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MACEDONIAN DENTAL REVIEW **Contents**

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GUIDED BONE REGENERATION IN ANTERIOR MANDIBLE FOR PREDICTABLE IMPLANT PLACEMENT – CASE REPORT

ВОДЕНА КОСКЕНА РЕГЕНЕРАЦИЈА ВО АНТЕРИОРНА ЗОНА НА МАНДИБУЛА ЗА ПРЕДВИДЛИВО ПОСТАВУВАЊЕ НА ДЕНТАЛНИ ИМПЛАНТИ - ПРИКАЗ НА СЛУЧАЈ

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Abstract

Introduction: The rehabilitation of missing teeth with the use of dental implants is an established treatment with high success rate. Unfavorable clinical conditions may be present in many cases that would prevent the possibilities for implant placement. Augmentation of the alveolar bone with the use of the guided bone regeneration method, GBR, gives successful and long-term results. **Material and Method:** A male patient, aged 32, with present periodontal infection around the roots of three mandible incisors. Removal of the affected teeth and complete removal of the periodontal lesion at the same time after which GBR was performed using xenograft (Cerabone plus – Bottis) and allograft (Maxgraft cortico cancellous – Bottis) materials covering them with collagenous membrane (Jason membrane – Bottis) as preparation for implant placement. Nine months later, perfect conditions are achieved for placement of implants. **Discussion:** Using evidence-based protocols, GBR is indicated in many cases when there is need to extend or to preserve the alveolar bone width. Ensuring the appropriate thickness of the alveolar ridge, like we have achieved in this case, significantly reduces the risks of peri-implantitis and other complications related to healing and maintenance of dental implants. **Conclusion:** Horizontal bone augmentation in patients with significant bone loss in the region of future implantation zone, using bone substitutes of the xenograft type in combination with allograft and their appropriate fixation with a resorbable collagenous membrane, gives positive results in ensuring the appropriate thickness of future toothless alveolar ridge as precondition for proper placement of dental implants. **Key Words:** GBR, guided bone regeneration, dental implants, xenografts, allografts.

Апстракт

Вовед: Рехабилитацијата на заби кои недостасуваат со употреба на дентални импланти е вообичаен метод и со висока стапка на успех. Во многу случаи постојат неповолни услови каде поставувањето на имплантите е контра индицирано. Задебелувањето на алвеоларната коска со употреба на методот на водена коскена регенерација, ВТР, дава успешни и долгорочни резултати. **Материјал и метод:** Машки пациент, 32 години, со присуство на пародонтална инфекција околу корените на три мандибуларни централни инцизиви. Отстранување на зафатените заби како и целосно отстранување на пародонталната лезија по што е направен ВТР со употреба на ксенографт (Cerabone plus – Bottis) и алографт (Maxgraft cortico cancellous – Bottis), покриени со колагенозна мембрана (Jason membrane – Bottis) како подготовка за поставување на импланти. Девет месеци подоцна постојат совршени услови по што се поставуваат имплантите на предвидените места. **Дискусија:** Користејќи однапред докажани протоколи, ВТР е индицирана во многу случаи кога има потреба да се задебели или да се зачува ширината на алвеоларната коска. Обезбедувањето на соодветна дебелина на алвеоларниот гребен, како што постигнавме во овој случај, значително ги намалува ризиците од пери-имплантит и други компликации поврзани со заздравувањето и одржувањето на имплантите. **Заклучок:** Хоризонталната коскена аугментација кај пациенти со значително губење на коска во предел на идната имплантациона зона, со користење на коскени супституенти од типот на ксенографт во комбинација со алографт и нивна соодветна фиксација со колагенозна мембрана, дава позитивни резултати во обезбедувањето на соодветна дебелина на идниот беззаб алвеоларен гребен како предуслов за правилно поставување на импланти. **Клучни зборови:** ВТР, водена коскена регенерација, дентални импланти, ксенографт, алографт.

Introduction

The rehabilitation of totally or partially edentulous jaws, as well as to single-unit edentulous patients, with the use of dental implants is a usual method and established treatment with high success rate[1]. However, unfavorable clinical conditions may be present in many cases that would prevent the possibilities for implant placement, such as those where there is a lack of height and width of the alveolar bone ridge. Augmentation of the alveolar bone with the use of the method of guided bone regeneration presents option for treatment in such cases

where osseous support is needed for proper osseointegration of the dental implants[2]. The known procedures for bone augmentation of the alveolar bone with the use of the guided bone regeneration method, also known as GBR, gives successful and long-term results[3-5].

Autogenous bone grafts are considered as the "golden standard" in terms of material used during augmentation of the bone, because it is the only biomaterial that possess perfect combination of properties like osteogenesis, osteoinduction and osteoconduction[6-7]. However, disadvantages like morbidity at the donor site, limited availability, tooth sensitivity and risk of dehiscence of the wounds [6,8-10] have led to investigations of the development and application of bone substitutes for the regeneration of the alveolar bone ridge[10-12].

Xenografts and allografts have shown to be excellent alternative with exceptional properties for GBR, like its biocompatibility, formation of a scaffold (osteoconduction), slow resorption rates, and the ability to define and maintain the volume for bone gain[11-13]. However, there is a relative disadvantage in the use of these materials compared to the autogenous bone in terms of the maturation period of the material, which can take from nine to twelve months[9,11-13] as well as the demand and need of collagen membranes for guided bone regeneration procedures, which must provide cell occlusion and a better biocompatibility with the soft tissue, reducing the risk of complications such as wound dehiscence[10-13].

The aim of this case report is to describe guided bone regeneration with the use of xenograft and allograft materials covered with collagen membrane in horizontal bone augmentation of intercanine part of the mandible, performed immediately after the removal of three mandibular incisors as well as removal of large chronical diffuse periodontal infection. In addition, post-operative healing time is shown after which implant placement is completed and follow-up of the implants is described.

Case report

Male patient, aged 32, came to our clinic seeking to solve functional and aesthetical problem which was present in the front part of the lower jaw (Figure 1). After the initial clinical exam and the analysis of his orthopantomogram x-ray (Figure 2), it was found that the patient was missing one tooth in the upper jaw (upper left second premolar), several teeth had large composite fillings and three teeth had root canal treatments, one of which was the lower left central incisor. Additionally, during the analysis of the x-ray, indistinct lesion around the roots of the lower central incisors and the right lower lateral incisor was detected, however it was unclear whether the left lower lateral incisor was affected as well. The clinical exam also showed presence of gingival recession on the buccal as well as the lingual side around the central incisors and presence of bad and inad-

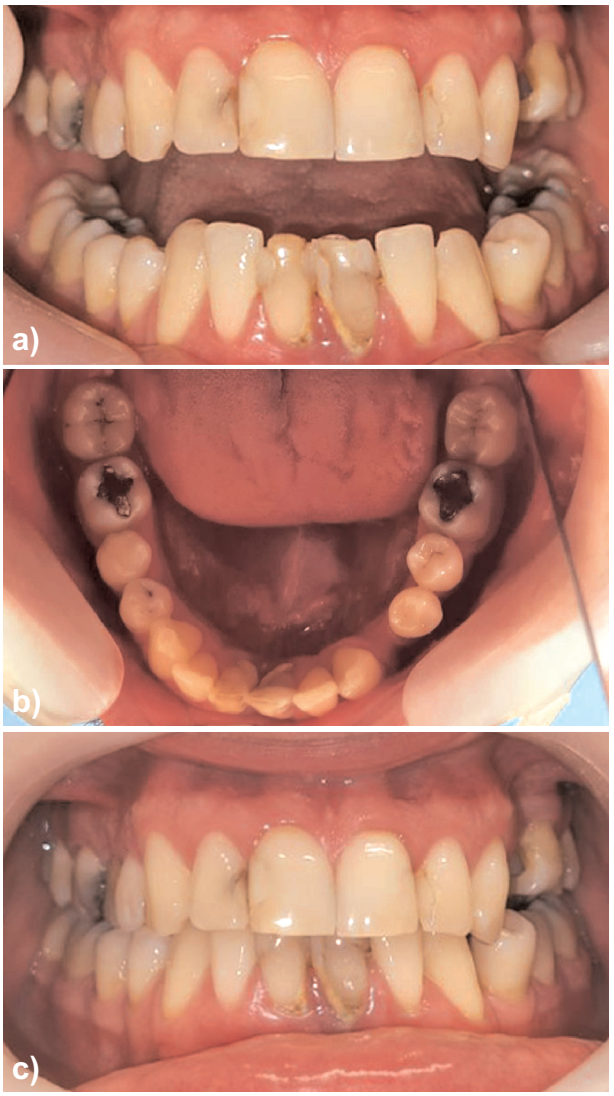


Figure 1. *(a),(b),(c) - Intraoral view of the initial situation*

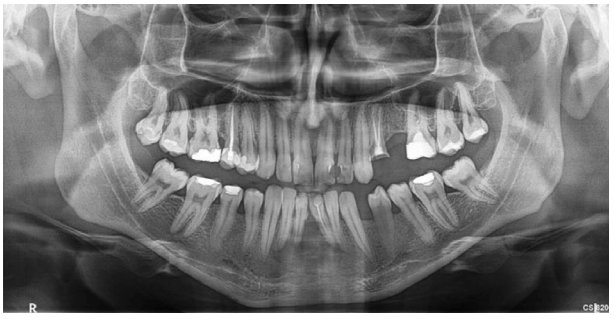


Figure 2. *Orthopantomogramic x-ray shows visible pathologic change in the part of the mandible incisors*

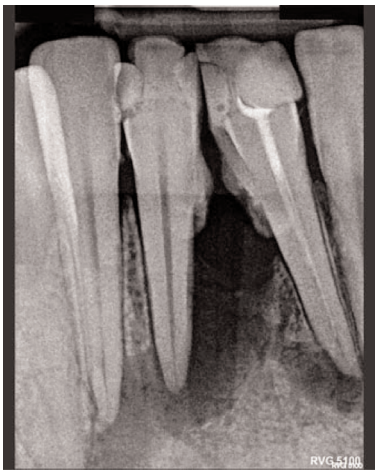


Figure 3. *Retroalveolar x-ray to confirm the presence of pathologic change around the mandibular incisors*

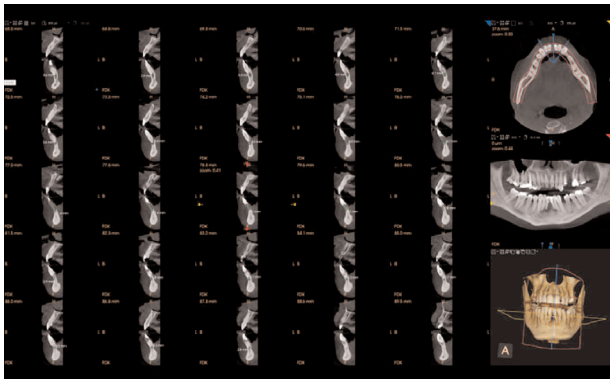


Figure 4. *Cone Beam Computer Tomography with measurements of the change and its dimensions*

equate composite fillings on those teeth (Figure 1). In order to confirm the existence of pathological lesion around the roots of the mandibular incisors, (Figure 3) cone-beam computer tomography imaging (CBCT) was done as well (Figure 4). The CBCT analysis confirmed that infection was present in that region in the form of chronic diffuse periodontal infection that affected teeth #31, #41 and #42. The measurements that were done on the CBCT showed that the infection in the part between the two central incisors was 11.2 mm cranio-caudally and 4.5 mm in anterio – posterior direction (Figure 4).

It was decided that the affected teeth (#31, #41 and #42) should be extracted and the lesion will be surgically removed. Following this, a guided bone regeneration would be performed with the use of xenograft (Cerabone plus – Bottis) and allograft (Maxgraft – Bottis), material that would allow predictive results, an acceptable percentage of success and a small percentage of complications as well as reduction of the morbidity of the patient[14]. In addition, the placement of a collagenous membrane

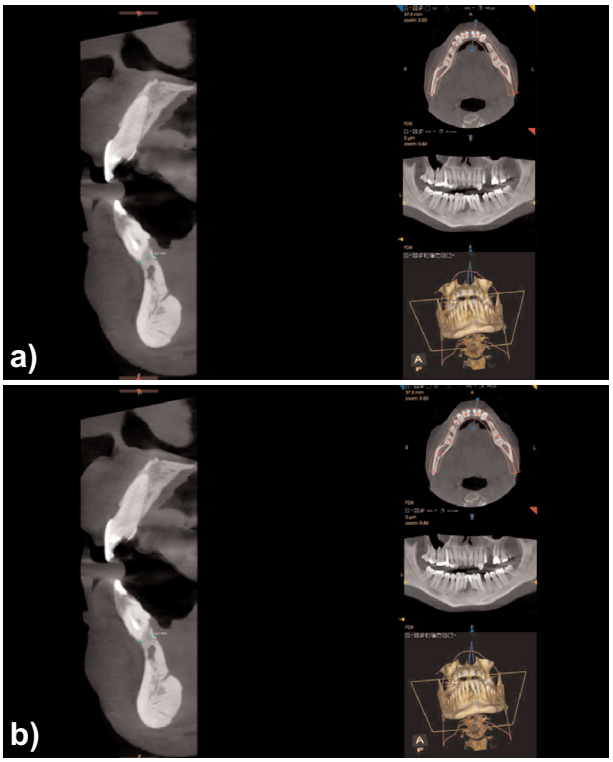


Figure 5 (a), (b). *Measurements of the width of the future alveolar bone ridge where implants should be placed. (a) Measurements of position 31, prior to extraction shows 4.7 mm in width. (b) Measurements of 42, prior to extraction shows 6.2 mm in width*

(Jason - Bottis) was also planned, in order to preserve the dimension of the residual bone ridge. At positions #31 and #42, the future positions of the dental implants, the thickness of the ridge at the site of the left mandibular incisor gave a value of 4.7 mm, which is insufficient for adequate implant placement, while the position for the second implant at the site of the right mandibular incisor gave a satisfactory value of 6.7 mm (Figure 5).

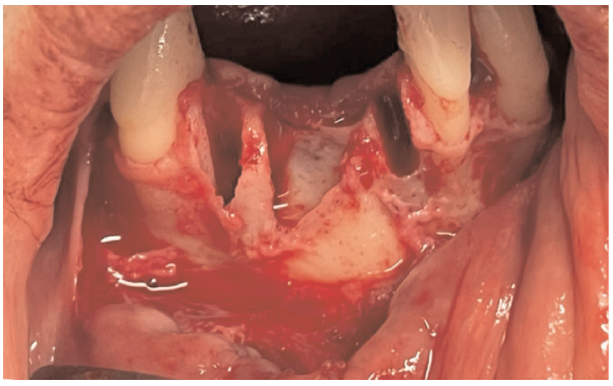


Figure 6. *Shows the enormous bony defect after the removal of the incisors and the curettage of the pathologic change*

At the beginning of the treatment, local anesthetic, articaine (artinibsa 4%) was applied buccally and lingually to all six frontal mandibular teeth. The incision was intrasulcular in the region from #43 to #33, with small vertical releases at the distal of this incision. The mucoperiosteal flap was raised, after which the two central mandibular incisors as well as the right lateral incisor were extracted (Figure 6). Curettage of the pathological lesion and the surrounding alveolar bone was done. After the complete removal of the lesion, which was not a compact entity and due to the frequency of recurrences of this type of lesions, soft tissue debridement was also performed. Due to the size of the lesion itself and the expected bleeding from it, a dressing with 2 ml of a solution of hydrogen peroxide diluted to 3% was used occasionally. A copious saline rinse was performed and after the lesion was removed, the wound was rinsed with 4 ml of povidone-iodine (Betadine) 1% solution, intended for oral use, which was left in the wound for one minute.

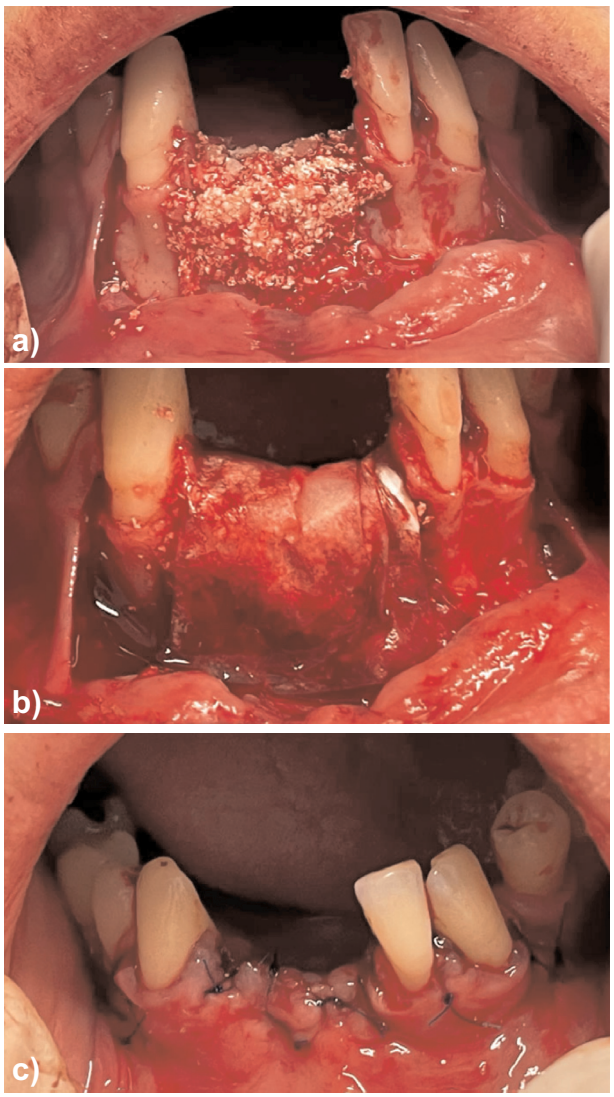


Figure 7. (a),(b),(c). *– (a) Shows the grafted bone with Xenograft and Allograft, (b) Shows the collagen membrane placed over the bone graft, (c) Shows the completed surgery with polyamide sutures over the grafted bone*

In the second part of the treatment, the application of the regeneration materials followed. Xenograft 0.5mg (Cerabone plus – Bottis) and 0.5mg allograft (Maxgraft cortico cancellous granules – Bottis) were properly prepared and hydrated in combination with pure saline solution 0.9%, after which they were applied to the site of the bony defect, as well as to the placement sites of the future implants (Figure 7-a). After the application of the xenograft and allograft was completed, a collagenous membrane (Jason membrane – Bottis) with dimensions of 30x20mm was placed (Figure 7-b). Proper adaptation was performed over the grafted area, covering the lingual, occlusal and buccal sides of the alveolar ridge. The membrane was fixed with two sutures of resorbable polymer (P.G.A – 4-0). After the collagenous membrane was properly fixed, sutures were placed, using non-resorbable monofilament (Polyamide 4-0). Two horizontal mattress sutures were placed for additional fixation of the membrane above which several individual single sutures were placed (Figure 7-c). At the very end of the treatment, an ampoule of corticosteroid (Dexamethasone 4 mg) of 1 ml was applied I.M.

Written recommendations for appropriate behavior and wound care were given to the patient. An antibiotic was prescribed, amoxicillin cum clavulanic acid, a.1000, s.2x1 – one tablet every 12 hours, starting one hour after the treatment, as well as serapeptase capsules, a.250000 i.e. at least five days, one per day, starting from the next morning, 30 minutes before the first meal. In addition, recommendations were given for analgesics as needed, nimesulide a.100 mg. Cold compresses after the treatment were suggested, at an interval of 15-20 min application of the compress and a 30-40 min break during the

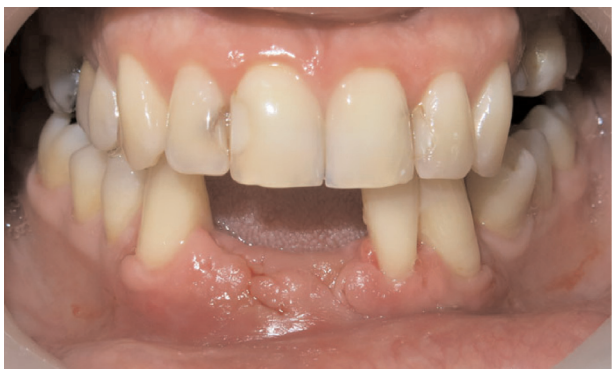


Figure 8. *10th day after treatment, the look of the wound at the date of suture removal*

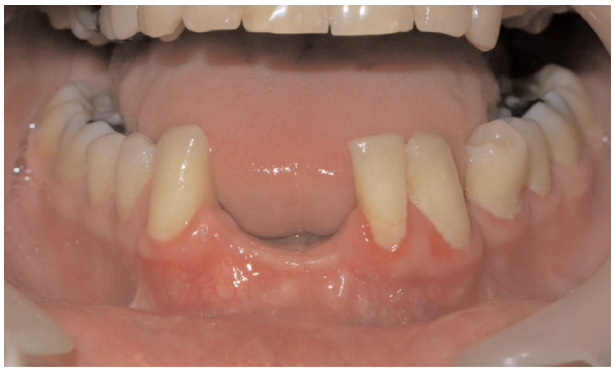


Figure 9. *3 months after treatment*

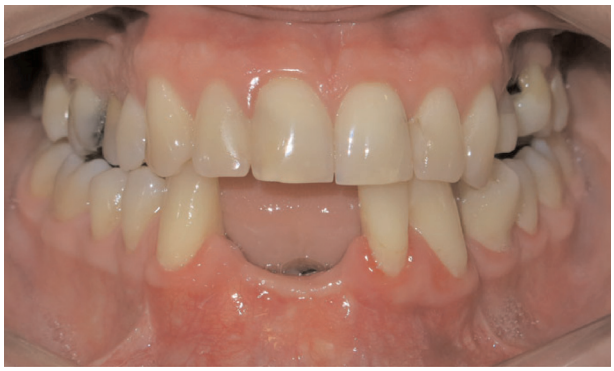
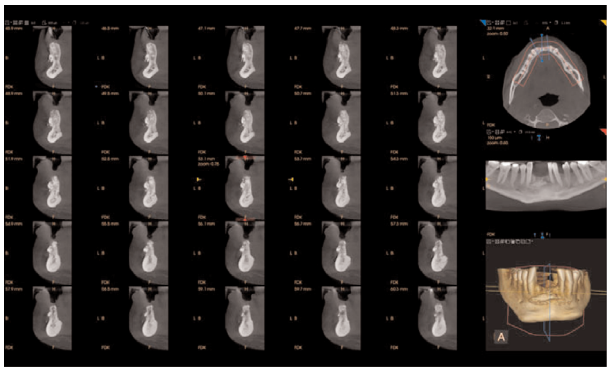


Figure 10. *6 months after treatment*

first day, as well as recommendations for rinsing the wound the next day with a solution based on chlorhexidine 0.20%, two times a day, seven days, morning and evening.

The patient came for check-up the second day of the treatment, the wound was without any signs of infection or loosening of the sutures. On the 10th day from the intervention, the sutures were removed, and the healing was progressing well (Figure 8). Three months from the day of the operation (Figure 9) and six months after the treatment, control examinations were done again, adequate healing was visible (Figure 10). In the period between the eighth and ninth month from the intervention, a control CBCT image was done (Figure 11). Sufficient values of bone were visible and it was determined that the next phase, placement of the dental implants, could be continued (Figure 12).

Nine months after the teeth extraction, the patient was again scheduled for surgery. Plexus anesthesia was applied, buccally and palatally, articaine (artinibsa 4%) after which an incision was made along the edentulous ridge and two sulcus incisions buccally, on teeth #32 and #43. After the mucoperiosteal flap was raised, small smoothing of the bony ridge was done and the preparation of the implant beds was completed.



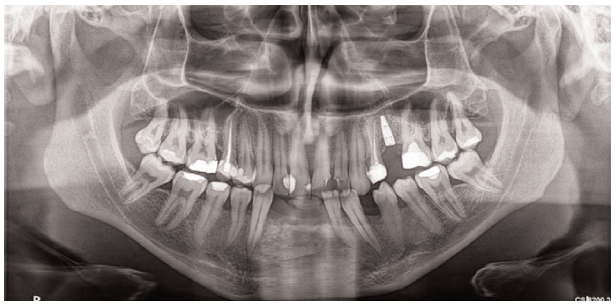
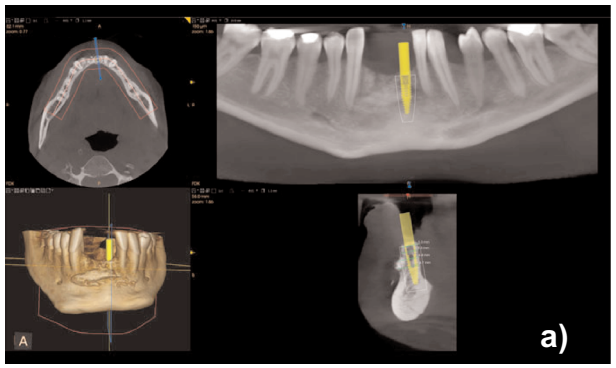


Figure 11 (a), (b). *(a) CBCT before implant placement; (b) Orthopantomogram x-ray before implant placement*



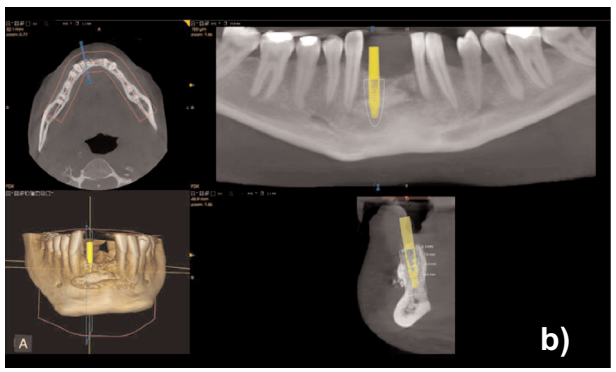


Figure 12 (a), (b). *(a) Shows the values and width of the bone at position #31; (b) Shows the values and width of the bone at position #42*

Two implants were placed, at position #42 (Straumann BLT – SLA, 3.3 – 12mm) and at position

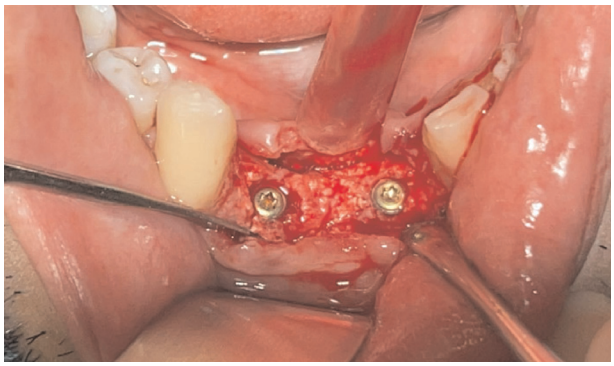


Figure 13. *Implants placed at the correct position. Sufficient bone is evident around the placed implants*

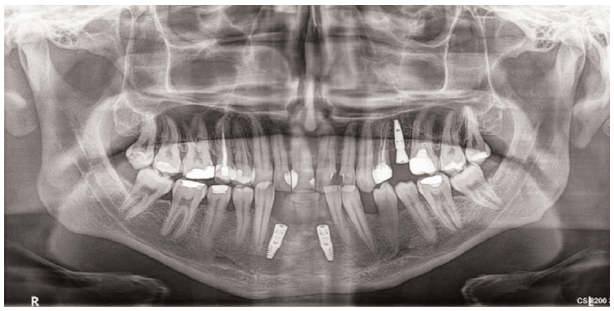


Figure 14. *Orthopantomogram x-ray after the implant placement*

#31 (Straumann BLT – SLA, 3.3 – 12mm) (Figure 13-14). Sutures, non-resorbable monofilament (polyamide 4-0) were placed. After the end of the treatment, 1 ml of dexamethasone was administered locally, in the submucosal tissue around the wound area. The same recommendations that were given after the first treatment were repeated this time as well. The same antibiotic prophylaxis using amoxicillin cum clavulanic acid was repeated.

