15].

### *Stress Distribution in the Peri-implant Bone*

The results of this study revealed that the stresses induced in the peri-implant bone upon loading were not high in the cortical and trabecular bone in the analyzed models. The highest stresses in the peri-implant bone are concentrated around the neck of the implants (i.e., in the cortical bone). Similar results have been reported in studies by Daas et al. and El-Zawahry et al.[16,17]. A review and meta-analysis conducted by Keshk et al. in 2017 on the impact of attachments on peri-implant bone resorption revealed no statistically significant differences among the analyzed attachment types regarding marginal bone loss, bleeding index, gingival index, and plaque index[18]. This result was also highlighted in this study. However, the dif-

ferent geometries of the two retention systems may reflect different, albeit not significant, stress distribution variations under a load.

### *Stress Distribution in the Posterior Part of the Residual Alveolar Ridge (RAR)*

This study found no significant difference in Von Mises stress values in the posterior part of the RAR between ball and locator attachments. However, the model with ball attachments produced better results, with lower Von Mises stress values. Further in vitro studies using the finite element method have confirmed that ball attachments provide a more uniform distribution of loading forces on both sides of the residual alveolar ridge[19,20]. Menicucci et al. investigated stress distribution in the bone around the implant and the posterior part of the mandibular alveolar ridge in two-implant overdentures retained with ball and bar attachments using the 3D finite element method. The study suggests that ball attachments are preferable to bar attachments as they provide better stress distribution in the posterior part of the mandibular alveolar ridge[20]. Bollineni et al. conducted an evaluation and comparison of stress distribution in the peri-implant bone and posterior mandibular bone caused by an overdenture retained on narrow-diameter implants using two types of ball attachments: rigid and resilient. According to the author, when narrow-diameter implants are used, the stress in the peri-implant bone and the posterior part of the alveolar ridge increases. However, in patients with narrow ridges where implant placement with a standard diameter is limited, the precise selection of retention elements/attachmentsbecomes a critical factor in distributing masticatory forces. The conclusion is that overdentures retained on implants with resilient attachments show better stress distribution than those with rigid attachments[21].

The loss of implants and retention systems during oral rehabilitation has negative consequences on denture stability, mastication, and patient comfort. To prevent complications, a proper analysis of occlusal forces is recommended, along with an adequate number of implants, their optimal topographical placement, the selection of an appropriate prosthetic restoration, and continuous medical care for the patient to ensure timely and appropriate interventions to eliminate any deficiencies that may arise.

## Conclusions

According to the results of this study, we can conclude that:

1. The highest stress values were observed at the implant necks and abutments in both models.

2. Regarding the peri-implant bone and the posterior part of the RAG, the highest stress values were observed in the model with a locator attachment.