At the follow-up examination, the second day after the treatment, the wound had good postoperative course. The patient had no complaints. On the tenth day from the intervention, the sutures were removed. The first month after the treatment (Figure 15), a control examination was performed and everything was in order and the third month after the placement of the implants, the sulcus formers were placed, after which the patient began the prosthetic procedure for making a bridge over the two implants.

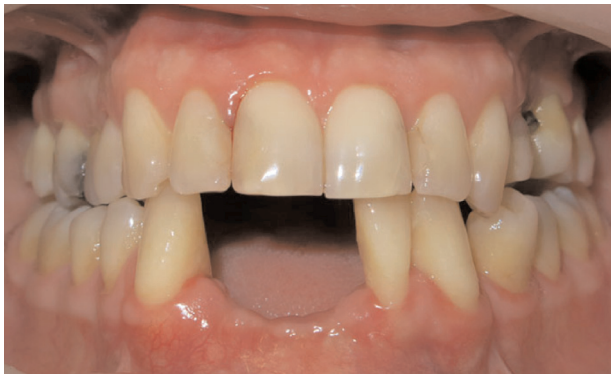


Figure 15. *One month after implant placement*

Discussion

Using evidence-based protocols, guided bone regeneration (GBR) is indicated in many cases when there is a need to extend or to preserve the alveolar bone width. Using xenograft and allograft material in combination with collagen membrane gives high level of success and survival of the placed dental implants in regions that previously had a significant defect and bone loss[5,9,15]. Adequate grafting of an edentulous alveolar ridge, immediately after tooth extraction, provides significantly better conditions for the placement of dental implants compared to ridges that heal spontaneously[16].

Maintenance of bone crest thickness at position 42 and increasing the ridge thickness at position 31 by more than 1 mm is a clear indicator of the importance of adequate grafting as a preparation for implant placement (Figure 5 and 12). Bone crest thickness at position 42 before tooth extraction was 6.7 mm, and nine months later is slightly reduced to 6.3 mm, which is still satisfactory and has enough bone for implant placement. Bone crest thickness at position 31 before tooth extraction was 4.2 mm and after nine months it is increased to 5.3 mm which shows bone gain of more than 25% in antero-posterior distance.

Moreover, GBR can compensate huge bone defects caused by pathological processes[3]. The complete removal of the existing periapical change in this case and the maintenance of the thickness of the alveolar ridge itself in certain zones, and the thickening of those zones is a clear indicator of the significance of this procedure.

Adequate healing of the soft tissues after the first operation, without additional complications such as exposure of the collagenous membrane, was of great importance for the success of regeneration (Figure 8, 9, 10). In addition, the correct healing of the soft tissues after the second operation, the placement of the implants, was also of great importance for proper osseointegration and prevention of the occurrence of peri-implantitis (Figure 15).

The collagenous resorbing membrane with its hydrophilic properties and the excellent interaction with blood coagulum and fibrin, further accelerate wound healing and epithelization and minimize the risk of dehiscence of the wound.

Ensuring the appropriate thickness of the alveolar ridge, like we achieved in this case, significantly reduces the risks of peri-implantitis and other complications related to the healing and maintenance of dental implants. Our

findings are in accordance with the findings of Chiapasco and Zaniboni, 2009[1], Aghaloo and Moy, 2007[3] and Hämmerle, Jung, Yaman, and Lang, 2008[11].

Conclusion

After the description and analysis of this case, it can be concluded that horizontal bone augmentation in patients with the presence of significant bone loss in the region of the future implantation zone, using bone substitutes of the xenograft type in combination with allograft and their appropriate fixation with a resorbable collagenous membrane, showed positive results in ensuring the appropriate thickness of the future toothless alveolar ridge as precondition for proper placement of dental implants.

Reference

1. M. Chiapasco and M. Zaniboni, "Clinical outcomes of GBR procedures to correct peri-implant dehiscences and fenestrations: a systematic review," Clinical Oral Implants Research, vol. 20, Supplement 4, pp. 113–123, 2009.
2. I. A. Urban, S. A. Jovanovic, and J. L. Lozada, "Vertical ridge augmentation using guided bone regeneration (GBR) in three clinical scenarios prior to implant placement: a retrospective study of 35 patients 12 to 72 months after loading," The International Journal of Oral & Maxillofacial Implants, vol. 24, no. 3, pp. 502–510, 2009.
3. T. L. Aghaloo and P. K. Moy, "Which hard tissue augmentation techniques are the most successful in furnishing bony support for implant placement?," The International Journal of Oral & Maxillofacial Implants, vol. 22, pp. 49–70, 2007.
4. M. Retzepi and N. Donos, "Guided bone regeneration: biological principle and therapeutic applications," Clinical Oral Implants Research, vol. 21, no. 6, pp. 567–576, 2010.
5. R. E. Jung, N. Fenner, C. H. F. Hämmerle, and N. U. Zitzmann, "Long-term outcome of implants placed with guided bone regeneration (GBR) using resorbable and non-resorbable membranes after 12–14 years," Clinical Oral Implants Research, vol. 24, no. 10, pp. 1065–1073, 2013.
6. J. H. Fu and H. L. Wang, "Horizontal bone augmentation: the decision tree," The International Journal of Periodontics & Restorative Dentistry, vol. 31, no. 4, pp. 429–436, 2011.
7. M. O. Klein and B. Al-Nawas, "For which clinical indications in dental implantology is the use of bone substitute materials scientifically substantiated?" European Journal of Oral Implantology, vol. 4, pp. 11–29, 2011.
8. T. von Arx and D. Buser, "Horizontal ridge augmentation using autogenous block grafts and the guided bone regeneration technique with collagen membranes: a clinical study with 42 patients," Clinical Oral Implants Research, vol. 17, no. 4, pp. 359–366, 2006.
9. I. A. Urban, H. Nagursky, and J. L. Lozada, "Horizontal ridge augmentation with a resorbable membrane and particulate autogenous bone with or without anorganic bovine bone derived mineral: a prospective case series in 22 patients," The International Journal of Oral & Maxillofacial Implants, vol. 26, no. 2, pp. 404–414, 2011.
10. I. A. Urban, H. Nagursky, J. L. Lozada, and K. Nagy, "Horizontal ridge augmentation with a collagen membrane and a combination of particulate autogenous bone and anorganic bovine bone-derived mineral: a prospective case series in 25 patients," The International Journal of Oral & Maxillofacial Implants, vol. 33, no. 3, pp. 299–307, 2013.
11. C. H. F. Hämmerle, R. E. Jung, D. Yaman, and N. P. Lang, "Ridge augmentation by applying bioresorbable membranes and deproteinized bovine bone mineral: a report of twelve consecutive cases," Clinical Oral Implants Research, vol. 19, no. 1, pp. 19–25, 2008.
12. L. Ohayon, "Ridge enlargement using deproteinized bovine bone and a bioresorbable collagen membrane: a tomodensitometric, histologic, and histomorphometric analysis," The International Journal of Periodontics & Restorative Dentistry, vol. 31, no. 3, pp. 237–245, 2011.
13. S. S. Jensen and H. Terheyden, "Bone augmentation procedures in localized defects in the alveolar ridge: clinical results with different bone grafts and bone-substitute materials," The International Journal of Oral & Maxillofacial Implants, vol. 24, pp. 218–236, 2009.
14. Würdinger, R., & Donkiewicz, P. "Allogeneic cortical struts and bone granules for challenging alveolar reconstructions: An innovative approach toward an established technique." Journal of Esthetic and Restorative Dentistry, 32(8), 747 – 756, 2020.
15. A. Friedmann, K. Gissel, M. Soudan, B. M. Kleber, S. Pitaru, and T. Dietrich, "Randomized controlled trial on lateral augmentation using two collagen membranes: morphometric results on mineralized tissue compound," Journal of Clinical Periodontology, vol. 38, no. 7, pp. 677–685, 2011.
16. Pagni G, Pellegrini G, Giannobile WV, Rasperini G. Postextraction "alveolar ridge preservation: biological basis and treatments." Int J Dent. 151030, 2012.

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THE EFFECT OF THE USE OF AUTOLOGOUS PLATELET-ENRICHED PLASMA ON THE SECONDARY STABILITY OF DENTAL IMPLANTS PLACED IN THE LOWER JAW

ВЛИЈАНИЕТО ОД УПОТРЕБАТА НА АВТОЛОГНА ПЛАЗМА ЗБОГАТЕНА СО ТРОМБОЦИТИ ВРЗ СЕКУНДАРНА СТАБИЛНОСТ КАЈ ДЕНТАЛНИ ИМПЛАНТИ ВО ДОЛНА ВИЛИЦА

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Abstract

Applicative use of growth factors in regenerative dentistry has a key role in the multifactorial osteointegrative process, affecting its acceleration and the success of the final therapy. **Objective:** The objective of this study is to determine the relationship between the level of early osseointegration and secondary stability of dental implants with and without the use of autologous platelet concentrate in all 3 phases, at the very placement of the dental implant, after 4 and after 8 weeks of placement. **Material and method:** In 32 patients of both sexes aged 31-77, dental implants were placed on the right side of the mandible with pre-prepared and locally applied autologous "protein-enriched plasma with appropriate concentration-PRP" on the implant bed (experimental group). The control group consisted of the same patients in whom only the standard protocol for implant bed preparation was applied on the contralateral side (left). After the completion of the oral surgical procedure, the stability of the placed dental implants was measured using a Penguin RF device, on the day of the intervention, after 4 and after 8 weeks after the placement of the implant. **Results:** In the experimental group, higher average values were observed regarding the stability of the dental implants, namely: postoperative -79.59; after 4 weeks - 80.46 and after 8 weeks - 84. The results showed statistical significance regarding the differences for all three periods: postoperative (p≤0.02), after 4 weeks (p≤;0.03) and 8 weeks (p≤; 0.04 compared to the control group). **Conclusion:** Dental implants that were placed with PRP showed a statistically significant difference in stability, in all three time periods, which is the reason to recommend this method for achieving satisfactory stability and for temporary loading of the dental implant. **Key words:** PRP, dental implants, osseointegration.

Апстракт

Апликативнатаупотребанафакторитенарастворегенеративнатастоматологијаимаатклучнаулогавомултифакторијалниотостеоинтегративенпроцес, влијаејќи-нанеговотозабрзувањеиуспехотнакрајнататерапија. **Цел:** Целта на оваа студија е да се утврди врската помеѓу нивото на рана остеоинтеграција и секундарната стабилност на имплантите со и без употреба на автологен тромбоцитен концентрат во сите 3 фази, при самото поставување на имплантот, по 4 и по 8 недели од поставувањето. **Материјал и метод:** Кај 32 пациенти од двата пола на возраст од 31-77 години, денталните импланти беа поставени на десната страна на мандибулата со претходно подготвена и локално аплицирана автологна „плазма збогатена со протеини со соодветна концентрација-PRP“ на имплантантниот кревет (експериментална група). Контролната група се состоеше од истите пациенти кај кои беше применет само стандардниот протокол за подготовка на имплантниот кревет на контралатералната страна (лево). По завршувањето на оралнохируршката процедура, стабилноста на поставените импланти беше мерена со помош на апарат PenguinRF, на денот на интервенцијата, по 4 и по 8 недели по поставувањето на имплантот. **Резултати:** Во експерименталната група забележани се повисоки просечни вредности во однос на стабилноста на денталните импланти и тоа: постоперативна -79,59; по 4 недели - 80,46 и по 8 недели - 84. Резултатитепостигнаастатистичказначајност на разликите за сите три периоди: постоперативно (p≤0,02), по 4 недели (p≤;0,03) и 8 недели (p≤; 0,04 споредено на контролнатагрупа). **Заклучок:** Денталните импланти кои беа поставени со PRP покажаа статистички значајна разлика во стабилноста, во сите три временски периоди, што е причина да се препорача овој метод за постигнување на задоволителна стабилност и за привремено оптеретување на денталниот имплант. **Клучни зборови:** PRP, дентални импланти, остеоинтеграција.

ntroduction

Modern methods and treatments for using bioactive materials to achieve osseointegration of dental implants can affect osteoblastic adhesion on the surface of the implant. Although it can be said that the technique of placing dental implants has not changed significantly, a number of studies are investigating the possibility of using and applying platelet concentrate (PRP- Platelet - RichPlasma) derived from plasma that can influence the improvement of the stability and osseointegrative process in placed dental implants.

PRP is, in fact, an "extract" from the blood that contains various growth factors, from which a final product for clinical application is obtained by centrifugation. Thrombin is a substitute for serine protease, which in humans is encoded by the "F2" gene and converts the soluble fibrinogen in insoluble fibrin[1].

Today, implant therapy is considered a predictive treatment with excellent and long-term results. The osteointegrative process is multifactorial, so the use of autologous materials can help and at the same time speed up the success of the therapy. PRP, as a method, has been a proven tool for a successful therapy in dentistry.

The stability of the placed dental implant is defined as the ability or condition to absorb adequate force coming from multiple directions, from an axial aspect, lateral or rotational movements.

Wound healing and bone regeneration are replete with a series of orchestrated sequences of biological factors that can be of crucial importance for the long-term durability of dental implants, for their primary and secondary stability. Perhaps one of the most "candidates" to provide the above is plasma enriched with platelets. This can be clarified by the fact that:

1) it is of autologous origin; without risk of disease transmission, and
2) contains natural growth factors that can influence bone regeneration[2,3,4.]

The aim of this stady

The objective of this paper is to evaluate the effect of platelet-rich plasma and its seven fundamental protein growth factors in improving the stability of the dental implant in relation to the topographic features of the implant surface.

Material and methods

Within the framework of this study, for the realization of the set goals, a total of 32 patients, of both sexes, with an indication for the implantation of dental implants in the lower jaw, depending on the loss and the remodeled bone surface, were observed in the Dentoria Dental Practice in Ohrid.

Inclusion criteria in this study were:

- patients aged 31-77;
- patients with bone resorption not < 6 mm in the lower jaw;
- patients with a lack of one or more teeth in the posterior/distal region;
- patients with adequate inter-occlusal distance and mesio-distal space sufficient for dental implantation;
- absence of acute or chronic symptomatology of an inflammatory nature that may affect the success of osseointegration of the dental implant;
- indication for the extraction of cariously destroyed teeth for the purpose of replacing dental implants;
- indication for performing multiple extractions for the purpose of planning and placing dental implants;
- partial or total toothlessness of the lower jaw;
- patients who have signed a written document for the surgical intervention, as well as consent for placement of dental implants.

Patients aged 31–77 years who met the inclusion criteria were selected in this double-blind, randomized clinical trial. A survey questionnaire was administered to all respondents along with consent for voluntary participation in our study, following WHO recommendations. This research was approved by the Ethics Committee of the Faculty of Dentistry-Skopje, UKIM. With the indication for the implantation of dental implants in the lower jaw, depending on the loss and the remodeled bone surface, the patients were then divided into two groups, experimental and control.

In the first group (experimental) dental implants were placed in the lower jaw-right side, with pre-prepared and locally applied autologous "protein-enriched plasma with appropriate concentration-PRP" on the implant bed, while in the second group (control), in the same patient on the left side of the mandible, only a standard protocol was used for the preparation of the implant bed without the application of concentrated autologous plasma.

Method of preparation of PRP

Venous blood was collected from each patient with venipuncture. The blood was stored in a plasmolifting tube with citrate as an anticoagulant, which has a patented separation gel, which, through the degranulation of blood clots, releases appropriate growth factors and other cytokines that stimulate the growth of bone and soft tissues. For producing the final product, all aseptic prerequisites for obtaining 8 ml of liquid blood from an

antecubital vein were met. After obtaining the blood, it was transferred to a sterile vacutainer containing 0.5 ml of 3.2% sodium citrate whose action is based on the principle of anticoagulant.

The test tubes were centrifuged at 4000 rpm for 6 minutes, after which the required plasma was obtained in the upper-superior part of the test tube. In the lower part, the erythrocytes, leukocytes and the separation gel are denatured. The obtained plasma was injected before the placement of the implants in the formed place for the implant itself, on the surface of the dental implant, as well as after the placement of the implant. After the completion of the oral surgery procedure, the stability of the placed dental implants was measured using the device for resonant frequency analysis (Penguin RFA) on the day of the intervention - immediately after its completion, on the 4th week from placement and on the 8th week from implant placement

The obtained results were statistically processed, where the student's "t" test was used to determine the significance of the differences between the examined and the control group, where $p \leq 0.05$ values were considered statistically significant.

Results

In the research, 32 implants from the experimental and 28 implants from the control group (Table 1) were analyzed, although, everything was for the same patients, we had to take a look of the characteristics of the groups, which could affect the outcome of the therapy.

Table 1. Structural distribution

		f	%
Group	implants WITH plasma *	32	53.3
	implants without plasma **	28	46.7
	Total	60	100.0

χ^2=0.267, df =1, p=0.606, f = frequency , %= percentage ;
*PRP group , ** Control group

Table 2. Type on dental implant

		f	%
Length (mm)	8 mm	6	10.0
	10 mm	54	90.0
	Total	60	100.0
Form	Cylinder	60	100.0
Diameter (mm)	3.5 mm	26	43.3
	4.0 mm	34	56.7
	Total	60	100.0

f = frequency, %= percentage;

It is evident from table 2 that 6 implants were built with length of 8 mm (10%) and 54 implants with length of 10 mm(90%), and with cylindrical shape. A total of 26 implants (43.3%) have a diameter of 3.5 mm (43.3%), and the rest 34 have a diameter of 4 mm (56.7%).

The average age of the patients ranges from Min=31 to Max=77 years (Table 3). The average age of the total number of patients (sample) is M=54.91 ± 10.45 years. The age of the PRP group is M=54.50 ± 10.45 years, and the control group has a mean value of M=55.39 ± 10.63. These samples of respondents are leveled according to the average value of years (F =0.107, p =0.745).

Table number 4 shows the structural distribution of patients by gender, in which the female patients are represented by 34.3% (N =11). A total of 65.7% (N =21) are male respondents. If we consider only the observation of dental implants as a statistical unit, then the groups are equivalently equalized in terms of gender (χ^2=0.033, df =1, p =0.855). The group of respondents with PRP is represented by 56.6% of males and 34.4% of females, and in the control group, males dominate with 67.9% compared to females 32.1%.

Table 3. Average old age on the respondents

	Min	Max	M	SD	F	p
PRP group	31.00	77.00	54.50	10.45	0.107	0.745
Control group	31.00	77.00	55.39	10.63		
In total respondents	31.00	77.00	54.91	10.45		

Min=maximum value on the sample, Max=minimum value on sample, M=arithmetic mean, SD=standard deviation,
F – ANOVA test, p=statisticsignificance

Table 4. Structural distribution of patients by gender

			Group		all respondents
			PRP group	Control group	
Gender	**male**	f	21	19	40
		%	56,6%	67,9%	66,7%
	female	f	11	9	20
		%	34,4%	32,1%	33,3%
Total		f	32	28	60
		%	100.0%	100.0%	100.0%

Table 5. Stability of dental implant – difference between PRP and control group

		Group	N	M	SD	t	df	p
Dental stability postoperatively	implant	PRP group	32	79.59	2.72	3,166	58	**0.002**
		Control group	28	77.50	2.34			
Dental implant stability after 4 weeks	implant	PRP group	32	80.46	2.44	3,063	58	**0.003**
		Control group	28	78.53	2.42			
Dental stability after 8 weeks	implant	PRP group	32	84.00	2.09	2,970	58	**0.004**
		Control group	28	82.50	1.77			

N = number of respondents, M = arithmetic mean, SD = standard deviation, t – t test , df- degree of freedom, p = statistical significance;

Table 5 shows the obtained results for the stability of the implants for the studied periods as well as the differences between the studied and the control group, it is evident that the studied group mean value for the stability of the implant postoperatively after 4 weeks and after 8 weeks is 79.59, 80.46 and 84.0, while in the control group, the mean value of the measured stability for the time intervals postoperatively was 77.50, after 4 weeks 78.53, and after 8 weeks 82.50. Statistical significance of differences of $p \leq 0.05$ was obtained for all time intervals. Thus, the achieved difference postoperatively reached a significance of differences of $p \leq 0.02$ for the period of 4 weeks $p \leq 0.03$ and the least significant but still statistically visible for the period of 8 weeks $p \leq 0.04$

Discussion

The stability of dental implants is one of the most important parameters that influence and are an indicator of early loading of the implant, which also affects the success of the osseointegrative process with the bone structure and geographical surface of the implant itself. Most studies that have examined the stability of dental implants based on the so-called ISQ - stability quotient, indicate that the implant with a value of ISQ<49 obtained postoperatively, should not undergo the next step, which is prosthetic loading, which is actually inversely proportional to the values with ISQ >54.

The process of healing and enabling bony regeneration represents one species of an orchestra on biologically sequences regulated from multiple factors which affect the bone healing, which is crucial for providing appropriate stability on the implant bearing. For promoting and encouraging wound osseointegration with qualitative bony formation, most researchers, laboratories and centers for development of innovative dental materials[3,5,6,7] suggested more types of modifications on the dental implant which, on the other hand, will provide maximum bone-implant contact for the whole period, everything until the moment of prosthetic burden.

The dental implant provides its first contact in the recipient human organism (i.e. oral cavity) through blood. One of the novelties in oral implantology, used in recent history, is actually the application of autologous platelet concentrate (PRP) on the very surface of the dental implant, immediately before applying it to the implant bed.

In our paper, the difference postoperatively between the examined group versus the control group was statistically significant for p = 0.002, which indicates slight stability at the beginning of the placement of the implants. According to the first innovator Kingsley[1] of this autologous concentrate, α -granules release growth factors in the first 3-5 days of platelet activation and their stimulation is reflected in the proliferative phase after 10 days of application. In fact, those growth factors activate, i.e. accelerate the healing process only when their level is functional with the reached level of platelet concentrate, which in turn will influence the synthesis of collagen and α - granules through the initial formation of callus in bone tissue. Platelets persist for 7-10 days and collide with other platelets, forming a stable fibrin network with a stable thrombus. In 1998, Marx et al.[8] for the first time used PRP as a basis that supported the reconstructive graft on a bone base, therefore a series of studies followed to prove and apply the postulate. When analyzing the experimental studies related to the applied application of plasma concentrate, most authors highlight the positive effect in improving bone quality and stability, enabling significantly improved bone regeneration compared to isolated application of autologous bone graft[9].

The local application of platelet concentrate during placement of dental implants is a relatively simple and simplified method that can contribute to ensuring early implant-osseous contact. According to a group of authors[10,11,12,13,] whose purpose was perceived in the immediate loading of dental implants in the distal segments of the lower jaw, where the probability of the maximum masticatory effect is precisely in those anatomical regions, suggest that the bioactive potential of the platelet concentrate can be affected directly or indirectly through several selected factors, some of them are: careful selection of the implant bed, computerized analysis of bone quality and quantity in order to ensure adequate length of the implant, ensuring satisfactory primary stability of the placed implants and excluding high-risk patients with compromised health, which may affect primary and secondary stability.As a result, our obtained results in this study for loading after 8 weeks recorded a statistical significance of p =0.004 which is correlated with some of the conclusions obtained in the study of the above-mentioned authors.

The results obtained in our paper are in accordance with some of the conclusions obtained in the study of a group of authors[13,14,15,16] where dental implants placed with platelet concentrate showed a statistically significant difference in stability measured using Penguin-resonance frequency analysis in all three time periods.

Conclusion

This study confirms that dental implants, which were placed with platelet concentrate (PRP), showed statistically significant difference in stability measured with help of the device for resonant frequent analysis Penguin and that in all three temporary periods and refers on the possibility for timely burden on dental implants.

We confirm that the use of autologous materials accelerates the osteointegrative process and affects the therapeutic success in dental implantology.

The obtained results of our examination allow us to recommend the use of PRP during the placement of implants, which will enable faster stabilization and the possibility of loading the implant.

Reference

1. Kingsley CS. Blood coagulation; evidence of an antagonist to factor VI in platelet-rich human plasma. Nature. 1954 Apr 17; 173(4407):723-4.
2. Zechner W, Tangl S, Tepper G, Fürst G, Bernhart T, Haas R, Mailath G, Watzek G. Influence of platelet-rich plasma on osseous healing of dental implants: a histologic and histomorphometric study in minipigs. Int J Oral Maxillofac Implants. 2003 Jan-Feb; 18(1):15-22.
3. Peeran S, Alsaid F. Platelet Rich Plasma, Is It Of Use In Human Intrabony Periodontal Defects. International Journal of Science and Technology Research. 2013;2(3):5.
4. Albanese A, Licata ME, Polizzi B, Campisi G. Platelet-rich plasma (PRP) in dental and oral surgery: from wound healing to bone regeneration. Immune Aging. 2013 Jun 13; 10(1):23.
5. Simonpieri A, Del Corso M, Vervelle A, Jimbo R, Inchingolo F, Sammartino G, Dohan Ehrenfest DM. Current knowledge and perspectives for the use of platelet-rich plasma (PRP) and platelet-rich fibrin (PRF) in oral and maxillofacial surgery part 2: Bone graft, implant and reconstructive surgery. Curr Pharm Biotechnol. 2012 Jun;13(7):1231-56.
6. Zechner W, Tangl S, Tepper G, Fürst G, Bernhart T, Haas R, Mailath G, Watzek G. Application of platelet-rich plasma for enhanced bone regeneration in grafted sinus. J Oral Maxillofac Surg. 2012 March; 70(3):657-64.
7. Donati M, La Scala V, Billi M, Di Dino B, Torrisi P, Berglundh T . Immediate functional loading of implants in single tooth replacement: a prospective clinical multicenter study. Clin. Oral Implants Res. 2008 Aug; 19(8):740-8.
8. Marx RE , Carlson ER, Eichstaedt RM ,SchimmeleSR, Strauss JR, GeorgeffRF Platelet-rich plasma: Growth factor enhancement for bone grafts, J. Oral Maxillofacial Surg. 1998 Jun;85(6):638-46.
9. Ning Zhang, Yong-Ping Wu , Sheng-Jun Qian , Chong Teng , Shuai Chen Research Progress in the Mechanism of Effect of PRP in Bone Deficiency Healing, The scientific world journal 2013 ART ID 134582.
10. Covani U, Marconcini S, Crespi R, Barone A. Bacterial plaque colonization around dental implant surfaces.Implant Dent. 2006;15: 298–304.
11. Abboud M, Koeck B, Stark H, Wahl G, Paillon R. Immediate loading of single tooth implants in the posterior region.

Int. J. Oral Maxillofac. Implants.2005;20: 61–8.
12. Calandriello R, Tomatis M, Vallone R, Rangert B, Gottlow J. Immediate occlusal loading of single lower molars using Branemark system® wide-platform Ti - Unite™ implants: An interim report of a prospective open-ended clinical multicenter trial. Clin. Implant Dent. Relat. Res. 2003;5: 74–80.
13. Kumar NK, Shaik M, Nadella KR, Chintapalli BM. Comparative study of alveolar bone height and implant survival rate between autogenous bone mixed with platelet rich plasma versus venous blood for maxillary sinus lift augmentation procedure. J. Maxillofac. Oral Surg. 2015 Jun;14(2):417-22.
14. Shilpi Gangwar, US Pal, Sunita Singh, RK Singh, Vibha Singh, Lakshya Kumar Immediately placed dental implants in smokers with plasma rich in growth factor versus without plasma rich in growth factor: A comparison. Natl. J. Maxillofac.Surg. 2018 Jan-Jun;9(1):39-47.
15. Uma Shankar Pal, Dipti Daga R K Singh, Lakshya Kumar Mayank Singh,Comparison of stability with two-time use of platelet-rich growth factor versus one-time use of platelet-rich growth factor in immediate placement of dental implant in infected socket. Natl J Maxillofac Surg. 2018 Jul-Dec;9(2):209-214.doi: 10.4103/njms.NJMS_1_18.
16. Changxing Qu Feng Luo Guang Hong, Qianbing Wan BMC Oral Health. Effects of platelet concentrates on implant stability and marginal bone loss: a systematic review and meta-analysis. 2021 Nov 12;21(1):579. doi: 10.1186/s12903-021-01929-x.

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COMPARISON OF MCI - INDEX AND DEXA - TEST ON MENOPAUSAL WOMEN - ITS IMPORTANCE IN EARLY DETECTION OF OSTEOPOROSIS

СПОРЕДБА НА MCI - ИНДЕКС И DEXA - ТЕСТ КАЈ ЖЕНИ ВО МЕНОПАУЗА - НЕГОВАТА ВАЖНОСТ ВО РАНО ОТКРИВАЊЕ НА ОСТЕОПОРОЗА

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Abstract

Osteoporosis is a metabolic bone disease that mostly affects women in menopause, but men too are not excluded. The disease develops in a hidden form without any symptoms and often patients detect the disease only when fractures occur. Early detection of the disease is the objective of many researchers, since access to standard diagnostic methods such as the Dexa test (dual-energy X-ray absorptiometry) is limited in many countries of the world. **Aim:** The objective of this research was to determine the validity of the qualitative indicator MCI – index (Mandibular cortical index) the classification of changes in the structure of the lower cortex of the mandible C1 – C3 in the Panoramic Radiograph and the correlation with the bone mineral density in the L1-L4 vertebral region measured by DEXA – the test. **Material and methods:** Mandibular cortical index vas evaluated visually using orthopantomogram referring to Klemetti method: both sides of the mandibula in the region of foramen mental and compared with body BMD in 60 women, which were then divided in two groups according to T–score values. First group, study group diagnosed with osteoporosis T-score < -2.5 and control group without diagnose with osteoporosis with T-score -1 - 2,5 and T score > 1. Each group was divided in two subgroups according to age difference 50-60 years old and 60-80 years old (mean age of 63,7) to evaluate also the relationship of MCI with age. Results: To determine if there was a significant correlation between MCI and DEXA – test and MCI with age, Fisher's exact test was used. Statistical analysis showed significant correlation of DEXA – test and MCI index p<0.001. Using Pearson Chi-Square test, a significant correlation was found between MCI index and age. Pearson Chi-Square = 60,00 and p<0,001(p=0,00). **Conclusion:** MCI index, as a visual qualitative index, is a valid index to determine the early sign of osteoporosis using panoramic radiography. There is a significant correlation between C2 and C3 MCI - index and DEXA – test. Also, a significant correlation was determined between age and MCI index. Further research in this field is necessary. **Key words:** Klemetti index, osteoporosis, osteopenia, panoramic radiography, mandibular cortical index, major public health problem.

Апстракт

Остеопорозата е метаболичко за болување на коските што најмногу ги погодува жените во менопауза, но не ги исклучува и мажите. Болеста се развива во скриена форма без никакви симптоми и често пациентите ја откриваат болеста само кога ќе се појават фрактури. Раното откривање на болеста е цел на многу истражувачи, бидејќи пристапот до стандардните дијагностички методи како што е тестот DEXA (апсорптиометрија со двојна енергија на X-зраци) е ограничен во многу земји во светот. **Цел:** Целта на ова истражување беше да се утврди валидноста на квалитативниот индикатор MCI – индекс (Mandibular cortical index), класификацијата на структурата на долниот кортекс на мандибулата C1 – C3 во панорамската радиографија и корелацијата со коскената минерална густина во вертебрален регион L1-L4 мерена со DEXA – тестот. **Материјал и методи:** Мандибуларниот кортикален индекс беше визуелно евалуиран со употреба на ортопантомограм кој се однесува на методот Kemetti: двете страни на мандибулата во пределот на форамен ментал и споредени со телесната BMD на лумбалната област L1-L4 со двојна енергетска апсорптиометрија кај 60 жени, кои што беа поделени во две групи според вредностите на T-критериуми. Првата студиска група дијагностицирана со остеопороза T-критериуми -2,5 и контролната група без дијагноза со остеопороза T критериуми 1, -1 - -2,5. Секоја група, студиска и контролна група беа поделени во две подгрупи според возрасната разлика 50-60 години и 60-80 години, за да се оцени и односот на MCI со возраста. **Резултати:** За да се утврди дали постои значајна поврзаност помеѓу MCI и DEXA - тестот и MCI со возраста, се користеше точниот тест на Fisher. Статисичката анализа покажа значајна корелација помеѓу DEXA – тестот и MCI индексот p<0.001. Со користење на Pearson Chi-Square тестот, беше утврдена значајна врска помеѓу индексот MCI и возраста. Pearson Chi-Square = 60,00 и p<0,001(p=0,000) / Monte Carlo Sig. (2-страно). **Заклучок:** Индексот MCI како визуелен квалитативен индекс е валиден индекс за одредување на раниот знак на остеопороза со помош на панорамска радиографија. Постои значајна врска помеѓу MCI -index C2 и C3 и DEXA – тест. Исто така, беше утврдена значајна врска помеѓу возраста и DEXA – тестот и возраста и MCI индексот. Потребни се дополнителни истражувања на ова поле. **Клучни зборови:** Clementi индекс, остеопороза, остеопенија, панорамска радиографија, мандибуларен кортикален индекс, голем јавно здравствен проблем.

Introduction

Osteoporosis is a metabolic bone disease, which results as a consequence of the lack of proper harmonization between the process of formation and resorption of bone tissue. The disease is characterized by microarchitectural weakness, which further results in bone fragility and increased risk of fractures. The disease develops with progress in a latent form, and in most cases, it is diagnosed only when fractures occur[1].

The disease is more common in women as a result of hormonal imbalance, especially in menopause stage above the age of 50. One in three women and one in five men suffer from osteoporosis, and the same is not detected until a fracture occurs. Around 200 million women in the world suffer from osteoporosis, while the resulting fracture occurs every three seconds. Loss of bone mass is related to low estrogen levels during menopause, which is accompanied by gradual loss of trabecular and cortical bone. The largest rate of bone loss occurs in the first 4 - 7 years of menopause to slow down in the following years. Osteopenia is not treated as a pathological condition, but the diagnostic values of osteopenia increase the preventive vigilance, which is one of the fundamental goals in the fight against the osteoporosis, which has rightly been declared as the "silent epidemic".

Since it is a latent disease with a high mortality rate, approximately 40% of women with osteoporotic fractures of the spine die five years after the first fracture occurs. As a result, osteoporosis is considered a special public health and social problem and constitutes a heavy economic burden for the state as well.

Bone mineral density - BMD represents the amount of bone mass in a given bone volume. DEXA-test is one of the examination methods that is described as the gold standard for the diagnosis of osteoporosis, which evaluates the density of the bones at the level of the vertebrae, femur, forearm and neck.

Based on the WHO criteria, the BMD values are divided in clinical diagnostic guidelines:

Normal T-score > - 1.0, osteopenia T-score between - 1.0 - 2.5 and osteoporosis T-score < -2.5.

According to the WHO criteria, osteoporosis is defined as a BMD of 2.5 standard deviations below the mean peak mass (average of young adults) measured by dual-energy X-ray absorptiometry (DEXA)[2,3,4,5,6].

Since the disease is latent and has serious consequences, access to diagnostics is also limited, this has led researchers to expand the range of research for new forms of examinations for the purpose of detecting the disease in its early stage. Early detection prevents the disease and enables starting the treatment before complications occur.

Numerous studies of the last decade have been focused on researching and highlighting the relationship between body BMD and mandibular BMD using more accessible diagnostic tools. Panoramic radiography is considered a valuable diagnostic tool, given its low cost, small radiation dose and routine use in daily dental practice.

One of the reliable indicators used is the Mandibular Cortical Index - MCI, which was described by Klemetti. MCI describes the degree of porosity of the mandibular cortex. This visual assessment of porosity on both sides of the mandible distal to the mental foramen is used to investigate early signs of osteoporosis[7,8].

The general bone loss that occurs during osteoporosis is characterized by morphological changes in the jawbones. The cortical part of the mandible is conditioned more by the general condition of the bones of the body, while the trabecular part or the remaining ridge is subject to continuous resorptive processes that are influenced also by other factors besides osteoporosis. The morphological changes are characterized by thickness reduction of the lower edge of the mandible, and the porosity of the lower border of the mandible. Evaluation of bone density of the jaws is necessary in the preparatory dental therapeutic procedures.

Horner and Dalvin in their longitudinal studies have found a significant correlation between MCI and BMD of the mandible. Tauchi and colleagues in their studies of 150 Japanese women have concluded that dentists have enough clinical information to refer women for final examinations. Research in Japan has shown that 95% of Japanese women with identified changes in the shape of the mandibular cortex resulted with osteopenia and osteoporosis. Studies by Dutra et al. have highlighted that changes in the mandibular bone are related to loss of overall bone density[8,9,10].

MCI - index or Klemetti's index is a qualitative index that is based on the appearance of the inferior cortex and is classified based on the criteria defined by Klemetti:

- C1 - The endosteal margin of the cortex is sharp and clear on both sides of the mandible.
- C2 - Semi lacunar defects are seen in the endosteal margins (lacunar resorption).
- C3 - The cortical layers form residual remains and it is clearly porous.

The validity of the MCI - index is closely related to the skills of the examiner[10,11,14,17,18].

Aim

The aim of our research was to evaluate the MCI index in panoramic radiography, evaluation of the correlation of MCI with Dexa test values as well as the correlation of the MCI index with age.

Material and methods

The research included 60 women divided into two groups based on DEXA - test values.

Study group, 30 women with T – score < – 2.5 divided into two subgroups with age deference 50-60, 60-80 years old.

Control group, 30 women without diagnose with osteoporosis with T score > -1, T score > - 2,5 divided into two subgroups with age deference 50-60, 60-80 years old.

Each group was divided in two subgroups based on age difference to evaluate the correlation of MCI - index with age.

The criteria for the selection of patients were:

- Women age 50 – 80 years old.
- Total edentulous of the maxilla and mandible, carrier of total prostheses.
- All women were in the natural postmenopausal stage.
- Women who have been under therapy that affects bone metabolism biphosphates, vitamin D minerals, hormonal therapy, where not included in our study.
- Women suffering from systemic diseases that attack bone metabolism (renal insufficiency, hyperparathyroidism, hypoparathyroidism, gastrointestinal diseases, rheumatoid arthritis) were not included in the research.

The patients were examined and the detailed anamnesis was recorded.

The research was approved by the Ethics Committee of the Chamber of Dentists of Kosovo. The general bone density was determined by the Dexa test (Dual-energy – ray absorptiometry) using MEDILINNK, model: MEDIX DR 2020. Each patient further underwent a radiological examination by means of Panoramic Radiography using Sirona - Orthophos E.

The index was visually evaluated twice by one examiner and was classified based on the classification according to Klemetti:

Mandibular Cortical Index – MCI, Klemetti index

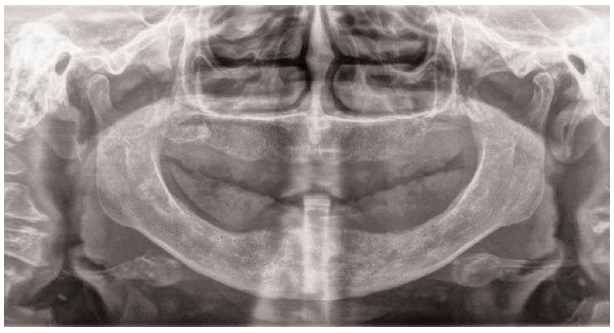


Figure 1. *C1 - Klemetti index: normal where the margins of the cortex are visible and clear*

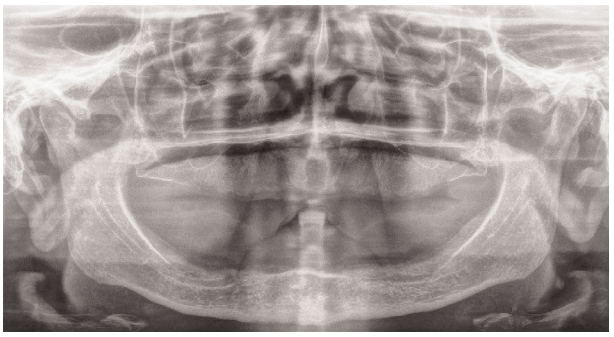


Figure 2. *C2 - Klemetti index: the margins of the cortex show moderate erosion in the form of lacunar resorption*

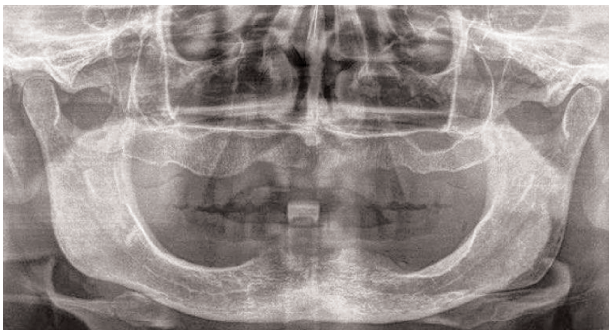


Figure 3. *C3 - Klemetti index: the cortex shows marked erosion with remained highlighted residuals*

Results

30 patients from the study group with DEXA < -2.5, 0 of them had C1- category of MCI index,

21(70%) of them had C-2category of MCI - index, and 9 (30%) of them had C-3 category of MCI index.

10 (47.6%) patients from 30 of them from control group, with T- score > -2,5 had C1 - category of MCI and 11(52,4%) of them had C- 2 category of MCI - index.

A significant association between DEXA - test and MCI index is found for p<0,001.

1. Osteoporosis: T- score < - 2.5, 2. Osteopenia - score >- 2.5, 3. Normal T – score >-1, MCI, C1- normal cortex, C2 - moderate changes of cortex, C-3 - significant changes of mandibular cortex

In patients aged 60-80 years old from study group, we have 34,4% with C2 category, and 44% with C3 category of MCI - index.

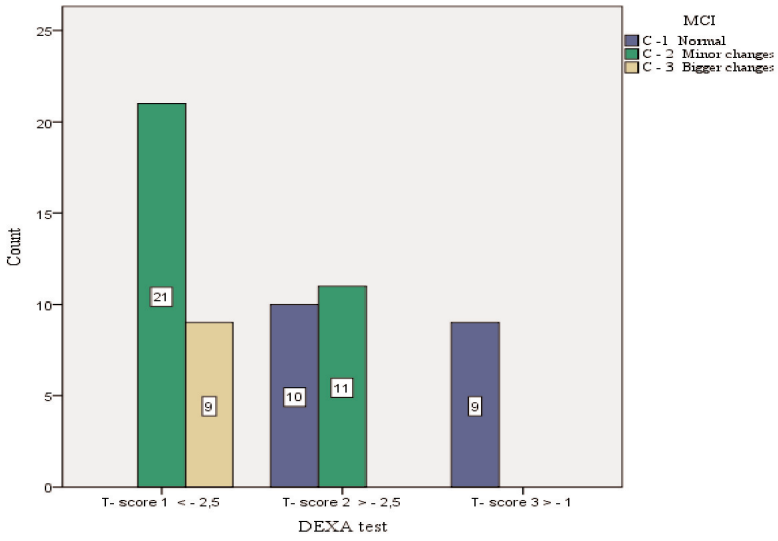
Also in the control group, with increasing age, the category that identifies porosity of mandibular cortex increases: 60-80 years old 6 (31.6%) have C1 and 9 (28,1%) have C2 category of MCI -index, 50 - 59 years old we have (68,4%) with C1 category and 2 (6.3%) with C1 category of MCI index. A significant association between MCI index and age was found for p<0.001.

Table 1. Data of analysis for association between DEXA – test and MCI index

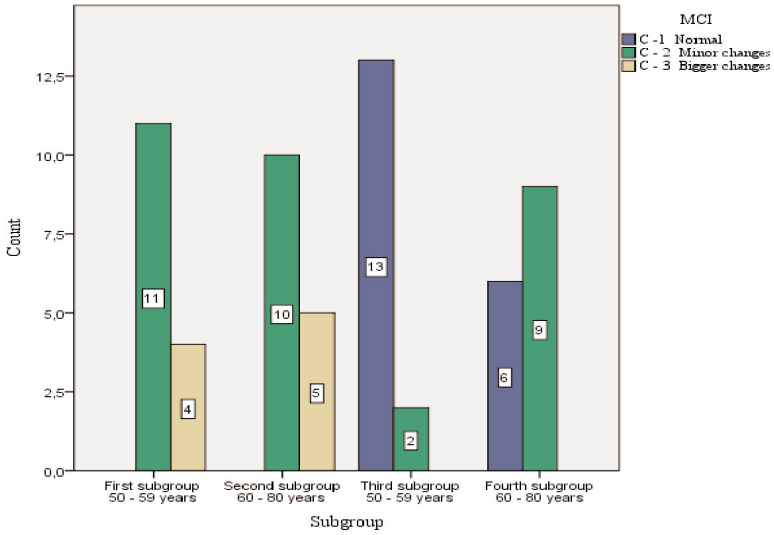
			MCI			Total
			C1 Normal	C2 moderate changes	C 3 very porous cortex	
DEXA test	T – score < - 2,5	Count	0	21	9	30
		%	0,0%	70,0%	30,0%	100.0%
	T – score > - 2,5	Count	10	11	0	21
		%	47,6%	52,4%	0,0%	100.0%
	T – score > - 1	Count	9	0	0	9
		%	100,0%	0,0%	0,0%	100.0%
Total		Count	19	32	9	60
		%	31,7%	53,3%	15,0%	100.0%

Table 2. Data of analysis for correlation between MCI - index and age

Subgroups			MCI			Total
			C1	C2	C 3	
	First 50 - 59 years	Count	0	11	4	15
		%	0,0%	34,4%	44,4%	25,0%
	Second 60 - 80 years	Count	0	10	5	15
		%	0,0%	31,3%	55,6%	25,0%
	Third 50 - 59 years	Count	13	2	0	15
		%	68,4%	6,3%	0,0%	25,0%
	Fourth 60 - 80 years	Count	6	9	0	15
		%	31,6%	28,1%	0,0%	25,0%
Total		Count	19	32	9	60
		%	100.0%	100.0%	100.0%	100.0%



Graph 1. *Data of analysis for association between DEXA – test and MCI index*



Graph 2. *Correlation of MCI - index and age*

First subgroup from study group 50-80 years old, second subgroup from study group 60 - 80 years old. Third subgroup from control group 50 - 60 years old, fourth subgroup from control group 60-80 years old. MCI, C1- normal cortex, C2- moderate changes of cortex, C3 – very porous cortex.

Discussion

Osteoporosis is a progressive metabolic disease that develops in a completely latent form. In most cases, the disease is detected only when fractures occur spontaneously or after an insignificant trauma. Given the high rate of disability and mortality, scientists have opened the way for research on the early identification of signs of osteoporosis.

Bone density is mainly measured by the Dexa test, which also stands out as gold standard. Many countries do not meet the screening standards for osteoporosis required by the WHO (10 DEXA testing machines per 1000 inhabitants) because access to the equipment has a high cost. Therefore, researchers have explored alternative screening methods for early detection of the disease[1,2,3].

Panoramic radiography is considered a valid tool to assess the condition of the mandibular cortex and to measure the radio morphometric indicators, considering that it offers optimal observation of the necessary structures, a clear view of the reference points, is very accessible and low-cost[6]. In this context, our research was developed, giving us grounded data that fulfill other researches.

The Klemetti index is categorized into three levels C1-C3 depending on the changes in the cortex of the mandible. The indicator is visually assessed at the level distal from the mental foramen because this part is considered to be constant and not subject to the influence of other factors. C1, shows the normal mandibular cortex, which is clear and well demarcated C2, shows moderate changes in the mandibular cortex where visible changes are seen in the form of lacunar resorption and C3 where the changes are very visible with pronounced porosity of the mandibular cortex and with remaining deposits. Studies show a direct correlation between reduced T-score values and advanced age. With age the risk of osteoporosis also increases[7,8].

In our study, of 30 patients diagnosed with osteoporosis, 0 of them had MCI - C1 category or normal cortex, 21(70%) of them had C-2 category of MCI - index, and 9 (30%) of them had C-3 category of MCI index.

10 women (47.6%) that weren't diagnosed with osteoporosis with T- score > -2,5 had C1 - category of MCI, or normal mandibular cortex, 11(52,4%) of them had C-2 category of MCI.

Data analysis from our study shows that as the T-score values decreases the degree of porosity of the mandibular cortex increases. We found a significant correlation between osteoporosis and MCI - index with p<0,001.

C2 and C3 - MCI categories increase with age, while category of C1 - MCI index that represents the normal cortex is seen more in subgroups of younger women. Tabela 2, graph 2.

We found a significant correlation between MCI and age with p<0,001.

However, there is still no agreement among researchers on the degree of reliability of MCI indicator in detecting early signs of osteoporosis. Horner and Devlin showed that both MCI and MI (mental index) were significantly correlated with mandibular BMD and body BMD, on the other hand, Gulashi et al. in their

study have not found a relationship between MCI and osteoporosis.

Klemetti found a sensitivity of 71% and specificity of 40% for MCI index. Tauchi et al. found that for normal postmenopausal women with any cortical erosion the sensitivity of MCI is 86.8% and specificity is 63.6%. Healing found that that a negative finding of MCI, CI<2 is a high predictor of the absence of osteoporosis. Marandi found that MCI is a simple three-graded classification of the changes in the cortex with high sensitivity in detecting osteopenia and osteoporotic patients. Cakur et al. also provided the same data from their research[9,10,11,12,13,18].

Conclusion

Mandibular cortical index as a qualitative index can give us very useful data to identify the early signs of osteoporosis. In our study C2 and C3 category of MCI-index have shown a significant relationship with the values of Dexa-test.

We consider that combined with other radio morphometric measurements they can serve as a very important guide to identify the early signs of osteoporosis by dentists.

Dentists, if they trained how to evaluate the MCI index and other radiomorphometric indicators, will be able to identify the early signs of osteoporosis and guide the patients for additional final examinations by specialists.