3. Ball attachments provide a more even distribution of load forces compared to locator attachments.

## Reference


1. Sharma S, Makkar M, Teja SS, Singh P. Implant-supported overdenture: a review. J Pharm Biomed Sci 2017; 07(7):270–277.
2. Kobayashi M, Srinivasan M, Ammann P, Perriard J, Ohkubo C, Müller F, Belser UC, Schimmel M. Effects of in vitro cyclic dislodging on retentive force and removal torque of three overdenture attachment systems. Clin Oral Implants Res. 2014 Apr;25(4):426-34. DOI: 10.1111/clr.12156. EPUB2013 Apr 9. PMID: 23566266.
3. Schmidt MB, Rauch A, Schwarzer M, Lethaus B, Hahnel S. Combination of Digital and Conventional Workflows in the CAD/CAM-Fabrication of an Implant-Supported Overdenture. Materials (Basel). 2020 Aug 20;13(17):3688. DOI: 10.3390/ma13173688. PMID: 32825488; PMCID: PMC7503874.
4. Geckili O, Cilingir A, Erdogan O, Kesoglu AC, Bilmenoglu C, Ozdiler A, Bilhan H. The influence of momentary retention forces on patient satisfaction and quality of life of two-implant-retained mandibular overdenture wearers. Int J Oral Maxillofac Implants. 2015 Mar-Apr;30(2):397-402. DOI: 10.11607/jomi.3774. EPUB2014 Dec 5. PMID: 25506644.
5. Stamenković D, Nastić M. Stomatološka protetika: parcijalne proteze. Beograd: Zavod za udžbenike i nastavna sredstva; 2000.
6. Ozan O, Ramoglu S. Effect of Implant Height Differences on Different Attachment Types and Peri-Implant Bone in Mandibular Two-Implant Overdentures: 3D Finite Element Study. J Oral Implantol. 2015 Jun;41(3):e50-9. DOI: 10.1563/AAID-JOI-D-13-00239. EPUB2014 Jan 28. PMID: 24471769.
7. Pammer D. Evaluation of postoperative dental implant primary stability using 3D finite element analysis. Comput Methods Biomech Biomed Engin. 2019 Feb;22(3):280-287. DOI: 10.1080/10255842.2018.1552682. EPUB 2019 Jan 24. PMID: 30676075.
8. Панчевска С. Тридимензионална анализа на дистрибуцијата на оклузалните сили кај парцијални протези со дистално слободни седла според методот на конечни елементи. (докторска дисертација) Скопје, 2010.
9. Satheesh Kumar P, Satheesh KK, John J, Patil G, Patel R. Force transfer and stress distribution in an implant-supported overdenture retained with a harderbar attachment: a finite element analysis. ISRN Dent. 2013 Dec 26;2013:369147. DOI: 10.1155/2013/369147. PMID: 24459589; PMCID: PMC3888690.
10. Helmy, M.A. Kothayer, M. Effect of two different overdenture attachments on the biting force and occlusal force distribution.Egypt. Dent. J. 2019, 65, 1723–1732.
11. Bhattacharjee B, Saneja R, Singh A, Dubey PK, Bhatnagar A. Peri-implant stress distribution assessment of various attachment systems for implant-supported overdenture prosthesis by finite element analysis - A systematic review. J Oral Biol Craniofac Res. 2022 Nov-Dec;12(6):802-808. DOI: 10.1016/j.jobcr.2022.09.002. EPUB 2022 Sep 7. PMID: 36159066; PMCID: PMC9490590.
12. El-Taftazani I, Moubarak A, El-Anwar M. Locator attachment versus ball attachment: 3-Dimensional finite element study. Egypt. Dent. J. 2011;57(2)
13. Morneburg T. R. Success rates of microimplants in edentulous patients with residual ridge resorption. The International Journal of Oral & Maxillofacial Implants. 2008;23(2):270–276.
14. S. Storelli, A. Caputo, G. Palandrani, M. Peditto, M. Del Fabbro. Use of Narrow-Diameter Implants in Completely EdentulousPatients as a Prosthetic Option: A Systematic Review of the Literature.

15. Valera-Jiménez JF, Burgueño-Barris G, Gómez-González S, López-López J, Valmaseda-Castellón E, Fernández-Aguado E. Finite element analysis of narrow dental implants. Dent Mater. 2020; 36:927-935.
16. Daas M, Dubois G, Bonnet AS, Lipinski P, Rignon-Bret C. A complete finite element model of a mandibular implant-retained overdenture with two implants: comparison between rigid and resilient attachment configurations. Med Eng Phys. 2008 Mar;30(2):218-25. DOI: 10.1016/j.medengphy.2007.02.005. EPUB 2007 Mar 26. PMID: 17383925.
17. El-Zawahry MM, Ibraheem EM, Nassani MZ, Ghorab SA, El-Anwar MI. Stress analysis of mandibular implant overdentures retained with one, two, or four-ball attachments: A finite element study. Dent Res J (Isfahan). 2018 Nov-Dec;15(6):437-443. PMID: 30534172; PMCID: PMC6243807.
18. Keshk AM, Alqutaibi AY, Algabri RS, Swedan MS, Kaddah A. Prosthodontic maintenance and peri-implant tissue conditions for telescopic attachment-retained mandibular implant overdenture: Systematic review and meta-analysis of randomized clinical trials. Eur J Dent. 2017 Oct-Dec;11(4):559-568. DOI: 10.4103/ejd.ejd_23_17. PMID: 29279687; PMCID: PMC5727746.
19. Menicucci G, Lorenzetti M, Pera P, Preti G. Mandibular implant-retained overdenture: finite element analysis of two anchorage systems. Int J Oral Maxillofac Implants. 1998 May-Jun;13(3):369-76. PMID: 9638007.
20. Unsal GS, Erbasar GNH, Aykent F, Ozyilmaz OY, Ozdogan MS. Evaluation of Stress Distribution on Mandibular Implant-Supported Overdentures With Different Bone Heights and Attachment Types: A 3D Finite Element Analysis. J Oral Implantol. 2019 Oct;45(5):363-370. DOI: 10.1563/aaid-joi-D-19-00076. Epub 2019 Sep 19. PMID: 31536445.
21. Bollineni U, Shetty R, Singh I, Gopalakrishna S.Influence of Attachment Configuration on Stresses in Completely Edentulous Mandibular Ridge with an Implant-retained Overdenture: A Finite Element Analysis.WorldJ Dent 2018;9(3)208-214