Reference

1. Anne C. Looker, Ph.D., and Neda Sarafrazi Isfahani, Ph.D., National Center for Health Statistics; and Bo Fan, M.D., and John A. Shepherd, Ph.D., University of California, San Francisco FRAX-based Estimates of 10-year Probability of Hip and Major Osteoporotic Fracture Among Adults Aged 40 and Over: United States, 2013 and 2014
2. Gullberg B, Johnell O. Kanis JA. Worldwide projections for hip fracture. Osteoporosis International, 1997, 7:407–413.
3. Chrischilles E, Shireman T, Wallace R. Cost and health effects of osteoporosis fractures. Bone, 1994, 15:377–386.
4. Cosman F, de Beur SJ, LeBoff MS, Lewiecki EM, Tanner B, Randall S, Lindsay R; National Osteoporosis Foundation. Clinician's Guide to Prevention and Treatment of Osteoporosis. Osteoporos Int. 2014 Oct;25[10]:2359-81. doi: 10.1007/s00198-014-2794-2. Epub 2014 Aug 15. Erratum in: Osteoporos Int. 2015 Jul;26[7]:2045-7. PMID: 25182228; PMCID: PMC4176573.
5. LeBoff MS, Lewiecki EM, Tanner Randall S, et al. Clinician's guide to prevention and treatment of osteoporosis. Osteoporosis Int 2014; 25:2359-81.
6. Yamada S, Uchida K, Iwamoto Y, Sugino N, Yoshinari N, Kagami H, et al. Panoramic radiography measurements, osteoporosis diagnoses and fractures in Japanese men and women. Oral Dis 2015; 21:335-41.
7. Horner K, Devlin H. The relationship between mandibular bone mineral density and panoramic radiographic measurements J Dent 1998; 26:337-43.
8. Anders Halling, G. Rutger Persson, Johan Berglund Owe Johansson, Stefan Revert Comparison between the Klemetti index and heel DXA BMD measurements in the diagnosis of reduced skeletal bone mineral density in the elderly
9. Horner K, Devlin H. The relationships between two indices of mandibular bone quality and bone mineral density measured by dual energy X-rayabsorptiometry.Dentomaxillofac Radiol1998; 27:17-21.
10. Horner K, Devlin H. The relationship between mandibular bone mineral density and panoramic radiographic measurements J Dent 1998; 26:337 43.
11. Dutra V, Devlin H, Susin C, Yang J, Horner K, Fernandes AR. Mandibular morphological changes in low bone mass edentulous females: evaluation of panoramic radiographs. Oral
12. Taguchi A. Triage screening for osteoporosis in dental clinics using panoramic radiographs. Oral Di s. 2010; 16:316–27
13. Zlatarić DK, Celebić A. Clinical bone densitometric evaluation of the mandible in removable denture wearers dependent on the morphology of the mandibular cortex. J Prosthet Dent. 2003; 90:86–91.
14. Lawrence G Rais Pathogenesis of osteoporosis: Concepts, conflicts, and prospects J. Clin Invest 2005 Dec; 115[12]:3318-2
15. Estera Balcikonyte, Irena Balciuniene, Vidmantas Alekna, Baltic Dental and Maxillofacial Journal 6 Panoramic Radiographs in Assessment of the Bone Mineral Density 17- 19, 2004.
16. Srdan D. Postic, Changes in jaw dimensions and Bone Density in patients with osteoporosis, SDJ vol 56, N 1, 2009
17. Klemetti. E Kolmakow S Morfology of the mandibular cortex on panoramix on panoramic radiographs as an indicator of bone quality. Dentomaxillofacial Radiol 1997:26 [1] :22 – 5
18. Cakur B Sahin A, Dagistan S, Altun O caglayn F, Miloglu O, Harorli A dental Panoramic Radiography in the Diagnosis of osteoporosis J Int med Res 2008:36[4]:792-9
19. Postic D. Srdan,Vujasinovi Stupar Nada, Asoti, Mithat,3 Rakocevi} Zoran, Systemic non-malignant osteoporosis and reduction of edentulous alveolar ridges, Sanamed, 2014:9[10;13 – 23
20. E. Calciolari, N. Donos, J.C. Park, A. Petrie, and N. Mardas J Dent Panoramic Measures for Oral Bone Mass in Detecting Osteoporosis A Systematic Review and Meta-Analysis Res. 2015 Mar; 94[3 Suppl]: 17S–27S
21. GroenJ J, Duyvensz F, Halsted JA. Diffuse alveolar atrophy of the jaw [non-inflammatory form of paradental disease] and pre-senile osteoporosis. GerontClin 1960; 2: 68-86.
22. Cakur B, Dagistan S, Sahin A, Harorli A, Yilmaz AB. Reliability of mandibular cortical index and mandibular bone mineral density in the detection of osteoporotic women. Dentomaxillofac Radiol 2009; 38: 255-261
23. Seok Jin Hong1,2, Byoung Eun Yang1,3, Dae Myoung Yoo4, Sung Jae Kim5, Hyo Geun Choi1,4,6 and Soo Hwan Byun1,3 Analysis of the relationship between periodontitis and osteoporosis/ fractures: a cross-sectional study Hong et al. BMC Oral Health [2021] 21:125
24. Arvind Tripathi, MDS Saumyendra V. Singh, MDS Himanshi Aggarwal, MDS Ashutosh Gupta, MDS . Effect of mucostatic and selective pressure impression techniques on residual ridge resorption in individuals with different bone mineral densities: A prospective clinical pilot study Jpd volume 121, issue 1
25. Yukinori Maruo Goro Nishigawa Masao Irie Morihiko Oka Tetsuya Hara Kazuomi Suzuki Shogo Minagi Stress distribution prevents ischemia and bone resorption in residual ridge Arch Oral Biol, 2010 Nov;55[11]:873-8
26. Hrvoje Kršek and Nikša Dulčić Functional Impressions in Complete Denture and Overdenture Treatment Acta Stomatol Croat. 2015 Mar; 49[1]: 45–53.
27. Ivana Savić Pavičin, Matea Sipina, Tomislav Badel, Tomislav Jukić The impact of osteoporosis in women older than 40 years old Acta stomatal Croat. 2013;47[4]:329-335.
28. Jose López-López, Jose-Manuel Álvarez-López, Enrique Jané-Salas, Albert Estrugo-Devesa, Raul Ayu¬so-Montero, Eugenio

Velasco-Ortega, Juan-Jose Segura-Egea Computer-aided system for morphometric mandibular index computation [Using dental panoramic radiographs]

29. D. Prasanna Kumar S. Jayachandran N. Thilagavathy Diagnostic Validity of Orthopantomogram Comparedto Dual Energy X-ray Absorptiometry Scan in Detecting Osteoporosis

UDK: 616.314-77:615.461

ADVANTAGES AND DISADVANTAGES OF IMPROVISED NYLON POLYAMIDES USED AS DENTURE BASE MATERIALS FOR FLEXIBLE PROSTHESIS - LITERATURE REVIEW

ПРЕДНОСТИ И НЕДОСТАТОЦИ НА ИМПРОВИЗИРАНИТЕ НАЈЛОНСКИ ПОЛИАМИДИ КОИ СЕ КОРИСТАТ ЗА ИЗРАБОТКА НА ФЛЕКСИБИЛНИ ПРОТЕЗИ - РЕВИЈАЛЕН ТРУД

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Abstract

This paper is a review of studies on flexible dentures and analysis of the results obtained after testing the properties of modified thermoplastic polymers (polyamides)used for producing partial dentures. In the past, the use of flexible dentures was limited due to their inconsistency. Over time and after numerous studies, manufacturers have been able to improve the properties of thermoplastic resins,thereby their use in dentistry has increased. The analysis and comparison of scientific papers published on PubMed in the last 20 years show that the flexibility and low degree of elasticity of these materials contribute to the comfort and longevity of the prosthesis. The problem of high water sorption was overcome by changing the chemical composition of the polyamide, whereas improving the polishing technique resulted in achieving an acceptable smoothness of the surface, which in turn reduced bacterial colonization. During the color stability tests, a color change was observed after immersion of thermoplastic resin samples in coloring liquids consumed in the daily diet. **Key words:** flexible dentures, polyamide, thermoplastic dentures, nylon.

Апстракт

Овој труд претставува преглед на студии за флексибилни протези и анализа на резултатите од испитувањата на својствата на модифицираните термопластични полимери (полиамиди) користени за изработка на парцијални протези. Во минатото, употребата на флексибилните протези била ограничена поради нивната непостојаност. Со тек на време и по бројни истражувања, произведувачите успеале да ги подобрат својствата на термопластичните смоли така што нивната употреба во стоматологијата се зголеми. Анализата и споредбата на научни трудови издадени на PubMed во последните 20 години покажуваат дека флексибилноста и нискиот степен на еластичност на овие материјали придонесуваат за удобност и долготрајност на формата на протезите. Со промена на хемискиот состав на полиамидот се надминал проблемот со висока сорпција на вода, а усовршувањето на техниката на полирање овозможила постигнување на прифатлива мазност на површината, со што пак се намалува бактериската колонизација. При испитување на стабилноста на бојата констатирана е промена на бојата по потопување на примероци од термопластични смоли во пребојувачки течности кои се конзумираат во секојдневната исхрана. **Клучни зборови:** флексибилни протези, полиамид, термопластични протези, најлон.

Introduction

Removable partial dentures are a common treatment choice for partial edentulism in everyday dental practice. Despite the great progress in the field of Implantology, many patients still use removable dentures to compensate for their missing teeth, instead of deciding for bridges over dental implants. The advantages of these prostheses over the fixed partial dentures are lower cost, easier maintenance in aspect of hygiene, overcoming the biomechanical as well as pragmatic issues associated with dental implants and avoiding possible implant failure[1].

The two standard types of removable partial dentures are **all acrylic resin prosthesis** (also known as acrylic flippers) and **cast partial dentures** (partial dentures comprised of a cast metal framework and acrylic resin prosthetic teeth). These two types of prostheses retain on the patient's remaining teeth using metal clasps. However, the visibility of metal clasps affects the aes-

thetic. Edentulous treatment implies rehabilitating both function and aesthetic, therefore, contemporary dentistry offers a third, aesthetically superior denture – the **flexible partial denture**. Flexible partial dentures are much more cosmetically pleasing, since they are comprised of direct retainers fabricated in a colored material instead of metal clasps. They fit more comfortably because they are made of thermoplastic materials, such as nylon, that are more flexible than the acrylic resin and chrome cobalt alloy, typically used in producing traditional dentures. Also, they are a suitable substitute for traditional dentures for patients who suffer from resin monomer and metal allergy. Flexible dentures are known to have better retention than acrylic prosthesis because of their improved adaptation to the tissue and the ability to utilize existing undercuts[2,3].

The most suitable and commonly used material for fabrication of flexible removable partial dentures is Valplast (Valpalst Int. Corp. USA). Other flexible materials available are Flexiplast(Bredent Germany), Lucitone FRS (Densply International Inc. Germany), Flexite, Flexite plus, Flexite M.P. (Flexite Company USA), Sun flex, Pro flex[4].

The aim of this study is to review literature regarding the mechanical, physical and clinical characteristics of improvised nylon polyamides used as denture base materials, with special reference to the reported disadvantages such as water sorption, warpage, surface roughness, bacterial contamination, difficulty in polishing and color deterioration.

Materials and methods

For the realization of this paper, a review of the available online literature on flexible dentures was made. Problems in clinical use that have arisen in the past were identified. Amore detailed analysis of the achievements and improvements of the flexible materials was made byresearching the electronic database of PubMed for studies published in the last 20 years, from 2001 to 2021, using the key words: flexible dentures, polyamide, thermoplastic denture, nylon.

Discussion

Polymethyl methacrylate (PMMA) is the most commonly used denture base material. Its usefor denture base fabrication dates back to 1937[5]. The materialremained popularto this day because of its numerous advantages including excellent aesthetic characteristic, low water sorption and solubility, adequate strength, low toxicity, easy repairand a simple molding processing technique. However, PMMA is not an ideal material due to discrepancies in its physical and mechanical characteristics. Problems like polymerization shrinkage, weak flexural strength, lower impact strength, and low fatigue resistance can often lead to denture failure (fracture) when chewing or when falling out of the patient's hand. Various efforts have been madein order to enhance some properties of PMMA, including addition of metal wires or plates, fibers, metal inserts and modification of chemical structure. In recent years, nylon polymer has attracted attention as a denture base material[6].

Nylon is a generic name for certain types of thermoplastic polymers belonging to the class known as polyamides. Nylon polyamides were first introduced in the construction of denture bases in the 1950s. The early forms of nylon polyamides were not as developed, thus the early flexible prosthesis had certain disadvantages. When compared to polymethylmethacrylate, nylon materials were rugged, less rigid, highly resilient, resistant to abrasion and practically unbreakable. Also they were very prone to discoloration and staining. On that account, their use was restricted to limited clinical cases such as repeated denture fractures, proven allergy to polymethylmethacrylate, lack of neuromuscular coordination and construction of orthodontic appliances. However, over time, nylon materials have been modified to gain dimensional stability, lower water sorption, better strength, thereby increasing their usage as a dental base material. With the progress in technology and understanding of material, these materials have surpassed their limitations and are finding novel applications in the fabrication of removable partial dentures, small to medium sized complete dentures, occlusal splints etc[7].

Flexibility

Because of its excellent balance of strength, ductility and heat resistance, nylon is the most suitable material available for flexible removable partial dentures[8].

Soygun and al. investigated the mechanical and thermal characteristics of Valplast (the most commonly used thermoplastic nylon) versus reinforced PMMA denture base materials. They came to the results that Valplast has higher transverse strength (117.22 ± 37.80 MPa) as well as impact strength (0.76 ± 0.03 kN) when compared to PMMA (transverse strength: 92.00 ± 11.13 MPa; impact strength: 0.44 ± 0.15). Also, the modulus of elasticity of Valplast was found to be lower than those of PMMA sample groups[9].

Polyamide materials have significantly lower flexural modulus than the PMMA polymers[10]. The flexibility of these materials prevents prosthesis from getting fractured and makes them more comfortable for the patient as they are lightweight[11].

Gokay and al. used a conventional heat-polymerized resin, QC-20 (Dentsply International Inc., Chicago, Il., USA), and a high-impact polyamide resin, Deflex (Nuxen SRL, Buenos Aires, Argentina), for testing the transverse strength and internal adaptation. Polyamide samples were more flexible PMMA and did not break during flexural strength tests.Polyamide test samples showed the significantly lower elastic modulus mean values (3705.93 MPa) contrasted with PMMA test samples values (6821.97 MPa). In contrast, the lower deflection mean values were evaluated from the PMMA samples[12].

Wieckiewicz and al. tested the elasticity of Polyamide-12 after artificial aging. For that matter, Polyamide-12 specimens were tested firstly dry, as obtained from the dental laboratory and then after 1000, 3000, and 7000 thermocycles. The results did not show any statistically significant differences (P >0.81) in the Elastic moduli as a consequence of the artificial aging thus proving the stability of the material[13].

Water sorption

The initial attempts to replace PMMA with polyamide as a base material did not achieve clinical success. Although it solved the problems of allergies and mechanical trauma, the early PA materials rapidly lost color, shape and stability due to continuous water uptake. Hence, contemporary dental laboratories developed improved PA materials that have a different chemical composition than the ones used in the 1950s, but the exact same chemical structure.

In order to measure water sorption and water solubility of the modern polyamide materials, Nguyen used two polyamide materials - Valplast and Breflex and compared them to PMMA. After several cycles of drying and immersing the specimens in water that ended with them being stored in a desiccator until the "reconditioned mass" was achieved, weight measuring showed that both Breflex and Valplast had a net increase in weight, which means they retain water. Although the obtained results were within the limits of the standard requirements,there was a notabledifference between the water sorption and solubility values of all three tested materials.Breflex had the highest water sorption that continued up to 8 weeks, while Valplast had the lowest. However, Valplast released a monomeric structure, contrary to Breflex that was chemically stable with no released compounds[14].

Similarly, Takabayashi concluded that different thermoplastic resins show different water sorption capacity. Only one of the polyamide resins -Lucitone had higher water sorption than the PMMA, whereas all the other resins (polyamide:Valplast and Flexite®supreme; polycarbonate: Reigning and Jet Carbo Resin; polyethylene terephthalate Estheshot) showed lower water sorption than PMMA. Nonetheless, the water sorption values of all the tested materials met the ISO standard for denture base materials, indicating that thermoplastic resins are stable and hygienic materials[15].

When evaluating sorption and solubility of PMMA and flexible denture base resin, Shah and al. concludedthat the flexible resin Valplastabsorbs less water and is less soluble than PMMA[16].

Surface roughness and polishing

Polishing or achieving adequately smooth and glossy surface is an important part of denture fabrication because surface roughness promotes adhesion and colonization of denture plaque[17]. Namely, surface roughness is positively correlated with the rate of bacterial/fungal colonization of biomaterials, so if rough surfaces become exposed to the oral environment, they may be more susceptible to microorganism adhesion and biofilm formation and can lead to infections[18].

Abuzar et al. pointed out that it is difficult to provide a satisfactory polished surface of polyamide dentures because of the low melting point of the material. Additionally, polishing causes overheating of the polyamides' surface, exposure of their fibers and fraying at the margins, so using pumice solution during polishing procedure helps reduce the problem of overheating.

In their study, they investigated the surface roughness (Ra) and clinical acceptability of polyamide denture base material and PMMA before and after polishing (lathe with pumice followed by high shine buffs). The difference in the Ra values of the polished polyamide and PMMA surfaces was found to be significant. Polyamide specimens produced a rougher surface both before and after the polishing. When polished, they became more than 7 times smoother, whereas PMMA became more than 20 times smoother using the same polishing technique. Still, the measured surface roughness of polyamide met the accepted norm of 0.2 μm Ra. That is to say, polyamide produces a clinically acceptable smoothness after conventional polishing by lathe, therefore can be used as a denture material in the oral cavity[19].

El-Din and al. studied the effect of different polishing techniques on surface roughness of three types of denture base materials: heat cured PMMA, thermoplastic polyamide and thermoplastic acetal. Two polishing techniques were used, the first one was pre-polishing rubberizing with brown rubber disc (1500 rpm, for one minute), followed by wet rag wheel polishing, 1500 rpm, with a fine pumice, for two minutes; while the second technique was the same as the previous one but addi-

tionally followed by dry rag wheel polishing (1500 rpm) with Tripoli compound for two minutes.

The results and analysis showed that surface smoothness of all materials was improved after polishing with a PMMA as the highest affected material. PMMA polished with both techniques showed a significant difference compared to thermoplastic polyamide and thermoplastic acetal, but there was no significant difference between thermoplastic polyamide and thermoplastic acetal[20].

Bacterial colonization

The bacterial colonization and the tissue compatibility of the polished polyamide (Valplast) and PMMA resin were examined in a vivo performed study by Olms and al. The results showed that an average of 17.8 different bacterial species grew on the PMMA specimens (24 as the highest number of different bacterial species), and 17.3 on the polyamide specimens with a similar bacterial distribution. The micronuclei in the examined palatal mucosa cells, as a marker for genotoxic potential of dental materials, were not detected. This study indicates that the composition of the bacterial biofilm developed after four weeks is not influenced by the type of resin itself. The two materials showed no cytological changes on the oral mucosa. This investigation suggests that both, polyamide and PMMA are suitable for clinical use as a denture base material[21].

Freitas Fernandes and al. used Polymethyl methacrylate (PMMA) resin (Acron MC) and polyamide resin (Flexite M.P.) specimens when testing the efficacy of denture cleansers on Candida spp. biofilm. The highest Candida spp. biofilm growth was shown to occur on polyamide resin when compared with PMMA[22].

Color changes

Color stability is the crucial aesthetical concern regarding flexible dentures. Color and translucency should be maintained during processing and resins should not get stained or change color during their clinical use. Intrinsic and extrinsic factors, or a combination of both, may affect color performances of the denture's material. Intrinsic factors include: degree of conversion, presence of residual monomer, as well as porosity due to inappropriate processing, pressure variation or overheating. The extrinsic stain is time-dependent and associated with eating habits, such as consumption of tea, red wine, cola and coffee, which cause color alteration due to the material's absorption and adsorption of these staining liquids. Discolored prostheses can lead to an unfavorable appearance and patient dissatisfaction. In addition, the absorption and adhesion of the colorants deteriorate the quality of the material by causing surface roughness, accumulation of debris, and colonization of infection-causing organisms like Candida albicans, which in turn can lead to damage to the underlying soft and hard tissues[23].

Sagsoz and al. examined the color changes of polyamide (thermo-injectable resin Deflex®) and polymethyl methacrylate, after storing them in tea, coffee, distilled water or denture cleaner. The color of the materials was evaluated at the baseline and after 7 and 30 days of storage in each of these solutions. Results showed that PMMA denture base resin has greater color stability than polyamide denture base resin. The lowest color change was observedin cases of PMMA stored in denture cleanser, while the highest color change was observed when the polyamide denture material was stored in coffee[24].

Contrary, Banu and al. concluded that thermoplastic resin is the least staining denture base material when compared to conventional PMMA and high-impact PMMA. This conclusion was reached when samples of the three materials were divided into two groups; one group was immersed in coffee, the other in cola, and change was noted after 12 and 24 hours. Afterwards, the samples were cleansed using a denture cleanser and analyzed again, but no significant difference in cleanability was observed[25].

Takabayashi used three types of commercially available thermoplastic resins in his study:

- Polyamide (PA-type) resins [Valplast (VAL), Lucitone® FRSTM (LTF) and Flexite®supreme (FLS)],
- Polycarbonate (PC-type) resins [Reigning (RP) and Jet Carbo Resin (JCR)], and
- Polyethylene terephthalate (PET-type) resin [Estheshot(EST)].

As a control group, he prepared polymethyl methacrylate (PMMA) [Acron (AC)] specimens.

All the tested materials were in the shade of "pink", as to resemble the typical denture base color.

The specimens were soaked in a coffee solution at 70°C and in curry for 60 hours. The spectrophotometric color measurements before and after soaking showed that the color stability of PC was the same as that of acrylic resin. However, PA and PET exhibited staining after soaking, particularly in the curry solution, suggesting that the color stability needs to be improved in these materials[26].

Sepúlveda-Navarro and al. tested the color stability of two heat-cured denture base acrylic (Lucitone 550, VipiCril) and one nylon denture base resin (Transflex) after immersion in beverages. The beverages used in this study were coffee, cola, red wine and distilled water. After 15 and 30-day periods of immersion, authors noted chromatic changes exhibited by specimens immersed in red wine, coffee and cola, pointing to red wine as the bever-

agethat causes the most significant staining of all resins[27].

Goiato and al. evaluated the chromatic alterations of flexible resinsPpflex and Valplast in comparison to the conventional resin Triplex when submitted to accelerated aging.Valplast presented the greatest chromatic alteration after accelerated aging[28].

Conclusion

The commitment to improve thethermoplastic denture base materials as well as the manufacturing techniques, contributed to successfully overcoming the disadvantagesof flexible partial dentures. Excellent balance of strength and low module of elasticity make nylon polyamide dentures comfortable and long-lasting. The measured values of water sorption and surface roughness of thermoplastic resins meet the accepted standards for denture base materials. Color stability is still a point of issue, thus more studies and modifications are necessary in order to achieve sublime aesthetics.

Reference

1. Sharma A. Partial Edentulousness and Treatment Options Chosen. Global Journal of Oral Science, 2021, Vol. 7
2. Alloush NT, Sanad ME, Kabeel MS Evaluation of retention of a recently suggested flexible denture base material. AL-AZHAR Dental Journal For Girls, Vol. 6, No. 1, January (2019) - PP. 109:113
3. Akinyamoju CA, Ogunrinde TJ, Taiwo JO, Dosumu OO. Comparison of patient satisfaction with acrylic and flexible partial dentures. Niger Postgrad Med J 2017;24:143-9
4. Sharma A, Shashidhara H.S. A Review: Flexible Removable Partial Dentures. Journal of Dental and Medical Sciences, Volume 13, Issue 12 Ver. VI (Dec. 2014), PP 58-62
5. Zafar MS. Prosthodontic Applications of Polymethyl Methacrylate (PMMA): An Update. Polymers (Basel). 2020 Oct 8;12(10):2299.
6. Vojdani M, Giti R. Polyamide as a Denture Base Material: A Literature Review. J. Dent. 2015;16:1–9.
7. Kohli S, Bhatia S Polyamides in dentistry-A Review. International journal of Scientific Study, April-June 2013, Volume 01, Issue 01
8. Sharma A, Shashidhara H.S. A Review: Flexible Removable Partial Dentures. Journal of Dental and Medical Sciences, Volume 13, Issue 12 Ver. VI (Dec. 2014), PP 58-62
9. Soygun K, Bolayir G, Boztug A. Mechanical and thermal properties of polyamide versus reinforced PMMA denture base materials. J Adv Prosthodont. 2013 May;5(2):153-60
10. Yunus N, Rashid AA, Azmi LL, Abu-Hassan MI. Some flexural properties of a nylon denture base polymer. J Oral Rehabil. 2005;32:65–71
11. Shah J. Comparative Evaluation of Sorption, Solubility and Microhardness of Heat Cure Polymethylmethacrylate Denture Base Resin & Flexible Denture Base Resin. J. Clin. Diagn. Res. 2014;8:ZF01–ZF04
12. Gokay G D, Durkan R, Oyar P. Evaluation of physical properties of polyamide and methacrylate based denture base resins polymerized by different techniques. Niger J Clin Pract 2021;24:1835-40
13. Wieckiewicz M, Opitz V, Richter G, Boening KW. Physical Properties of Polyamide-12 versus PMMA Denture Base Material, BioMed Research International, vol. 2014, Article ID 150298, 8 pages, 2014
14. Nguyen LG, Kopperud HM, Øilo M. Water sorption and solubility of polyamide denture base materials, Acta Biomaterialia Odontologica Scandinavica, 2017, 3:1, 47-52, DOI: 10.1080/23337931.2017.1326009
15. Takabayashi Y. Characteristics of denture thermoplastic resins for non-metal clasp dentures, Dental Materials Journal/Volume 29 (2010) Issue 4, Pages 353-361
16. Shah J, Bulbule N, Kulkarni S, Shah R, Kakade D. Comparative evaluation of sorption, solubility and microhardness of heat cure polymethylmethacrylate denture base resin & flexible denture base resin. Journal of clinical and diagnostic research: JCDR. 2014 Aug;8(8):ZF01
17. Rao DC, Kalavathy N, Mohammad HS, Hariprasad A, Kumar CR. Evaluation of the surface roughness of three heat-cured acrylic denture base resins with different conventional lathe polishing techniques: A comparative study. The Journal of the Indian Prosthodontic Society. 2015 Oct;15(4):374
18. Pereira-Cenci T, Del Bel Cury AA, Crielaard W, Ten Cate JM. Development of Candida-associated denture stomatitis: new insights. Journal of applied oral science. 2008 Apr;16(2):86-94
19. Abuzar MA, Bellur S, Duong N, Kim BB, Lu P, Palfreyman N, Surendran D, Tran VT. Evaluating surface roughness of a polyamide denture base material in comparison with poly (methyl methacrylate). Journal of oral science. 2010;52(4):577-81
20. S El-Din M, Badr AM, Agamy EM, Mohamed GF. Effect of Two Polishing Techniques on Surface Roughness Of Three Different Denture Base Materials (An In Vitro Study). Alexandria Dental Journal. 2018 Dec 1;43(3):34-40
21. Olms C, Yahiaoui-Doktor M, Remmerbach TW, Stingu CS. Bacterial colonization and tissue compatibility of denture base resins. Dentistry Journal. 2018 Jun;6(2):20
22. De Freitas Fernandes FS, Pereira-Cenci T, Da Silva WJ, Ricomini Filho AP, Straioto FG, Cury AA. Efficacy of denture cleansers on Candida spp. biofilm formed on polyamide and polymethyl methacrylate resins. The Journal of prosthetic dentistry. 2011 Jan 1;105(1):51-8.
23. Banu F, Jeyapalan K, Modi K. Comparison of Colour Stability Between Various Denture Base Resins on Staining and Denture Cleansing Using Commercially Available Denture Cleansers. Cureus. 2020 Jan 19;12(1)
24. Sagsoz NP, Yanıkoglu N, Ulu H, Bayındır F. Color changes of polyamid and polymetyhl methacrylate denture base materials. Open Journal of Stomatology. 2014 Oct 24;4(10):489
25. Banu F, Jeyapalan K, Modi K. Comparison of Colour Stability Between Various Denture Base Resins on Staining and Denture Cleansing Using Commercially Available Denture Cleansers. Cureus. 2020 Jan 19;12(1)
26. Takabayashi Y. Characteristics of denture thermoplastic resins for non-metal clasp dentures, Dental Materials Journal/Volume 29 (2010) Issue 4, Pages 353-361
27. Sepúlveda-Navarro WF, Arana-Correa BE, Ferreira Borges CP, Habib Jorge J, Urban VM, Campanha NH. Color stability of resins and nylon as denture base material in beverages. Journal of Prosthodontics: Implant, Esthetic and Reconstructive Dentistry. 2011 Dec;20(8):632-8.
28. Goiato MC, Santos DM, Haddad MF, Pesqueira AA. Effect of accelerated aging on the microhardness and color stability of flexible resins for dentures. Brazilian oral research. 2010 Mar;24(1):114-9

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COMPARISON OF DIFFERENT TYPES OF ORTHODONTIC BRACKETS AND ADHESIVE SYSTEMS ON THE TOTAL AMOUNT OF ARI INDEX ON THE TOOTH SURFACE

КОМПАРАЦИЈА НА РАЗЛИЧНИ ВИДОВИ ОРТОДОНТСКИ БРЕКЕТИ И АДХЕЗИВНИ СИСТЕМИ ВРЗ ВКУПНАТА КОЛИЧИНА НА ARI ИНДЕКС НА ЗАБНАТА ПОВРШИНА

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Abstract

Aim: The purpose of this study is to determine the difference in the total amount of adhesive remnants when using different types of brackets bonded with different adhesive systems. The main hypothesis is based on the postulate that a stronger bond is created in porcelain brackets, applied with a system of total etch of the enamel, but with simultaneous appearance of a larger amount of adhesive remnants and enamel microcracks. **Material and method:** A total of 40 premolars, all extracted for orthodontic reasons, were divided into 4 groups. In groups 1 and 2, 10 metal and 10 porcelain brackets were bonded with the adhesive system of GC Fuji ORTHO LC and GC Fuji Ortho Conditioner (GC, Japan). In groups 3 and 4, 10 metal and 10 porcelain brackets were bonded with the adhesive system of OrmcoEnlight Light Cure Adhesive (Ormco, USA) and etching gel (Ivoclar, Vivadent, Liechtenstein).After 48 hours, all brackets were debonded. Using a microscope (Apochromatic Stereo Microscope ZEISS Stemi 508), we calculated the total area of the adhesive residue remaining on the tooth surface and on the bracket base surface expressed in μm2. We further used these values to obtain the adhesive remnant index using theARI formula. **Results:** The value of the ARI index was highest in Group 4: ORMCO PORCELAIN (78.45 ± 17.02) followed by Group 2: FUJI PORCELAIN (59.33 ± 17,129), followed by Group 3: ORMCO METAL (54.54 ± 11.67) and lowest in Group 1: FUJI METAL (44.81 ± 16, 86). **Conclusion:** In both adhesive systems (FUJI/ORMCO), the amount of adhesive remnants is without exception always higher in porcelain brackets compared to metal. The porcelain brackets that were bonded with RMGJC (FUJI) resulted in a lower ARI index values and enamel microcracks compared to the porcelain brackets bonded with composite resin (ORMCO). **Key words:** enamel damage, brackets, ARI index, adhesives, ultrasound

Апстракт

Цел: Целта на ова истражување е да се утврди разликата вовкупната количина на адхезивен остаток приупотреба на различни видови брекети бондирани со различен адхезивен систем. Главната хипотеза се базира на постулатот дека кај порцеланските брекети аплицирани со систем на тотално нагризување на емајлот се создавапојака врска, но со истовремена појава на поголемо количество адхезивен остаток имикропукнатини на емајлот. **Материјал и метод:** Вкупно 40 интактни премолари, сите екстархирани поради ортодонтски причини, беа поделени во 4 групи. Во група 1 и 2, 10 метални и 10 порцелански беа бондирани со адхезивниот систем на GC Fuji ORTHO LC и GC Fuji Ortho Conditioner (GC, Japan). Во група 3 и 4, 10 метални и 10 порцелански брекети беа бондирани со адхезивниот ситем наOrmco Enlight Light Cure Adhesive (Ormco, USA) иетching gel (Ivoclar, Vivadent, Liechtenstein). После 48 часа, сите брекети беа дебондирани. Користејќи микроскоп Apochromatic Stereo Microscope ZEISS Stemi 508), беше калкулирана вкупната површина на адхезивен остаток кој останува на забната површина и на базата на брекетата изразена во μm2. Овие вредности понатаму ги искористивме за да го пресметаме индексот на адхезивен остаток (ARI) користејќи ја ARI формулата. **Резултати:** Најголема вредност на ARI индекс добивме во Група 4: ORMCO PORCELAIN (78.45 ± 17.02), следено со група 2: FUJI PORCELAIN (59.33 ± 17,129), следено со група 3: ORMCO METAL (54.54 ± 11.67), а најниска вредност на ARI индекс добивме во група 1: FUJI METAL (44.81 ± 16, 86). **Заклучок:** И кај двата адхезивни системи(FUJI/ORMCO) адхезивниот остаток е без исклучок секогаш поголем кај порцеланските брекети споредено со металните. Притоа, порцеланските брекети кои беа бондирани со СМГЈЦ (FUJI) резултираа со помала вредност на на ARI индек и микропукнатини на емајлот во споредба со порцеланските брекети бондирани со композитна смола (ORMCO). **Клучни зборови:** емајлово оштетување, брикети, АРИ индекс , атхезиви, ултразвук

Introduction

The debonding process is used to remove the orthodontic attachments and all of the adhesive remnants from the tooth in order to restore the enamel surface to its original pre-treatment condition[1]. Many studies have shown that the process of debonding can cause enamel loss and its damage in the form of microcracks, scratches, grooves and even fractures, which are often visible to the nakedeye. These damages can compromise the integrity of the enamel and can cause aesthetic problems for the patiens[2].

Adhesives used to bond orthodontic brackets, such as composite resins, are considered to be the most important advances in clinical orthodontics[3,4]. Nowadays, the traditional technique of complete etch is widely accepted by most orthodontics as a routine procedure for bonding orthodontic brackets. However, this technique leads to the creation of a strong shear bond strength between the enamel and the bracket, which can lead to iatrogenic damage to the enamel surface during the debonding process of the brackets[1,3,5]. A factor that additionally affects the damage of the enamel surface is exactly the type of brackets used in the orthodontic therapy. Enamel damage of as much as 63.3%, was observed when porcelain brackets were debonded in an in-vitro study, which concluded that enamel damage was more likely to occur with porcelain brackets than with metal brackets[6].

The use of resin-modified glass ionomer cements, as orthodontic bonding agents, has been increased in the recent years. A factor that encourages their use is not only their ability to release fluoride but also the ability to reduce enamel loss during orthodontic treatment[7].

Determination of the ARI index (Adhesive remnant index) is a simple method that calculates the amount of adhesive remnants which remain on the tooth surface, after debonding the brackets, according to the formula of Artun and Bergland[8].

It must be noted that the ARI index depends on many factors, such as: the type of bonding technique (direct/indirect)[9], the type of bracket (metal, porcelain), the type of acid use for etching (orthophosphoric or polyacrylic)[7,10], the type of adhesive material (composite resin/glass-ionomer cement conventional or resin modified)[7], the position of the teeth in the jaw (front or buccal)[11], as well as the tooth surface on which the brackets are bonded (vestibular/lingual)[12].

The aim of this study is to determine the difference in the total amount of adhesive remnants when using different types of brackets bonded with different adhesive systems. The main hypothesis is based on the postulate that a stronger bond is created in porcelain brackets bonded with the system of total etch of the enamel, but with simultaneous appearance of a larger amount of adhesive remnants and enamel microcracks.

Material and method

Material:

- Teeth: 40 extracted permanent premolars
- Orthodontic brackets: 20 metal brackets and 20 porcelain brackets (Dentaurum, Germany)
- Adhesive systems:
  1. Resin modified glass-ionomer cement (GC Fuji ORTHO LC; GC Japan) and 10% polyacrylic acid (GC Fuji Ortho Conditioner; GC Japan),
  2. Composite resin (OrmcoEnlight Light Cure Adhesive; Ormco USA) and 37% orthophosphoric acid (IvoclarVivadent, Liechtenstein)
- Instruments for debonding brackets: orthodontic pliers (Dentaurum, Germany)

Method

The clinical trial was performed on 40 permanent premolars, all extracted for orthodontic reasons. The extracted teeth were intact, without enamel damage, restorations or carious lesions on the buccal surfaces. In order to avoid dehydration, the extracted teeth were stored in saline at a temperature of 37 OC .The specimens were divided into 4 groups:

Group 1 (FUJI METAL):Metal orthodontic brackets, bonded with the adhesive system of GC Fuji Ortho LC (GC, Japan), were applied on 10 extracted permanent premolars.

Group 2 (FUJI PORCELAIN):Porcelain orthodontic brackets, bonded with the adhesive system of GC Fuji Ortho LC (GC, Japan), were applied on 10 extracted permanent premolars.

Group 3 (ORMCO METAL): Metal orthodontic brackets, bonded with the adhesive system of OrmcoEnlight Light Cure Adhesive (Ormco, USA), were applied on 10 extracted permanent premolars.

Group 4 (ORMCO PORCELAIN):Porcelain orthodontic brackets, bonded with the adhesive system of OrmcoEnlight Light Cure Adhesive (Ormco, USA), were applied on 10 extracted permanent premolars.

Procedure

The buccal surfaces were cleaned with a pumice and water to eliminate plaque and other organic debris left after extraction, and then washed with distilled water

and dried. The procedure is performed for all test specimens. Depending on the group of the sample, the brackets were bonded to the tooth surface according to the manufacturer's instructions.

- **Application procedure of the adhesive system of GC Fuji Ortho LC (GC, Japan):**

According to the manufacturer's instructions, the buccal surfaces of the samples are etched with GC Fuji Ortho Conditioner (10% polyacrylic acid) for 20 seconds and then washed for 20 seconds. It is important that conditioned surfaces remain moist. On a glass plate, 2 drops of liquid are applied and 1 teaspoon of powder, which is divided into two parts, whereby the first oneis mixed with all the liquid for 10 seconds, then the second part is added and mixed for 10-15 seconds. Thus prepared, the material is applied to the base of the bracket, and isthen positioned on the buccal surface of the tooth (the middle of the mesiodistal width and the middle of the gingivo-incisal length of the tooth) and pressed to release the excess adhesive. The excess is then removedand the adhesive is polymerized for 40 seconds.

- **Application procedure of the adhesive system of Ormco Enlight Light Cure Adhesive (Ormco, USA):**

According to the manufacturer's instructions, the buccal surfaces of the specimens were etched with 37% orthophosphoric acid for 30 seconds, washed for 30 seconds, and dried for 15 seconds until a white matte surface was obtained. Then, a thin layer of bond is applied to the etched surface and is polymerized for 20 seconds. Afterwards, a layer of Ormco Enlight adhesive is placed on the base of the bracket, then the bracket is positioned on the buccal tooth surface (in themiddleof the mesiodistal width and in the middle of the gingivo-incisal length of the tooth) and pressed to release excess adhesive. The excess adhesive is removed and the tooth is polymerized for 40 seconds.

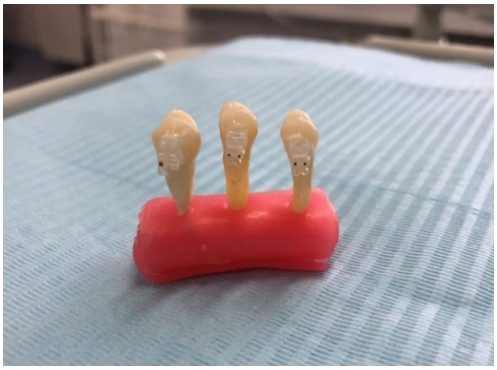
In order to achieve the maximum bond between the tooth surface and the bonded brackets, the dental specimens were stored in saline at room temperature for 48 hours. This is followed by debonding the brackets using orthodontic pliers from everyday clinical practice. The samples were coated with methylene blue, for easier microscopic detection of adhesive remnants at the brackets base,and on the tooth surface.

Microscopic analysis

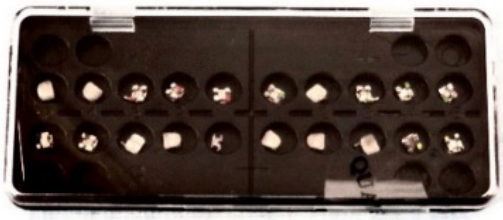
The remaining adhesive residues on the surface of the tooth and on the bracket are analyzed using microscopic analyses.The used microscope is Apochromatic Stereo Microscope ZEISS Stemi 508, with Axiocam ERc 5s camera (Carl Zeiss Microscopy GmbH, 2018) and 50 × (magnification) magnification of the surface. Using this microscope, we calculated the total area of the adhesive remnants remaining on the tooth surface and on the brackets base, expressed in μm^2.

Furthermore, we used these values to obtain the adhesive remnant index (ARI) according to Artun and Bergland8, which estimates the amount of adhesive that remains on the tooth surface after debonding the orthodontic brackets, and is calculated according to the following formula:

ARI = area of residual resin/area of bracket base x 100



***Picture 1**. Applied porcelain brackets on*



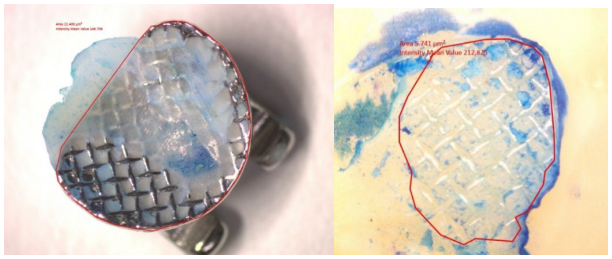
***Picture 2**. Metal brackets*

***Picture 3.** Apochromatic Stereo Microscope extracted premolars ZEISS Stemi 508*

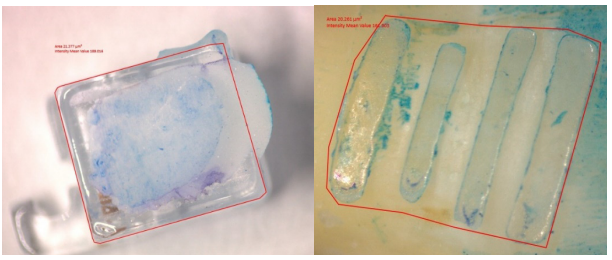
***Picture 4**. Adhesive system Ormco Enlight LC (Ormco, USA)*

***Picture 5**. Adhesive system GC Fuji Ortho LC (GC, Japan)*

***Picture 6, 7**. Coating the teeth surfaces and bracket basewith methylene blue for easier detection of adhesive residues under a microscope*



***Picture 8, 9.** Measurement of the total area of the metal bracket baseand the total area ofthe adhesive remnants left on the tooth surface in μm² after debonding metal bracket using a Microscope Apochromatic Stereo ZEISS Stemi 508*



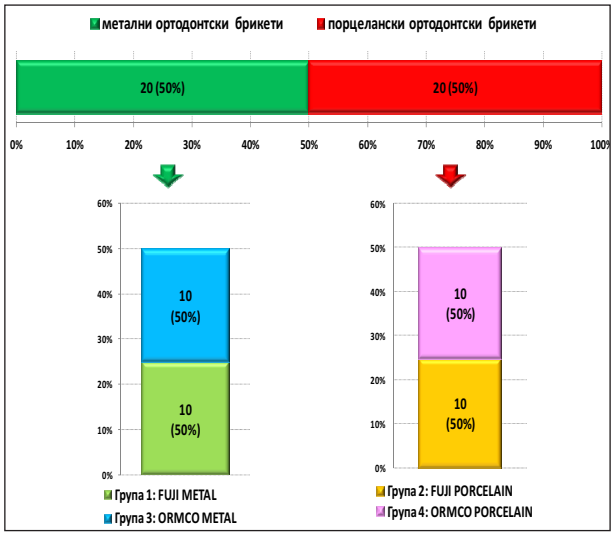
***Picture 10, 11.** Measurement of the total area of the porcelain bracket baseand the total area ofthe adhesive remnants left on the tooth surface in μm² after debonding porcelain bracket using a Microscope Apochromatic Stereo ZEISS Stemi 508*

Results

The research is a prospective clinical study, which analyzed the change in the integrity of the enamel surface of the premolars.

The sample of 40 (100%) extracted permanent premolars was divided into 2 samples: a) 20 (50%) premolars with applied metal orthodontic brackets (Group 1 and Group 3), and b) 20 (50%) premolars with applied porcelain orthodontic brackets (Group 2 and Group 4). Each of the two samples of premolars (metal and porcelain) was divided into a group of 10 (50%) premolars with applied adhesive system - FUJI (Group 1 and Group 2.) and a group of 10 (50%) premolars with applied adhesive system ORMCO (Group 3 and Group 4) (Graph 1.).

For each of the examined premolars, the total area of adhesive remnants in μm2that remains at thebracket base was determined, i.e. the total area of adhesive remnants in μm2that remains on the tooth surface.



***Graph 1.** Algorithm of procedures during the research*

Additionally, according to the obtained values, the adhesive remnant index (ARI) was determined, through which the amount of adhesive that remains on the tooth surface after debonding the brackets was estimated.

1. Comparison of ARI index - Group 1: FUJI METAL and Group 2: FUJI PORCELAIN

In group 1: FUJI METAL the average value of the ARI index after debonding the metal orthodontic brackets was **44.81 ± 16.86 µm²** with min/max. value of 21.43 / 68.09 µm².

In group 2: FUJI PORCELAIN the average value of the ARI index after debonding the porcelain orthodontic brackets was **59.33 ± 17.129 µm²** with a min/max. value of 33.74 / 81.10 m².

When comparing the two groups (Group 1: FUJI METAL/Group 2: FUJI PORCELAN), the analysis indicated that ***there wasno statistically significant difference*** in the height of the adhesive remnant index - ARI (Independent t-test: t (18) = - 1,911, p = 0.072). **We found that in group 2: FUJI PORCELAN, the height of the ARI index was insignificantly higher compared to group 1: FUJI METAL. (Table 1. and Graph 1.)**

2. Comparison of ARI index - Group 3: ORMCO METAL and Group 4: ORMCO PORCELAN

In Group 3: ORMCO METAL, the average value of the ARI index after debonding the metal orthodontic brackets was **54.54 ± 11.67µm²** with a min,/,max. value of 39.55 / 75.21µm²

In Group 4: ORMCO PORCELAN, the average value of the ARI index after debonding theporcelain orthodontic brackets was **78.45 ± 17.02 µm²** with min./max. value of 55.15 / 99.31 µm²

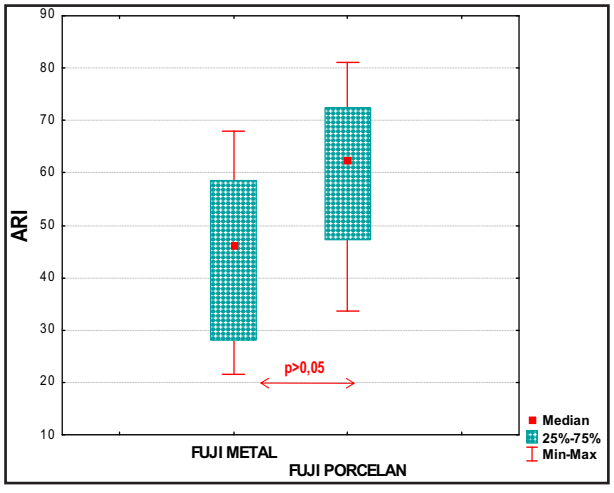
When comparing the two groups (Group 3: ORMCO METAL/Group 4: ORMCO PORCELAN), the analysis showed that ***there is a statistically significant difference*** in the height of the adhesive residue index - ARI (Mann Wihitney U test: Z = -2,873; p = 0.004). **We found that in Group 4: ORMCO PORCELAN, the height of the**

Table 1. *Comparison of ARI index between Group 1: FUJI METAL*

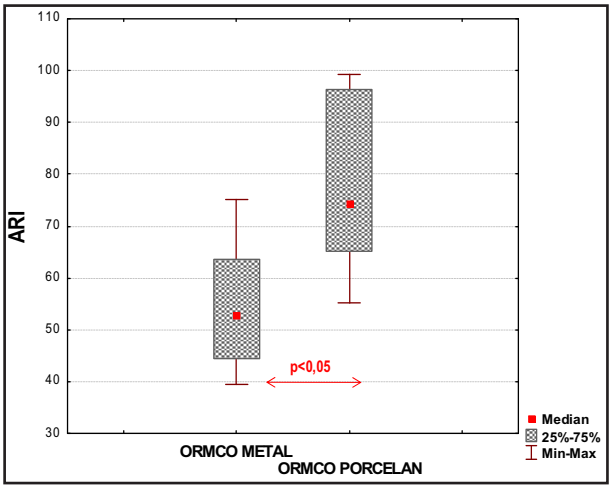
ARI	N	X̄ ± SD	Std. Error	95% Confidence Interval for Mean	
				Lower Bound	Upper Bound
Group 1: FUJI METAL	10	44,81±16,86	7,6011	(30,49)	1,45
Group 2: FUJI PORCELAN	10	59,33±17,129	7,6201	(30,65)	1,47
Independent t-test: t (18)=-1,911; p=0,072 significant for p<0,05					

Table 2. Comparison of ARI between Group 3: ORMCO METAL

ARI	N	X̄ ± SD	Std. Error	95% Confidence Interval for Mean	
				Lower Bound	Upper Bound
Group 3: ORMCO METAL	10	54,54±11,67	6,524	(37,61)	(10,19)
Group 4: ORMCO PORCELAN	10	78,45±17,02	6,524	(37,74)	(10,06)
Mann Wihitney U test: Z=-2,873; p=0,004* *significant for p<0,05					



Graph 1. *Comparison of ARI index between and Group 2: FUJI PORCELAN, Group 1: FUJI METAL and Group 2: FUJI PORCELAN*



Graph 2. *Comparison of ARI index between Group 3 Group 4: ORMCO PORCELANORMCO METAL and Group 4: ORMCO PORCELAN*

ARI index was significantly higher compared to Group 3: ORMCO METAL. (Table 2. and Graph 2.)

3. Comparison of ARI index between all four groups

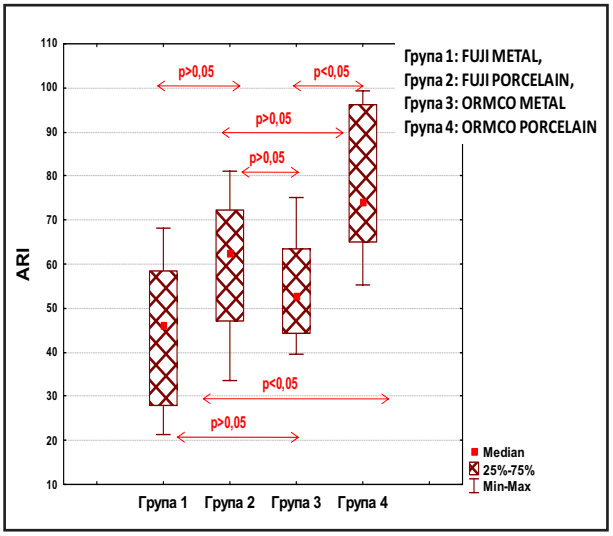
The analysis indicated that for p <0.5, **there is a statistically significant difference between the four groups** in terms of the height of the adhesive residue index - ARI (Kruskal-Wallis H test: Chi-square (3)=13,796; p= 0.003).

We found that the value of the ARI index **was highest in Group 4: ORMCO PORCELAN** (78.45 ± 17.02) followed by Group 2: FUJI PORCELAN (59.33 ± 17,129), followed by Group 3: ORMCO METAL (54.54 ± 11.67), **and the lowest value was observed in Group 1: FUJI METAL** (44.81 ± 16.86). In general, we concluded that in both adhesive systems (FUJI / ORMCO) **the adhesive residue is, without exception, always higher on the porcelain brackets compared to the metal ones.**

Table 1. Comparison of ARI index between all four groups

Groups	ARI (μm2)				p
	Group 1: FUJI METAL	Group 2: FUJI PORCELAN	Group 3: ORMCO METAL	Group 4: ORMCO PORCELAN	
	46,702	33,74	75,209	65,126	Kruskal-Wallis H test: Chi-square (3)=13,796; p=0,003*
	38,656	47,19	54,998	61,085	
	58,426	81,10	39,545	77,134	
	68,095	34,19	50,523	66,579	
	48,619	60,83	61,454	99,310	
	24,370	51,78	47,390	94,167	
	28,040	72,30	44,334	71,392	
	21,434	64,29	42,549	55,148	
	45,926	79,13	65,943	98,279	
	67,808	68,74	63,497	96,230	
$\bar{X}$ ± SD	44,81±16,86	59,33±17,129	54,54±11,67	78,45±17,02	

Гр 1/Гр 2 = Mann Wihitney U test: Z=-1,890; p=0,063
Гр 1/Гр 3 = Mann Wihitney U test: Z=-1,209; p=0,247
Гр 1/Гр 4 = Mann Wihitney U test: Z=-3,099; p=0,001*
Гр 2/Гр 3 = Mann Wihitney U test: Z=-0,756; p=0,481
Гр 2/Гр 4 = Mann Wihitney U test: Z=-1,965; p=0,052
Гр 3/Гр 4 = Mann Wihitney U test: Z=-2,873; p=0,004*
* сигнификантноза p<0,05



Graph 3. *Comparison of ARI index between all four-groups*

Discussion

The aim of this study was to determine the difference in the total amount of adhesive remnants when using different types of brackets bonded with different adhesive system. Additionally, the main hypothesis was based on a stronger bond that is created in porcelain brackets applied with a system of total etch of the enamel, but with the simultaneous appearance of a larger amount of adhesive remnants and enamel microcracks.

In their study, Lee and Lim[13] concluded that the type of adhesive used for bonding orthodontic brackets affects the amount of adhesive residue that remains on the tooth surface, i.e. from their results they concluded that resin-modified glass-ionomer cement has a lower value of ARI index compared to composite resin.

There is a direct correlation between the height of the ARI index and the shear bond strength[14]. The higher the bond strength, the higher the percentage of ARI[15]. According to the results of the author Uysal T. et al.[16], it was found that the bond strength of porcelain brackets is higher than that of metal brackets. In another study by Haidar et al.[17], the bond strength between light-polymerizing composite resin, light-polymerizing glass-ionomer cement, and light-curing compomer using metal and porcelain brackets, was compared. The shear bond strength was found to be significantly higher in porcelain brackets. The highest value of bonding strength was obtained in the group of porcelain brackets bonded with light-polymerizing composite resin (SBS = 20.17 MPa),

and the lowest in metal brackets bonded with light-polymerizing glass-ionomer cement (SBS=4.45MPa).

Reynolds[18] suggested that a minimum bond strength of 5.9-7.8 MPa was sufficient to bond the brackets to the enamel surface, while Lopez et al.[19] found that a bond strength of 7MPa ensured the clinically successful bonding of orthodontic brackets. Resin-modified GJCs have a lower bond strength (SBS) compared to composite resin, but according to new studies, this is quite sufficient for successful orthodontic bonding.

From the results obtained in our research, comparing all four groups individually we found that the value of ARI was highest in group 4: ORMCO PORCELAN (78.45 ± 17.02) followed by group 2: FUJI PORCELAN (59.33 ± 17,129), followed by group 3: ORMCO METAL (54.54 ± 11.67), and lowest value was observed in group 1: FUJI METAL (44.81 ± 16.86). In general, we can conclude that in both adhesive systems (FUJI / ORMCO) the adhesive remnant is without exception always higher on porcelain brackets compared to metal brackets.

We have the best result in group 1 (FUJI METAL), which is due to the lower bond strength created between the enamel and the resin-modified glass-ionomer cement when compared to the strength of the composite resin, which consequently results in a smaller amount of adhesive remnants (ARI). In addition, we have a stronger chemical bond that is created with porcelain brackets, compared to metal, which increases the risk of fractures or damage to the enamel. We can therefore confirm the main hypothesis, which is based on a stronger bond that is created in porcelain brackets, applied with a system of total etch of the enamel, but with the simultaneous appearance of a larger amount of adhesive remnants and enamel microcracks.

At the same time, our results coincide with those of N.J. Cochrane et al.[20] who concluded that enamel damage was more common in porcelain brackets (31.9%) compared to metal brackets (13.3%), therebythe porcelain brackets bonded with a resin-modified glass-ionomer cement resulted in lower enamel damage compared to porcelain brackets bonded with composite adhesive systems.

Conclusion

- The type of bracket affects the damage to the enamel surface. Metal brackets are a better choice than porcelain because the bonding strength of porcelain brackets is higher than that of metal, and their hardness is higher than that of enamel, which in the process of debonding increases the risk of damage to the enamel surface, in the form of microcracks and fractures of the enamel.
- The type of adhesive affects the amount of adhesive residue that remains on the enamel surface, i.e. according to our results, SMGJC (Fuji Ortho LC) has a lower value of ARI index compared to composite resin (OrmcoEnlight). In addition, it has other advantages such as fluoride release, easy removal, and lower risk of damage compared to the traditional total etch technique.
- There is a correlation between the ARI index and the bond strength, i.e. the higher the bond strength the higher the ARI index. It has been proven that the shear bond strength in composite resin is higher compared to that of SMGJC, which is confirmed by our results.

Reference

1. Ahrari F, Akbari M, Akbari J, Dabiri G. Enamel surface roughness after debonding of orthodontic brackets and various clean-up techniques. J Dent (Tehran). 2013;10(1):82-932.
2. Heravi F, Shafaee H, Abdollahi M, Rashed R. How Is the Enamel Affected by Different Orthodontic Bonding Agents and Polishing Techniques?. J Dent (Tehran). 2015;12(3):188–194.
3. Vicente A, Bravo LA, Romero M. Influence of a nonrinse conditioner on the bond strength of brackets bonded with a resin adhesive system. Angle Orthod 2005; 75: 400-405.
4. Scougall Vilchis RJ, Yamamoto S, Kitai N, Hotta M, Yamamoto K. Shear bond strength of a new fluoride-releasing orthodontic adhesive. Dent Mater J. 2007 Jan;26(1):45-51. doi: 10.4012/dmj.26.45. PMID: 17410892.
5. Bishara SE, Fonseca JM, Boyer DB. The use of debonding pliers in the removal of ceramic brackets: Force levels and enamel cracks. Am J Orthod Dentofac Orthop 1995; 108: 242-248.
6. Redd TB, Shivapuja PK. Debonding ceramic brackets: effects on enamel. J Clin Orthod. 1991;25:475–481.
7. Ireland AJ, Hosein I, Sherriff M. Enamel loss at bond-up, debond and clean-up following the use of a conventional light-cured composite and a resin-modified glass polyalkenoate cement. Eur J Orthod 2005;27:413-419.
8. Montasser M.A.; Drummond J.L. : Reliability of the Adhesive Remnant Index Score System with Different Magnifications, Angle Orthodontist, Vol 79, No 4, 2009
9. Vidor MM, Felix RP, Marchioro EM, Hahn L. Enamel surface evaluation after bracket debonding and different resin removal methods. 2015 Mar-Apr; 20(2): 61–67.
10. Fjeld M, Øgaard B. Scanning electron microscopic evaluation of enamel surfaces exposed to 3 orthodontic bonding systems. Am J Orthod Dentofacial Orthop. 2006;130(5):575-581. doi:10.1016/j.ajodo.2006.07.002
11. Knoll M, Gwinnett AJ, Wolff MS. Shear strength of brackets bonded to anterior and posterior teeth. Am J Orthod. 1986;89(6):476-479. doi:10.1016/0002-9416(86)90003-5
12. Brosh T, Strouthou S, Sarne O. Effects of buccal versus lingual surfaces, enamel conditioning procedures and storage duration on brackets debonding characteristics. J Dent. 2005;33(2):99-105. doi:10.1016/j.jdent.2004.08.005
13. Lee YK, Lim YK. Three-dimensional quantification of adhesive remnants on teeth after debonding. Am J Orthod Dentofacial Orthop. 2008;134(4):556-562.
14. Faria-Júnior ÉM, Guiraldo RD, Berger SB, Correr AB, Correr-Sobrinho L, Contreras EF. In-vivo evaluation of the surface roughness and morphology of enamel after bracket removal and polishing by different techniques. Am J Orthod Dentofacial Orthop. 2015;147(3):324–329

15. Osorio R, Toledano M, García-Godoy F. Enamel surface morphology after bracket debonding. ASDC J Dent Child. 1998;65(5):313-354.
16. Uysal T, Ustdal A, Kurt G. Evaluation of shear bond strength of metallic and ceramic brackets bonded to enamel prepared with self-etching primer. Eur J Orthod 2010; 32: 214-8.
17. Haydar B, Sarikaya S, Cehreli ZC. Comparison of shear bond strength of three bonding agents with metal and ceramic brackets. Angle Orthod 1999 Oct; 69(5): 457-62
18. Reynolds IR, von Fraunhofer JA. Direct bonding of orthodontic attachments to teeth: the relation of adhesive bond strength to gauze mesh size. British J Orthod 1976 Apr; 3(2): 91-5.
19. Lopez JI. Retentive shear bond strengths of various bonding attachment bases. Am J Orthod 1980 Jan; 77(1): 669-78
20. Cochrane NJ, Lo TWG, Adams GG, Schneider PM. Quantitative analysis of enamel on debonded orthodontic brackets. Am J Orthod Dentofacial Orthop. 2017;152(3):312-319. doi:10.1016/j.ajodo.2017.01.020

UDK: 616.314.17-008.1-085.27

THE EFFECT OF HYALURONIC ACID ON PERIODONTAL ATTACHMENT GAIN DURING GUIDED BONE REGENERATION

ВЛИЈАНИЕТО НА ХИЈАЛУРОНСКАТА КИСЕЛИНА ВРЗ ПОЗИЦИЈАТА НА ПРИПОЈНИОТ ЕПИТЕЛ ВО ТЕК НА ВОДЕНАТА ТКИВНА РЕГЕНЕРАЦИЈА

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Abstract

Introduction: The management of periodontal defects has been an ongoing challenge in clinical periodontics. This is mainly a result of the fact that tissues, which comprise the periodontium, the periodontal ligament, the cementum and alveolar bone, represent three unique tissues in their own right. Thus, reconstruction of the periodontium is not just a simple matter of regenerating one tissue but involves at least three quite diverse and unique tissues.More recently, attention has been paid on regenerative and reconstructive therapies, rather on resective therapies. Among the many mediators used in periodontal regeneration ishyaluronic acid. In the field of dentistry, hyaluronic acid has shown anti-inflammatory and anti-bacterial effects in the treatment of periodontal diseases. The main aim of our investigation was to follow up the effect of hyaluronic acid on periodontal attachment. **Material and method:** 30 patients took part in the study. Patients were selected according to the following criteria: aged between 20 - 45, without anamnestic data for general disease,non-smokers, similar type of periodontal destruction, both in volume and type, on one contralateral side. Prior to the intervention, all patients were given advice on proper oral hygiene. Modified Widmann method was applied for all patients. BioOss beef boneapplied to each patient on one side (control group) and BioOss with 16% BDDE hyaluronic acid from Stylage-Vivacy Paris in a ratio of 2:1, was applied on thecontralateral side, enough until a thick, sticky bone ratio is obtained - (examined group). Results were monitored by CBCT (computed tomography in which X-rays are divergent to form a cone beam) and measurements were made before and after 12 (twelve) months. **Results:** The obtained data showedthat regenerative approach using hyaloss in combination with guided tissue regeneration (GTR) for the treatment of human infrabony defects resulted inbenefit in terms of Clinical attachment (CAL) gains, periodontal probing depth (PPD) reductions and radiographic defect fill, as well as linear bone growth (LBG), compared to GTR alone. **Conclusion:** Therefore, we can conclude that hyaluronic acid has beneficial effects on periodontal tissues. **Key words:** hyaluronic acid, bone regeneration, periodontal regeneration and reconstructive therapies attachment gain.

Апстракт

Вовед: Управувањето со пародонталните дефекти е тековен предизвик во клиничката пародонтологија. Ова главно е резултат на фактот дека ткивата што го сочинуваат пародонтот, пародонталниот лигамент, цементот и алвеоларната коска, претставуваат три уникатни ткива сами по себе. Така, реконструкцијата на пародонтот не е само едноставна работа за регенерирање на едно ткиво, туку вклучува најмалку три сосема различни и уникатни ткива. Во поново време, вниманието е фокусирано на регенеративните и реконструктивните терапии, наместо на ресективните терапии. Меѓу многуте медијатори кои се користат во пародонталната регенерација е хијалуронската киселина. Во областа на стоматологијата, хијалуронската киселина покажа антиинфламаторно и антибактериско дејство во лекувањето на пародонталните заболувања. Главната цел на нашето истражување беше да се следи ефектот на хијалуронската киселина врз пародонталната приврзаност. **Материјал и метод:** 30 пациенти учествуваа во студијата. Пациентите беа избрани според следните критериуми: на возраст меѓу 20 - 45 години, без анамнестички податоци за општа болест, непушачи, сличен тип на пародонтална деструкција и по волумен и по тип на едната и контралатералната страна. Пред интервенцијата на сите пациенти им беа дадени совети за правилна орална хигиена. За сите пациенти беше применета модифицираната метода на Видман. BioOss говедска коска нанесена на секој пациент на едната страна (контролна група) и BioOss со 16% BDDE хијалуронска киселина од Stylage-VivacyParis во сооднос 2:1, беше нанесена на контралатералната страна, во доволна количина додека не се добие густ леплив коскен сооднос - (испитана група). Резултатите беа следени со CBCT (компјутерска томографија во која X-зраците се дивергентни за да формираат конусен зрак) и мерењата беа направени пред и по 12 (дванаесет) месеци. **Резултати:** Добиените податоци покажаа дека регенеративниот пристап со употреба на хијалос во комбинација со водена регенерација на ткиво (GTR) за третман на дефекти на човечки инфрабонски резултираше со придобивки во однос на придобивките од клиничкото прикачување (CAL), намалувањето на длабочината на пародонталното испитување (PPD) и радиографскиот дефект, пополнување, како и линеарен раст на коските (LBG), во споредба со само GTR. **Заклучок:** Затоа можеме да заклучиме дека хијалуронската киселина има поволни ефекти врз пародонталните ткива. **Клучни зборови:** хијалуронска киселина, регенерација на коските, пародонтална регенерација и придобивка од реконструктивни терапии.

Introduction

In the field of dentistry in the last 50 years, scientists have been focused on a number of important requirements of periodontology, of its etiopathogenesis, but theywere mostly focused on periodontal regenerative possibilities and therapy.

Hyaluronic acid has been identified in all periodontal tissues in varying amounts and is more pronounced in non-mineralized tissues, such as the gingival and periodontal ligaments, compared with mineralized tissues such as cement and alveolar bone. In addition, due to the high levels of hyaluronic acid in the circulating blood serum, it is constantly present in the gingival blood flow fluid (GCF) which is a factor in serum overload[1].

Hyaluronic acid is an anionic glycosaminoglycanic acid widely distributed throughout connective, epithelial, and nerve tissues. It is unique among glycosaminoglycans in that it is non-sulfated and forms in the plasma membrane instead of in the Golgi apparatus. The human synovial hyaluronic acid averages about 7 million daltons per molecule, or about twenty thousand disaccharide monomers, while other sources mention 3-4 million daltons. One of the major components of the extracellular matrix, hyaluronic acid, contributes significantly to cell proliferation and migration, and may also be involved in the progression of some malignancies. The average 70 kg person has approximately 15 grams of hyaluronic acid in the body, of which one third is degraded and synthesized every day[2]. Hyaluronic acid is also a component of group A streptococcal extracellular capsule, and is believed to play an important role in virulence. Hyaluronic acid is one of the most well-known hygroscopic molecules known in nature. When hyaluronic acid (HA) is incorporated in aqueous solution, hydrogen bonding occurs between adjacent carboxyl and N-acetyl groups; this feature allows hyaluronic acid to maintain conformational stiffness and retain water. One gram of hyaluronic acid can bind up to 6 L of water. As a physical material, it has functions in spatial filling, lubrication, shock absorption, and protein exclusion[3]. The viscoelastic properties of the material can slow down the penetration of viruses and bacteria, a feature of particular interest in the treatment of periodontal diseases. Hyaluronic acid, as a viscoelastic substance, helps in periodontal regenerative procedures by maintaining spaces and protecting surfaces[3]. By recognizing its hygroscopic and viscoelastic nature, hyaluronic acid can affect cell function by modifying surrounding cellular and extracellular micro and macro media. Hyaluronic acid has many structural and physiological functions within tissues, including extracellular and cellular interactions, the interaction between the growth factor and the regulation of osmotic pressure, and tissue lubrication, which helps maintain the structural and homeostatic integrity of tissues[4]. Xenografts are proper alternatives for bone repair and regeneration because of their similarity to the human bone[5]. Although, the available amount of autograft material is always limited, one can obtain as much xenograft as desired. Due to its hydroxylapatite structure, natural bovine bone is potentially a much better graft material than a synthetic bone substitute. However, unresorbed graft remains of bovine bone have been observed in histological analyses even after three years[6]. Because xenografts are osteoconductive rather than osteoinductive, it is important to identify methods to improve their effectiveness in vivo[7].

Considering the various beneficial effects of hyaluronic acid, we focused our interest on the effects of hyaluronic acid in combination with bone graft and their effect on periodontal attachment gain during Guided Bone Regeneration (GBR).

Materials and method

30 patients took partin the study. Patients were selected according to the following criteria:

- aged between 20 - 45
- without anamnestic data for any general diseases
- non-smokers
- finding of both sides, main andcontralateral similar type of periodontal destruction, both in volume and type

All patients hadclinical examination before the intervention and the followingfeatureswere measured:

- depth of the periodontal pocket,
- loss of attachment,
- recession,
- gingival bleeding and gingival inflammation (according to Silnes Loë gradient)

Prior to the intervention, all patients were given advice on proper oral hygiene. The modified Widmann method was applied toall patients.Afterwards,BioOss beef bonewasapplied to each patient on one side which was used as control. BioOss with 16% BDDE hyaluronic acid from Stylage, Vivacy- Paris in a ratio of 2:1 until a thick, sticky bone ratio was obtained,wasapplied on the contralateral side of each patient - which data served as examined group.

In all patients, the results were monitored by CBCT (computed tomography in which X-rays are divergent to form a cone beam) and measurements were made before and after 12 (twelve) months.

Table 1. Values for attachment loss for the control group before and 12 months after surgery

	Lost attachment X	Stand. Deviation	St.dev.	t	p
before operation	5,26	2,862			
after operation 12 months	3,26	1,509	1,26	1,26	0,00000

Table 2. Values for attachment loss for the examined group before and 12 months after surgery

	Lost attachment X	Stand. Deviation	St.dev.	t	p
before operation	6,012	2,254			
after operation 12 months	3,395	1,724	2,91	4,39	0,000121

Table 3. Difference in values forattachment gain for the examined group and control group12 months after surgery

	Attachment gain	Stand. Dev.	St.dev.	t	p
control group	3,26	1,96			
examined group	3,93	1,724	2,989	-0,124	0,834

Results

Table 1. shows the values for attachment loss before and after 12 months postoperatively. Main value before surgery was 5,26 mm and 3,26mm after 12 months. High statistical significance of the differences for the values can be established.

Table 2. shows the values for the test group where hyaluronic acid was used. Main value before surgery was 6,12 mm and 3,395 mm after 12 months. High statistical significance forthe differences for the values can be established.

Table 3. shows attachment gain post operatively in the test and in the control group, a significant benefit of attachment gainand reduction of pocket depthcan be seen in both groups, yet there was no statistical significance of the differences. However, when comparing the numbers, the result in the examined group is 0.6 mm better.

Discussion

Today, hyaluronic acid is widely used in many branches of medicine with interesting potential applications in dentistry for the treatment of acute and chronic inflammatory disease. Data obtained from the present review of 20 clinical studies demonstrates that, due to its positive action on tissue repair and wound healing, topical administration of hyaluronic acid could play a role not only in postoperative dental surgery, but also in the treatment of patients affected by gingivitis and periodontitis, with a significant improvement in their quality of life. Further, laboratory-based research and large-scale randomized controlled clinical trials on a larger scale are advisable to confirm these promising results. From the perspective of current research, hyaluronic acid-based bone regenerative scaffolds are more biocompatible and bioactive with biomimetic strategies. As a matrix component, hyaluronic acid, especially sulfated HA (hyaluronic acid) may trigger cell behavior modulation via several signaling pathways, leading to faster and more desirable bone formation. Scaffolds and carriers based on HA are shaped into either rigid forms or colloids. As a rigid scaffold material, when incorporated with other materials, hyaluronic acid may alter the scaffold morphology and improve mineralization, making it more desirable and more functional for bone regeneration. Moreover, hyaluronic acid is chemically versatile, with its properties changed via simple chemical modification and crosslinking. The viscidity,

rheological properties, pH, and charge properties of hyaluronic acid can be modulated into states suitable for gelation or delivery. This leads us to the carrier hyaluronic acid. Either by mixing, or by chemically or electrostatically encapsulating a diverse range of growth factors, drugs, mineralized components, or cells in hyaluronic acid-based carriers, bone formation can be markedly enhanced and accelerated. New bone formation could more closely resemble that of the original tissue. Some strategies can also perform superbly in osseointegration for implantation. Hyaluronic acid-based hydrogels and micro particles can covalently bind to metal implant surfaces and release bioactive components, resulting in better osteogenesis and osseointegration. However, the specific mechanisms behind the effects of hyaluronic acid on osteogenesis still require proper investigation-controlled delivery as well as biomimetic scaffold and carrier designs, not just hyaluronic acid-based forms.

More recently, cross-linked hyaluronic acid (HA) products were used as gel barriers to cover the osseous defects around the implants and implant recipient sites, thereby promoting guided bone regeneration(GBR)[8]. Claar performed a lateral coverage of the augmentation followed by use of cross-linked hyaluronic acid in gel form, which was developed especially for guided bone regeneration[9]. The principles of GBR applications[10,11] are as follows: - Cell exclusion: creating a barrier to prevent forming fibrous connective tissue by epithelial cells. - Tenting: new wound space beneath the membrane must be regenerated solely around soft tissues so that high quality of new tissue can be gained. - Scaffolding: at first, a fibrin clot is seen in this space which is a scaffold for progenitor cells. Adjacent hard tissues serve as storage for stem cells. - Stabilization: to gain successful healing, the defective area must be protected from environmental effects such as flap movement, bacterial invasion, exposure of region, etc. by fixing the membrane into position.

The findings of our investigation-clinical study indicate that the use of HA + Bioss, as a regenerative material, was found to be effective in improving the clinical parameters compared to bioss alone in guided tissue regeneration. After 12 months postsurgery, a greater amount of mean Clinical attachment gain (0.6mm) was observed in the HA with Bioss group when compared to the Bioss groupalone. The results obtained in the present study were compared with other studies reported on the use of esterified HA. CAL following regenerative therapy is the single most commonly used clinical outcome variable. Ballini et al.[12] reported the mean gain of 2.6 mm CAL following application of esterified HA in combination with autologous bone in treatment of infrabony defects. However, Vanden Bogaerde[8] reported a mean CAL gain of 3.3 mm at 12 months follow-up. The greater mean CAL gain in their study could be explained by the differences in initial PD. The clinical studies have demonstrated that the CAL gain following regenerative periodontal therapy is strongly dependent on the initial PD, the greater the initial depth, thehigher is the CAL gain[13].

In ourpresent study, significantly greater mean CAL gain of 0.6 mm observed in hyaluronic acid + GTR investigation group in comparison with Bioss andGTR alone group, could be related to molecular characteristics of hyaluronic acid, since HA is known to stimulate cell migration, cell proliferation and also act as a carrier for other molecules, such as BMPs-2.14,15. From clinical standpoint, it was more significant to observe that 100% of sites treatedwith hyaluronic acidin combination with GTR experienced CAL gain of more than 2,91 mm, while only 8.3% of sites treated with GTR alone showed CAL gain of nomore than 2 mm.

Reduction of pocket depth to limit the risk of local reinfection is a primary goal of periodontal therapy. Shallow pockets have a strong, negative predictive value for future disease progression while deep pockets in treated areas are risk indicators for periodontal disease progression. In our present study, pocket depth reductions were significantly greater in both test and control groups. Engström et al.[16] reported mean PPD reduction of 4.1 mm when hyaloss was used in combination with bioabsorbable polylactic acid (PLA) barrier. However, Vanden Bogaerde[5] reported mean PPD reduction of 5.8 mm (range: 0–10 mm) at 12 months following an application of HA. Greater reduction of PPD reported by Vanden Bogaerde[8] could be related to the inclusion of the initial probing pocket of variable depth, which may have possiblyinfluenced the treatment outcome. During the 12 months period, the infrabony lesions in this study responded well to hyaluronic acid combined with GTR treatment with regards to reduction in radiographic DD. It is the experience of the investigators that the most accurate means of determining osseous defect response (crestal changes as well as within the defect) is by direct visualization at re-entry surgery, but a major disadvantage of re-entry procedure is the need for a second surgical procedure to visualize the osseous defect[17]. To overcome this difficulty, radiographic monitoring of alveolar bone changes has been utilized with various degrees of success[18]. Radiographic bone measurement is a non-invasive, painless alternative to direct bone measurement. Therefore, in ourpresent study, radiographic monitoring of alveolar bone changes was carried out as end-point variable. The most reliable outcome variable for assessing periodontal regeneration is human histology. Due to ethical considerations and patient management limitations, no histological evidence was obtained to establish the proof of periodontal regeneration. The importance of wound

stability for bone and periodontal regeneration has been reported. Based on the histological evidence from human material, it may be assumed that the clinical improvements following esterified HA treatment may represent, at least to some extent, a real periodontal regeneration characterized by the increase of osteoblastic activity by stimulating differentiation and migration of mesenchymal cells[19]. Moreover, the physiochemical properties of HA help keep the growth factors responsible for tissue repair in situ[20].

Conclusion

The aim of our study was to evaluate the use of hyaluronic acid in periodontal surgery and its possibly beneficial effects on periodontal tissues and periodontal regeneration.

Although there was no statistical significance of attachment gain there was clinical attachment gain where hyaluronic acid was used.Therefore, we can recommend the use of hyaluronic acid for periodontal regeneration.

The results of this research are expected to contribute to the knowledge of the impact of hyaluronic acid on periodontal regeneration and its application in the daily life of periodontology.

The obtained research results, together with literature data, give us relevant knowledge for optimal scientifically supported planning and realization for successful periodontal treatment. The scientific contribution of this research is the optimism that the scientific findings from this research will inciteinterest and need for new research regarding this issue.

Reference

1. Embery G, Waddington RJ, Hall RC, Last KS. Connective tissue elements as diagnostic aids in periodontology. Periodontol 2000. 2000 Oct;24:193-214
2. Neumayer T, Prinz A, Findl O. Effect of a new cohesive ophthalmic viscosurgical device on corneal protection and intraocular pressure in small-incision cataract surgery. J. Cataract. Refract. Surg. 2008;34:1362-6
3. Laurent TC (ed.). In: The Chemistry, Biology and Medical Applications of Hyaluronan and its Derivatives. Portland Press, London, U.K. 1998
4. Weigel PH, Frost SJ, McGary CT, LeBoeuf RD. The role of hyaluronic acid in inflammation and wound healing. Int. J. Tissue React. 1988;10(6):355-65.
5. Masamichi Takami , Ayako Mochizuki, Atsushi Yamada, Keita Tachi, Baohong Zhao, Yoichi Miyamoto, Takahisa Anada, Yoshitomo Honda, Tomio Inoue, Masanori Nakamura, Osamu Suzuki, Ryutaro Kamijo.Osteoclast differentiation induced by synthetic octacalcium phosphate through receptor activator of NF-kappaB ligand expression in osteoblasts.Tissue Eng Part A.2009 Dec;15(12):3991-4000.
6. Hallman M, Lundgren S, Sennerby L. Histologic analysis of clinical biopsies taken 6 months and 3 years after maxillary sinus floor augmentation with 80% bovine hydroxyapatite and 20% autogenous bone mixed with fibrin glue. Clin Implant Dent Relat Res. 2001;3(2):87-96.
7. Suzuki O, Yagishita H, Yamazaki M, Aoba T. Adsorption of bovine serum albumin onto octacalcium phosphate and its hydrolyzates. Cells Mater. 1995;5(1):45-54.
8. Vanden Bogaerde L. Treatment of infrabony periodontal defects with esterified hyaluronic acid: clinical report of 19 consecutive lesions. Int. J. Periodontics Restorative Dent. 2009;29:315-23
9. Claar M: Hyaluronic acid in oral implantology. EDI Case Studies. 2013; 4: 64-68.
10. Wang HL, Carroll MJ: Guided bone regeneration using bone grafts and collagen membranes. Quintessence Int. 2001; 32: 504-515.
11. Hitti RA, Kerns DG: Guided bone regeneration in the oral cavity: a review. Open Pathol. J. 2011; 5: 33-45
12. Ballini A, Cantore S, Capodiferro S, Grassi FR. Esterified hyaluronic acid and autologous bone in the surgical correction of the infra-bone defects. Int J Med Sci 2009;6:65-71
13. Cortellini P, Pini Prato G, Tonetti MS. Periodontal regeneration of human intrabony defects with titanium reinforced membranes. A controlled clinical trial. J Periodontol 1995;66:797-803
14. Weigel PH, Frost SJ, McGary CT, LeBoeuf RD. The role of hyaluronic acid in inflammation and wound healing. Int J Tissue React 1988;10:355-65
15. Hunt DR, Jovanovic SA, Wikesjö UM, Wozney JM, Bernard GW. Hyaluronan supports recombinant human bone morphogenetic protein-2 induced bone reconstruction of advanced alveolar ridge defects in dogs. A pilot study. J Periodontol 2001;72:651-8.
16. Engström PE, ShiXQ, Tronje G, Larsson A, Welander U, Frithiof L, et al. The effect of hyaluronan on bone and soft tissue and immune response in wound healing. J Periodontol 2001;72:1192-200.
17. R A Yukna, D P Callan, J T Krauser, G H Evans, M E Aichelmann-Reidy, K Moore, R Cruz, J B Scott.Multi-center clinical evaluation of combination anorganic bovine-derived hydroxyapatite matrix (ABM)/cell binding peptide (P-15) as a bone replacement graft material in human periodontal osseous defects. 6-month results.J Periodontol.1998 Jun;69(6):655-63.
18. Bjorn H, Halling A, Thyberg H. Radiographic assessment of marginal bone loss. Odontol Revy 1969;20:165-79
19. Kang MK, Sison J, Nachnani S, Pilloni A, Bermard GW. Low molecular weight hyaluronic acid enhances osteogenesis of adult rat bone marrow cells in vitro. Int J Oral Biol 1998;23:149-55
20. SasakiT, WatanabeC. Stimulation of osteoinduction in bone wound healing by high-molecular hyaluronic acid. Bone 1995;16:9-15

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USE OF CARRIERE MOTION CLASS III APPLIANCE (CM3) IN THE TREATMENT OF SKELETAL MALOCCLUSION CLASS III IN MINIMALLY GROWING PATIENTS – CASE REPORT

УПОТРЕБА НА CARRIERE MOTION III АППАРАТ (CM3), ВО ТРЕТМАН НА СКЕЛЕТНА МАЛОКЛУЗИЈА КЛАСА III КАЈ ПАЦИЕНТИ СО МИНИМАЛЕН РАСТ - ПРИКАЗ НА СЛУЧАЈ

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Abstract

Introduction: Class III malocclusions include spectrum of antero-posterior irregularities ranging from dentoalveolar problems with functional anterior shift of the mandible to really serious skeletal maxillomandibular discrepancies. Due to its variety of clinical presentation, there are many therapeutical modalities. Although optimal treatment approach to skeletal class III is orthognathic surgery complemented by orthodontics, many patients refuse it, yet,they expect good outcome. One of the treatment alternatives in such cases is the use of Carriere Motion Class III (CM3) appliance. **Aim:** To describe the treatment effects of CM3 appliance prior bonding fixed appliances in the treatment of minimally growing patients with skeletal class III. **Method:** CM3 appliance was fixed in the mandible in combination with trans palatal arch and vacuum-formed retainer in the maxilla as an anchorage. Class III intermaxillary elastics were used from the moment of application of CM3 appliance, all three months prior the bonding of the fixed appliances. **Results:** After 3 months of treatment with CM3, dental class I relationship was achieved. Together with the immediate therapy with fixed appliances, positive overjet was attained. The consecutive reduction of the profile convexity and lower lip prominence led to improvement of the patient's extraoral appearance. **Conclusion:** CM3 appliance provides a novel approach of the management of class III in mature or minimally growing patients. This protocol offers an alternative to more aggressive therapies that can involve orthodontics alone or in combination with orthognathic surgery. **Key words:** skeletal class III malocclusion, non-growing patient, Carriere Motion Class III appliance, mandibular molar distalization, camouflage treatment.

Апстракт

Вовед: Малоклузиите III класа опфаќаат спектар на неправилности во антеро-постериорен правец, кои се движат од дентоалвеоларни промени со функционално антериорно придвижување на мандибулата, до сериозни скелетни максило-мандибуларни дискрепанци. Со оглед на разновидноста на клиничката манифестација, постојат многу тераписки модалитети. Иако оптимален тераписки пристап во лекувањето на скелетна трета класа е ортогната хирургија, голем дел од пациентите одбиваат, а и покрај тоа, очекуваат добар тераписки исход. Една од терапевтските алтернативи во вакви случаи е употреба на Carriere Motion Class III (CM3) апаратот. **Цел:** да се прикаже терапевтскиот ефект на CM3 апаратот пред бондирање на фиксните апарати, кај пациент со минимален раст и скелетна класа III. **Метод:** CM3 апаратот беше аплициран во мандибулата, во комбинација со транспалатинален лак и ретејнер формиран со вакуум формер апарат во максилата како упориште. Дадени беа инструкции за употреба на интермаксиларна тракција III класа во вкупно времетраење од 3 месеци пред поставувањето на фиксните апарати. **Резултати:** По 3 месеци терапија со CM3беше постигнат правилен меѓувиличен сооднос- дентална прва класа. Во комбинација со непосредната терапија со фиксни апарати, добивме позитивнахоризонтална инцизивна стапалка. Последователната редукција на конвекситетот на профилот и проминенцијата на долната усна, доведоа до подобрување на екстраоралниот изглед на пациентот. **Заклучок:** CM3 апаратот нуди нов пристап при менаџирањето на класа III кај адултни или пациенти со минимален раст. Овој протокол нуди алтернатива на поагресивни терапии од ортодонтска или ортодонтско-хируршка природа. **Клучни зборови:** скелетна малоклузија класа III, пациент со завршен раст, Carriere Motion Class III апарат, дистализација на мандибуларни молари, камуфлажна терапија.

Introduction

Class III malocclusions include spectrum of antero-posterior irregularities, which can range in severity - from dentoalveolar problems with functional anterior shift of the mandible to true skeletal problems with serious maxillomandibular discrepancies[1], where mesial relationship (anteposition) of mandible to the maxilla and/or cranial base is presented. The nature of this malocclusion can be of dentoalveolar or skeletal nature.

Class III malocclusions are the least common type of malocclusion, yet they are often more complicated to treat and more likely to require orthognathic surgery for optimal correction[2]. The reported incidence of this malocclusion ranges between 1% to 19%, with the lowest prevalence among the Caucasian populations[3,4] and the highest one among the Asian populations[5,6].

Despite its low incidence, the treatment of this malocclusion becomes huge challenge for the therapist, because even if early-diagnosed and interceptive, and early treatment measures are being undertaken, the factor of growth in later stages of development (pic of puberty), can compromise the achieved results, and the long-term outcome still remains uncertain.

Class III malocclusions can be generally categorized into two groups: developing and non-developing[7]. Regarding thedevelopment stage of the individual (growing or non-growing patient), and the severity of the malocclusion (dentoalveolar or underlying skeletal irregularity), there is a variety of treatment modalities in such cases.

For correction of skeletal Class III malocclusion, Proffitt states that there are three treatment options:

1) growth modification, use differential growth of the maxilla relative to the mandible;
2) camouflage of the skeletal discrepancy through tooth movements to correct the dental occlusion while maintaining the skeletal discrepancy; or
3) orthognathic surgical correction[8]. The treatment option is depending on the patient's age, the facial profile, the skeletal pattern, the alveolar bone reaction on mandibular incisors, and the severity of malocclusion before treatment[9].

Optimal treatment of a Class III malocclusion with skeletal disharmony requires orthognathic surgery complemented by orthodontics[10]. Treatment of these patients becomes even more challenging if they reject surgery but expect good outcome over the orthodontic therapy applied. Many therapeutical options are being suggested in such cases, including extractions (usually mandibular premolars), extraoral traction (horizontal traction of mandibular dental arch) or distalization of mandibular molars using different types of appliances[11,12,13].

This case report describes the therapeutical approach of resolving malocclusion Class III with underlying skeletal discrepancy, with camouflage treatment using Carriere Motion Class III Appliance (CM3) in patient refusing orthognathic surgery.

Appliance design

The design of Carriere Motion Class III Appliance was based on the principles of respect for human biology and the concepts of simplicity, biomimetics and biominimalism[14]. The anterior segment has a pad that bonds directly to the lower canine, with a hook for attachment of Class III elastics. An arm extends distally over the two lower premolars, with a slight curve following the contours of the dental arch and is bonded to the lower first molar by means of a distal pad. This rigid, half-round arm controls the lower canines while directing movement longitudinally. Between the second premolar and the first molar, it diminishes in size and forms an offset with a bayonet bend and toe-in angle, designed to produce a mild 10° distal rotation of the first molar. The bayonet bend has multilateral flexion to closely fit the patient's anatomical structure and facilitate the rotation; the posterior segment is flat to avoid interference with the maxillary teeth or brackets. Class III intraoral elastics connect the appliance with maxillary anchorage (either bonded appliances or a vacuum-formed retainer) to activate the mandibular posterior segment[15], moving it bodily into Class I relationship from canines to molars.

Diagnosis

An 18y3m old male patient was presented for treatment of mandibular prognathism. His chief complaint was bite discomfort and his unsatisfactory aesthetic appearance.

Extra oral findings of the patient revealed mandibular prognathism; concave profile with protruded lower third of the face, and thin retrusive upper lip. The frontal view showed an enlarged height of the lower facial third and mild facial hemihypertrophy on the right side (Figure 1).

Clinical examination revealed irregularities in both dental arches, mild crowding in the mandibular front, „tete-a-tete" bite, Class ½ III molar and canine relationship on the left side and full Class III molar and canine relationship on the right side (Figure 2).

The orthopantomogram showed that all permanent teeth are present and there is good bone support in general (Figure 3).

The skeletal analysis presented hypoplastic maxilla (maxillary retrognathism) with SNA value of 78 degrees, mandibular normognatism with SNB value of 81.2 degrees, a severe Class III skeletal relationship with ANB value of 3.2 degrees and Witts value of -6.1mm. The cephalogram analysis revealed tendency to skeletal open bite. The maxillary incisors were in severe protrusion and the mandibular incisors were slightly retruded. The patient was presented with an anterior growth pattern (Table 1).

In terms of muscular balance and function, we observed slight hypertonicity in the musculature in the

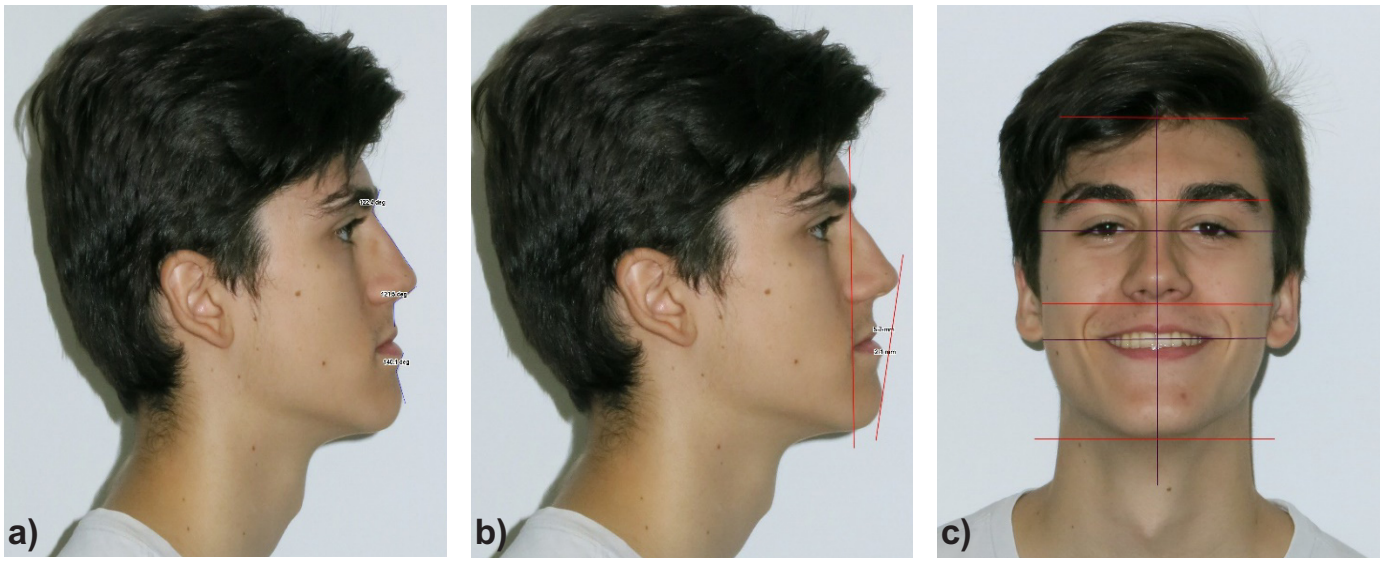

Figure 1. (a),(b),(c) *Pre treatment soft tissue analyses*

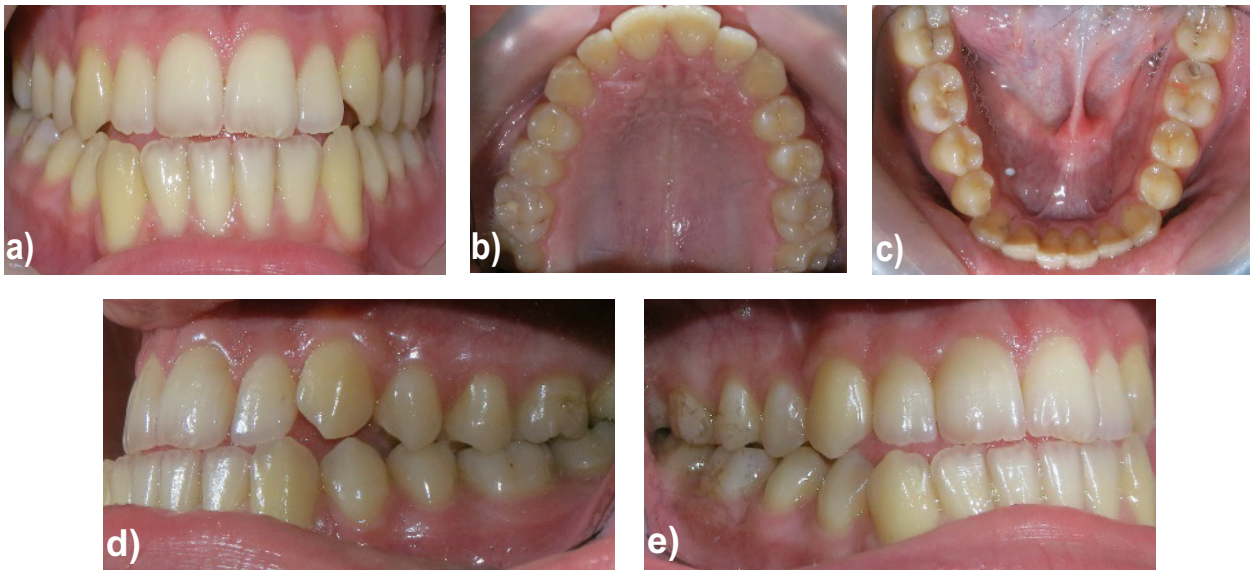

Figure 2. (a),(b),(c),(d),(e) *Pre treatment intraoral photographs*

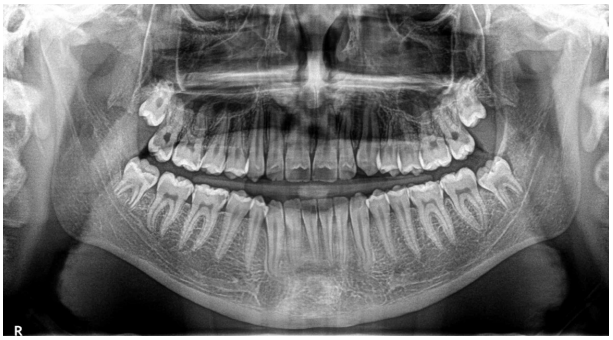

Figure 3. *Pre treatment orthopantomogram*

right side, as well as tongue thrust at deglutition. At rest, the tongue posture was on the floor of the mouth.

Although the patient was 18y3m old, his CVM analyses on the lateral cephalogram showed skeletal maturation stage 5. The means of the analyses is that his growth peak has already passed, but some horizontal growth is still expected, and an increase of mandibular body length (Table 2).

Table 1. Pre treatment cephalometric analyses

Measurement	Value	Normal	Std.Dev	Dev.Norm
Saddle/Sella Angle (SN-Ar) (ϵ)	118.7	124.0	5.0	-1.1
Articular Angle (ϵ)	152.7	138.0	6.0	2.4
Gonial/Jaw Angle (Ar-Go-Me) (ϵ)	119.6	120.8	6.7	-0.2
Sum Total: N-S-Art + S-Art-Go + Art-Go-Me (ϵ)	391.0	396.0	4.0	-1.3
Anterior Cranial Base (SN) (mm)	68.5	77.3	3.0	-3.0
Posterior Cranial Base (S-Ar) (mm)	35.8	37.0	4.0	-0.3
Nasion-Gonion Length (mm)	118.0	134.4	4.0	-4.1
Y-Axis Length (mm)	135.6	140.0	6.0	-0.7
SNA (ϵ)	78.0	82.0	3.5	-1.2
SNB (ϵ)	81.2	80.9	3.4	0.1
ANB (ϵ)	-3.2	1.6	1.5	-3.2
Beta Angle (ϵ)	42.7	31.0	4.0	2.9
Wits Appraisal (mm)	-6.1	-1.0	1.0	-5.1
Convexity (NA-APo) (ϵ)	-10.7	2.5	3.0	-4.4
Anterior Face Height (NaMe) (mm)	121.8	139.0	5.0	-3.4
Posterior Face Height (SGo) (mm)	83.5	90.0	5.0	-1.3
P-A Face Height (S-Go/N-Me) (%)	68.5	65.0	4.0	0.9
Lower Face Height (ANS-Xi-Pm)(ϵ)	47.2	45.0	4.0	0.6
Facial Plane to SN (SN-NPog) (ϵ)	83.2	82.0	4.0	0.3
Y-Axis (SGn-SN) (ϵ)	66.7	67.0	5.5	-0.0
Mandibular Body Length (Go-Gn)(mm)	83.9	80.0	4.4	0.9
Upper Gonial Angle (Ar-Go-Na) (ϵ)	45.5	49.0	7.0	-0.5
Lower Gonial Angle (Na-Go-Me) (ϵ)	74.1	72.0	6.0	0.3
MP - SN (ϵ)	31.0	33.0	6.0	-0.3
Ramus Height (Ar-Go) (mm)	50.0	53.0	4.5	-0.7
FMA (MP-FH) (ϵ)	24.7	22.9	4.5	0.4
IMPA (L1-MP) (ϵ)	90.1	95.0	7.0	-0.7
FMIA (L1-FH) (ϵ)	65.2	65.7	8.5	-0.1
U1 - NPo (mm)	0.5	5.0	2.0	-2.3
U1 - SN (ϵ)	113.6	103.1	5.5	1.9
U1 - NA (ϵ)	35.6	22.8	5.7	2.2
U1 - NA (mm)	7.8	4.3	2.7	1.3
L1 - NB (ϵ)	22.3	25.3	6.0	-0.5
L1 - NB (mm)	3.3	4.0	1.8	-0.4
L1 - Facial Plane (L1-NPo) (mm)	0.5	1.0	2.0	-0.3
Mand Plane to Occ Plane (ϵ)	18.3	18.6	5.0	-0.1
Interincisal Angle (U1-L1) (ϵ)	125.3	130.0	6.0	-0.8
Lower Lip to E-Plane (mm)	-3.2	-2.0	2.0	-0.6
Upper Lip to E-Plane (mm)	-7.6	-8.0	2.0	0.2
Z Angle (ϵ)	82.0	75.0	4.0	1.8

Table 2. CVM analysis

	Group/Measurement	Value
Depth of Concavity		
	C2 Concavity (mm)	1.7
	C3 Concavity (mm)	0.9
	C4 Concavity (mm)	1.6
Shape of Body		
	C3 Base Anterior Ratio (%)	90.2
	C3 Poserior Anterior Ratio (%)	103.5
	C4 Base Anterior Ratio (%)	110.0
	C4 Posterior Anterior Ratio (%)	112.3
SUMMARY ANALYSIS		
	C2 Concavity: Deep	
	C3 Concavity: Slight	
	C4 Concavity: Deep	

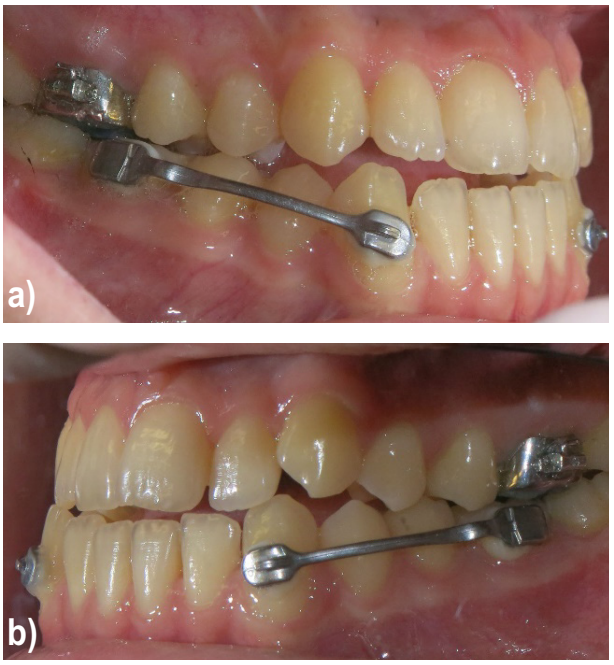

Figure 4. (a),(b) *Treatment stage one*

Treatment plan

Due to the underlying skeletal problems, orthognathic surgery was recommended, following the orthodontic therapy, but the patient and his family were strongly opposing surgery. Because of the severe proclination of the maxillary and retroinclination of the mandibular incisors, it was well-explained to the patient that camouflage therapy with extraction of the mandibular premolars was not an option. Then, a novel treatment solution using Carriere Motion Class III appliance was proposed, which is going to promote the correction of the dentoalveolar relationship as well as recovering to the proper mastication and improving facial and smile characteristics as a priority in the orthodontic treatment. The patient agreed with the given option.

To maximize mandibular dentoaveloar compensation, this protocol suggested extracting the mandibular third molars prior to the start of the treatment, to enable up-righting of the mandibular molars and to obtain space to retract the mandibular teeth.

Treatment sequence

The patient started the first phase of the treatment at the age of 18y4m, with bonding of the Carriere Motion III appliance on the lower jaw, aiming to treat the malocclusion to a Class I occlusion by distalization of each mandibular posterior segment, from canine to molar, as a unit. As an anchorage in the upper jaw, trans palatal arch (TPA) was bonded on the upper first molars. We made a vacuum formed retainer (Essix retainer) for the upper dental arch in order to improve the anchorage. The patient was given Carriere force I elastics for class III (¼, 6 Oz), and was instructed to wear them from the mesial hooks on the appliance on the lower jaw to the upper first molars during the night and a maximum number of hours during the day. After three months of continuous wear of the elastics and regular monthly check-ups, with the Carriere Class III Motion Appliance, a Class I relationship was achieved in the posterior segment, completing stage one (Figure 4).

In the second phase of the treatment, after achieving anteroposterior correction, the upper and lower fixed appliance was bonded, and the treatment continued with proper leveling and aligning of the dental arches, and torque correction. The initial leveling and aligning started with Nickel titanium round wire 0.012 and by consequently increasing the dimension of the wire in order to achieve good expansion in the upper jaw. In the lower anterior segment, interproximal reduction was done in the first phases of alignment to provide enough space for incisor alignment and to avoid additional protrusion of the frontal segment. After achieving good expansion and dental alignment, Stainless Steel square wires were engaged in the bracket slot in order to emphasize good torque correction. During the treatment it was indicated to add additional bending of the wire of first, second and third order on certain teeth. The active phase of the treatment was finished with a SS 0.019X.025 wire.The inte-

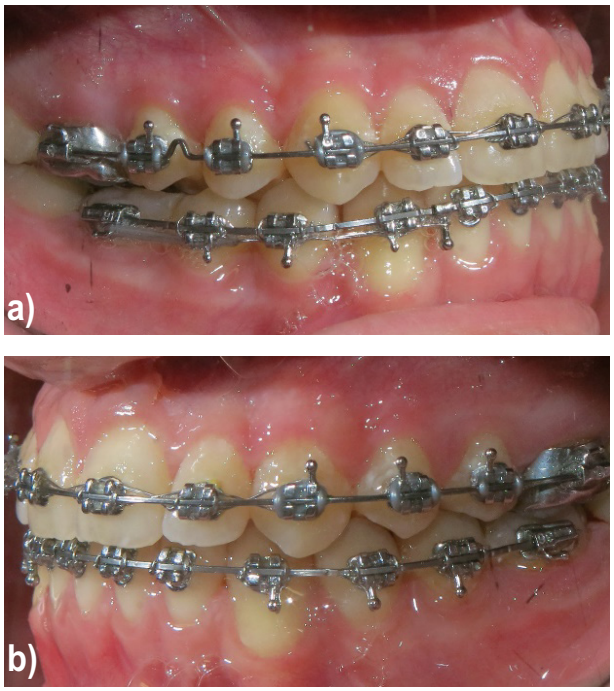

Figure 5. (a),(b) Treatment stage two

rocclusal relationships were controlled with short Class III elastics (3/16, 4,5 Oz), for a period of 1 year, which also improved the overjet and overbite (Figure 5). During this period, there was a short (3 months) interruption of the continuous orthodontic controls because of the Covid pandemic restrictions, the patient had missed few appointments and reported lesser compliance with wearing the elastics during that period.

After a total period of 2y3m, the treatment was successfully finished, achieving satisfactory dental alignment, Class I canine relationship on both sides, normal overjet and overbite and improved facial aesthetics (Figure 6). The patient was satisfied with his teeth and profile. Good intercuspation, interproximal contacts, and satisfactory root parallelism were achieved as well. The fixed appliances were removed, a 3-3 upper and lower lingual retainer was bonded, and a vacuum-formed aligner was delivered to retain the upper arch. For maintaining the mandibular position, functional appliance –activator, was given for the retention phase. Records taken 13 months after the end of the active treatment confirmed the stability of the results (Figure 7).

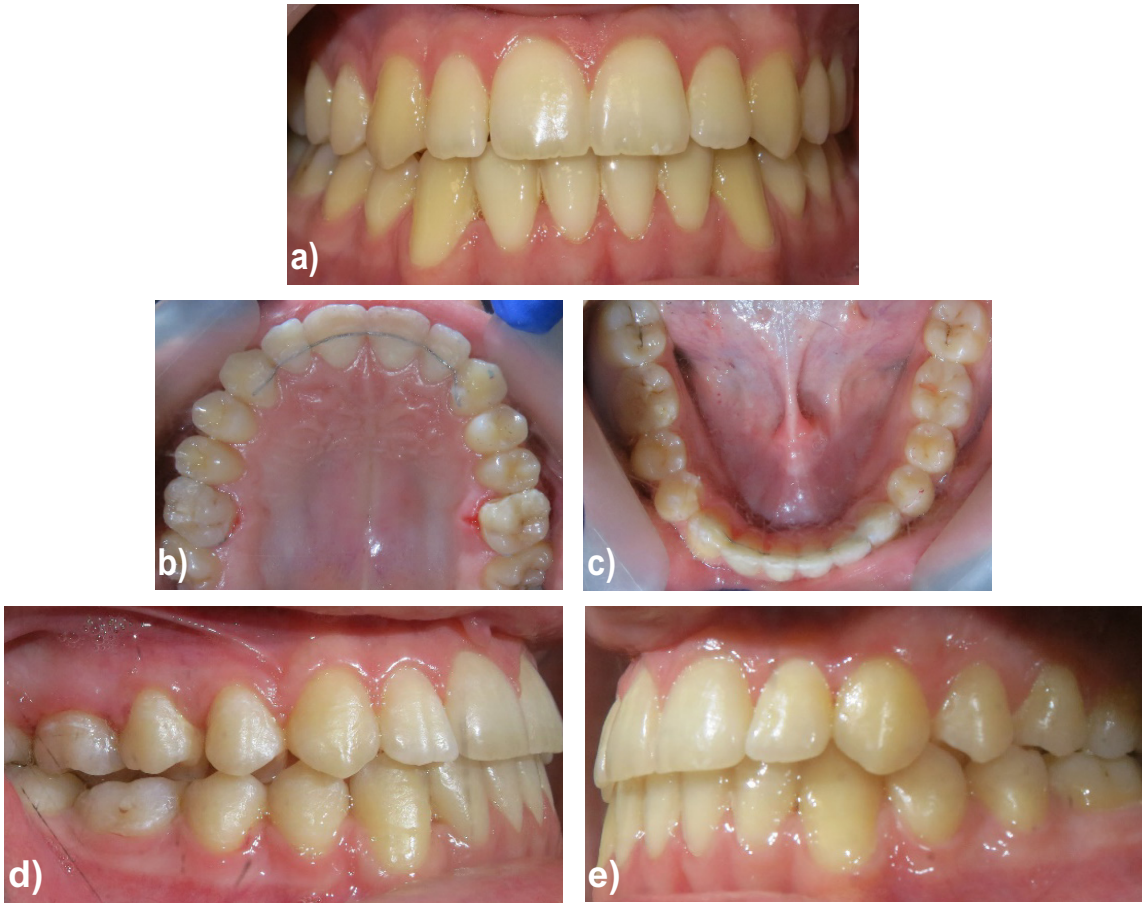

Figure 6. (a),(b),(c),(d),(e) Removal of the fixed appliances

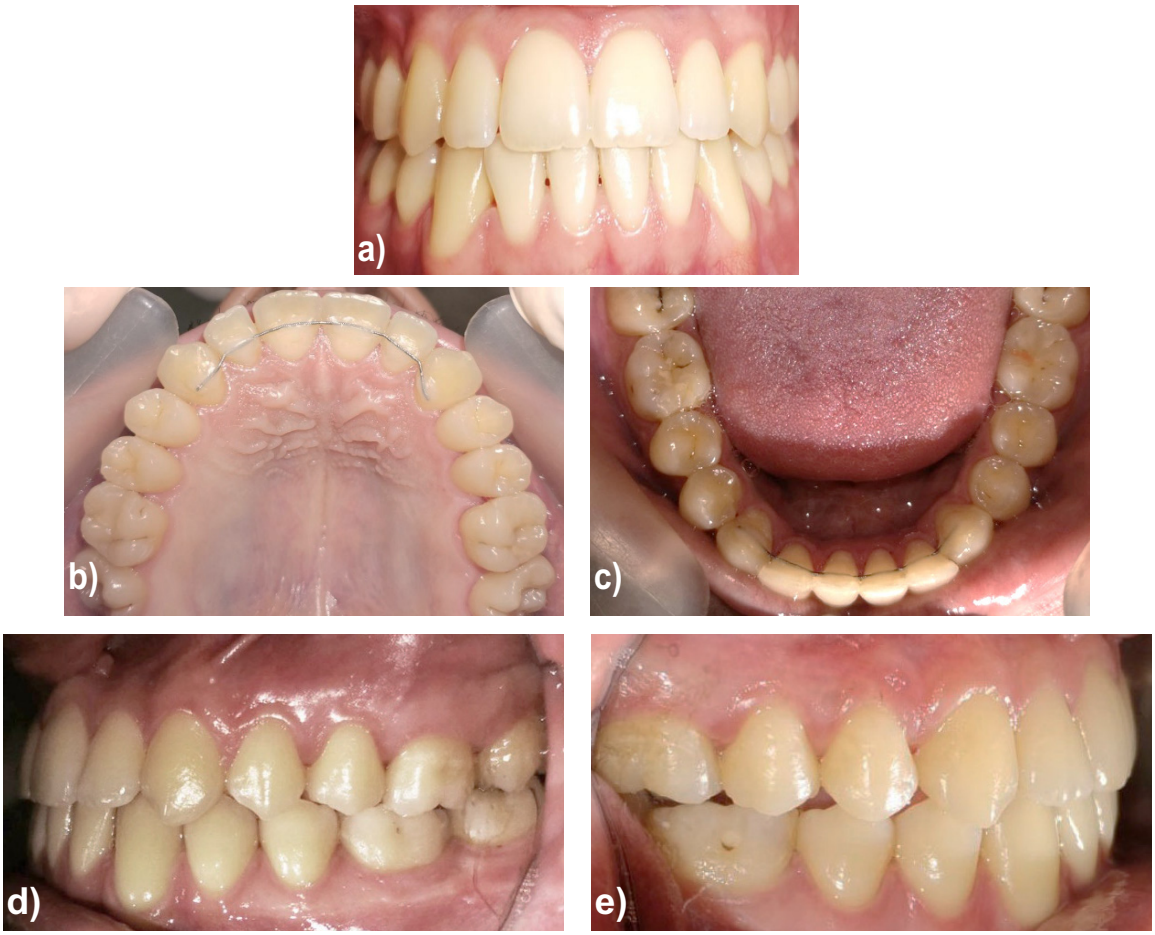

Figure 7. (a),(b),(c),(d),(e) *13 months in retention*

Treatment results

Cephalometric superimpositions indicated significant extrusion of upper molars. The upper incisors were slightly protruded for about 5 degrees. Lower molars were uprighted and moved distally, which improved the Class I dental relationship. The most significant change was made in the position of the lower incisors that were extruded and retruded, as well (Figure 8). All of this affected the occlusal plane which shifted in a counterclockwise rotation, as it can be seen in the change of the mandibular to occlusal plane angle in the cephalometric analyses (Table 3).

The vertical dimension was not altered, but the extraction of the lower third molars helped in controlling the vertical dimension in a patient who had a clinically long face.

The sagittal dimension was evidently improved, Class I canine relationship was achieved by the end of stage one, as the lower canines have been distalized enough to provide space for proper repositioning of the lower incisors, as determined by the diagnosis. The ANB angle didn't suffer any change, no skeletal effect was observed. But, at the end of treatment the Wits appraisal, reflecting the position of the dentition within their bony bases, was improved for 3.2 mm, and the therapy was finished with almost normal value (Table 4).

As it was expected, based on the values of the Bjork and the cervical vertebral maturation analyses, the values of mandibular prognathism mildly increased. The skeletal relationship between the upper and lower jaw didn't change at all, but the mandibular body length and forward position increased, the unfavorable growth was opposing the good results achieved with the appliance wear and made an insignificant increasement in the Z angle (Table IV). However, the soft tissue and smile line improved, due to the protrusion of the upper retrusive lip, into a more aesthetic and harmonious position, and better balance of the lower third was achieved by improving the mento-labial angle. The final profile was slightly improved even with the minimal unfavorable growth that had occurred (Figure 9).

Table 3. Post treatment cephalometric analyses

Measurement	Value	Normal	Std.Dev	Dev.Norm
Saddle/Sella Angle (SN-Ar) (ϵ)	118.7	124.0	5.0	-1.1
Articular Angle (ϵ)	150.5	138.0	6.0	2.1
Gonial/Jaw Angle (Ar-Go-Me) (ϵ)	121.9	120.8	6.7	0.2
Sum Total: N-S-Art + S-Art-Go + Art-Go-Me (ϵ)	391.1	396.0	4.0	-1.2
Anterior Cranial Base (SN) (mm)	67.9	77.3	3.0	-3.1
Posterior Cranial Base (S-Ar) (mm)	36.9	37.0	4.0	-0.0
Nasion-Gonion Length (mm)	117.9	134.4	4.0	-4.1
Y-Axis Length (mm)	139.8	140.0	6.0	-0.0
SNA (ϵ)	79.9	82.0	3.5	-0.6
SNB (ϵ)	83.0	--- 80.9	3.4	0.6
ANB (ϵ)	-3.1	1.6	1.5	-3.1
Beta Angle (ϵ)	43.2	31.0	4.0	3.1
Wits Appraisal (mm)	-2.9	-1.0	1.0	-1.9
Convexity (NA-APo) (ϵ)	-11.3	2.5	3.0	-4.6
Anterior Face Height (NaMe) (mm)	124.5	139.0	5.0	-2.9
Posterior Face Height (SGo) (mm)	84.4	90.0	5.0	-1.1
P-A Face Height (S-Go/N-Me) (%)	67.7	65.0	4.0	0.7
Lower Face Height (ANS-Xi-Pm)(ϵ)	46.3	45.0	4.0	0.3
Facial Plane to SN (SN-NPog) (ϵ)	85.3	82.0	4.0	0.8
Y-Axis (SGn-SN) (ϵ)	65.8	67.0	5.5	-0.2
--Mandibular Body Length (Go-Gn)(mm)	86.9	80.0	4.4	1.6
Upper Gonial Angle (Ar-Go-Na) (ϵ)	46.6	49.0	7.0	-0.3
Lower Gonial Angle (Na-Go-Me) (ϵ)	75.3	72.0	6.0	0.6
MP - SN (ϵ)	31.1	33.0	6.0	-0.3
Ramus Height (Ar-Go) (mm)	50.3	53.0	4.5	-0.6
FMA (MP-FH) (ϵ)	24.6	22.9	4.5	0.4
IMPA (L1-MP) (ϵ)	78.4	95.0	7.0	-2.4
FMIA (L1-FH) (ϵ)	77.1	65.7	8.5	1.3
U1 - NPo (mm)	1.5	5.0	2.0	-1.8
U1 - SN (ϵ)	118.5	103.1	5.5	2.8
U1 - NA (ϵ)	38.6	22.8	5.7	2.8
U1 - NA (mm)	8.9	4.3	2.7	1.7
L1 - NB (ϵ)	12.5	25.3	6.0	-2.1
L1 - NB (mm)	1.4	4.0	1.8	-1.4
L1 - Facial Plane (L1-NPo) (mm)	-1.7	1.0	2.0	-1.3
Mand Plane to Occ Plane (ϵ)	24.8	18.6	5.0	1.2
Interincisal Angle (U1-L1) (ϵ)	132.0	130.0	6.0	0.3
Lower Lip to E-Plane (mm)	-3.2	-2.0	2.0	-0.6
Upper Lip to E-Plane (mm)	-6.4	-8.0	2.0	0.8
Z Angle (ϵ)	84.4	75.0	4.0	2.3

Table 4. Comparison between pre and post treatment cephalometric values

Measurement	Value	Normal	Std.Dev	Dev.Norm
Saddle/Sella Angle (SN-Ar) (ϵ)	124.0	5.0	118.7	118.7
Articular Angle (ϵ)	138.0	6.0	152.7	150.5
Gonial/Jaw Angle (Ar-Go-Me) (ϵ)	120.8	6.7	119.6	121.9
Sum Total: N-S-Art + S-Art-Go + Art-Go-Me (ϵ)	396.0	4.0	391.0	391.1
SNA (ϵ)	82.0	3.5	78.0	79.9
SNB (ϵ)	80.9	3.4	81.2	83.0
ANB (ϵ)	1.6	1.5	-3.2	-3.1
Beta Angle (ϵ)	31.0	4.0	42.7	43.2
Wits Appraisal (mm)	-1.0	1.0	-6.1	-2.9
Convexity (NA-APo) (ϵ)	2.5	3.0	-10.7	-11.3
P-A Face Height (S-Go/N-Me) (%)	65.0	4.0	68.5	67.7
Lower Face Height (ANS-Xi-Pm)(ϵ)	45.0	4.0	47.2	46.3
Facial Plane to SN (SN-NPog) (ϵ)	82.0	4.0	83.2	85.3
Y-Axis (SGn-SN) (ϵ)	67.0	5.5	66.7	65.8
Mandibular Body Length (Go-Gn)(mm)	80.0	4.4	83.9	86.9
Upper Gonial Angle (Ar-Go-Na) (ϵ)	49.0	7.0	45.5	46.6
Lower Gonial Angle (Na-Go-Me) (ϵ)	72.0	6.0	74.1	75.3
MP - SN (ϵ)	33.0	6.0	31.0	31.1
IMPA (L1-MP) (ϵ)	95.0	7.0	90.1	78.4
FMIA (L1-FH) (ϵ)	65.7	8.5	65.2	77.1
U1 - NPo (mm)	5.0	2.0	0.5	1.5
U1 - SN (ϵ)	103.1	5.5	113.6	118.5
U1 - NA (ϵ)	22.8	5.7	35.6	38.6
U1 - NA (mm)	4.3	2.7	7.8	8.9
L1 - NB (ϵ)	25.3	6.0	22.3	12.5
L1 - NB (mm)	4.0	1.8	3.3	1.4
L1 - Facial Plane (L1-NPo) (mm)	1.0	2.0	0.5	-1.7
Mand Plane to Occ Plane (ϵ)	18.6	5.0	18.3	24.8
Interincisal Angle (U1-L1) (ϵ)	130.0	6.0	125.3	132.0
Lower Lip to E-Plane (mm)	-2.0	2.0	-3.2	-3.2
Upper Lip to E-Plane (mm)	-8.0	2.0	-7.6	-6.4
Z Angle (ϵ)	75.0	4.0	82.0	84.4
FMA (MP-FH) (ϵ)	22.9	4.5	24.7	24.6

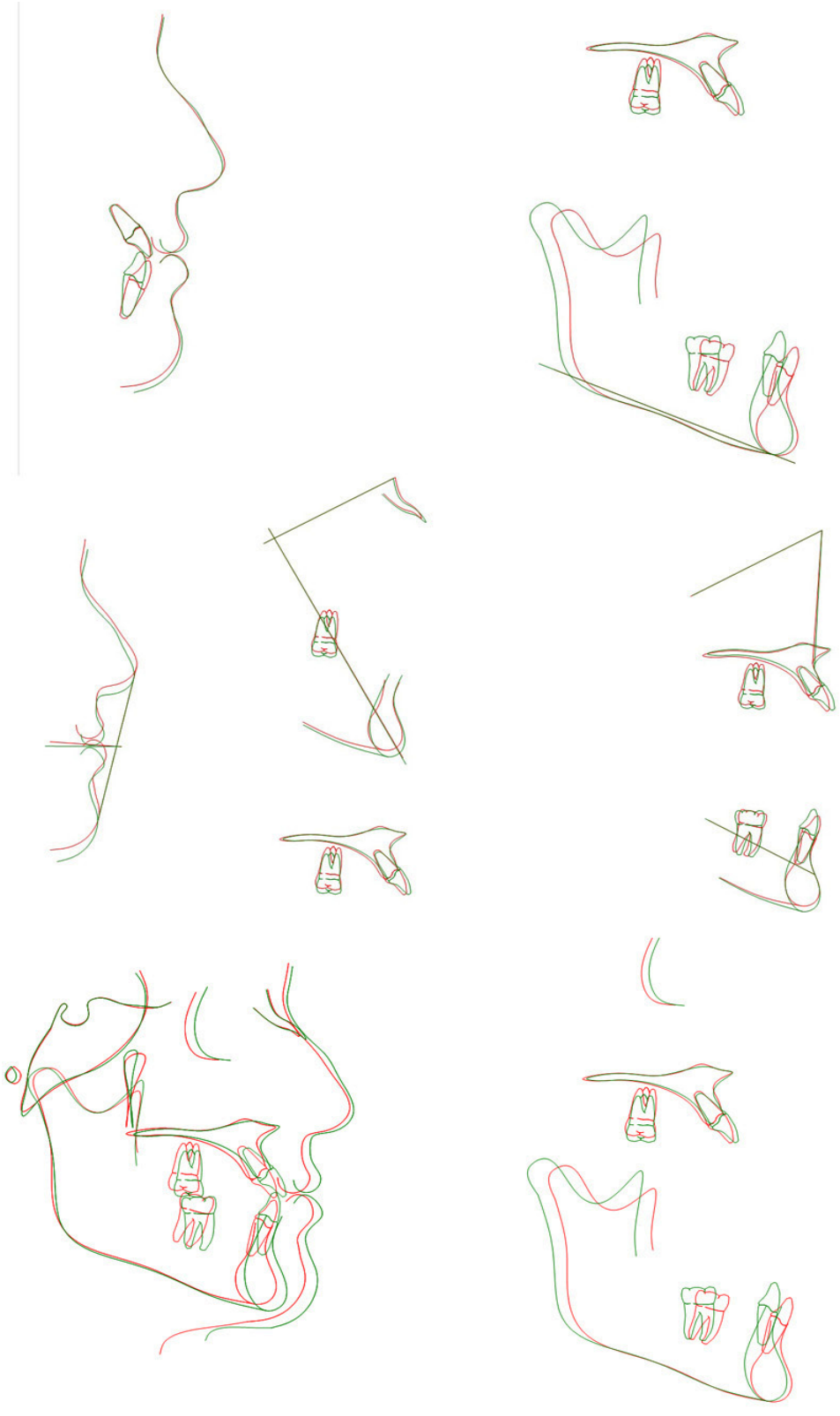

Figure 8. *Superimposition of cephalometric analyses*

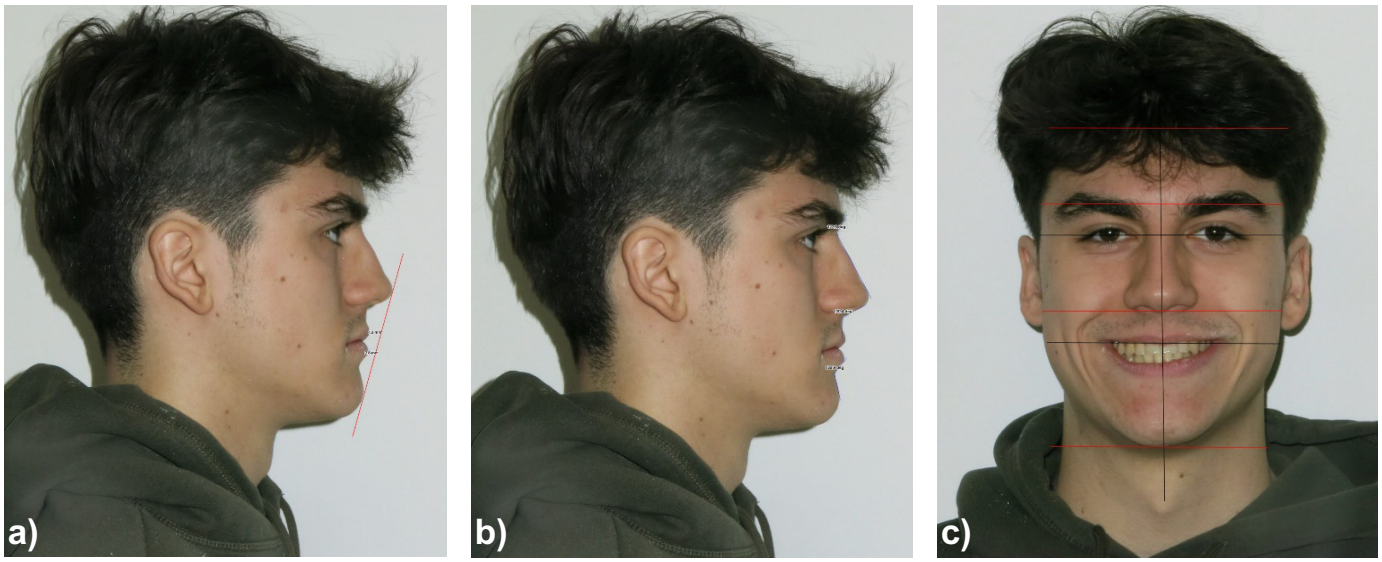

Figure 9. (a),(b),(c) *Post treatment soft tissue analyses*

Discussion

The Carriere Motion Class III appliance provides a novel approach of the management of Class III problems in mature or minimally growing patients. This protocol offers an alternative to more aggressive therapies that can involve orthodontics alone or a combination of orthodontics and orthognathic surgery, both with and without extraction of lower premolars.

Considering the limited literature concerning the Carriere Motion Class III appliance, the initial focus of this study was to describe in detail the treatment effects produced by the CM3 appliance on the relatively non-growing patient in whom the growth during treatment presumably would not be a factor.

Distalization is not the only effect of the Carriere Class III Motion Appliance, which is why it is not referred to as a distalizer. Clinical experience with this device has demonstrated skeletal and dental changes, alterations of the occlusal plane and the intermaxillary relationship, and improvement of soft tissue prognathic conditions.

Our findings are in concordance with the analysis of Luis Carriere (2016)[15], who also treated minimally/non-growing patient with The CM3 appliance and showed the same dentoalveolar changes that occurred during the treatment. With the Carriere III Motion appliance, the mandible is simultaneously repositioned for an improved sagittal relationship by counterclockwise movement of the posterior occlusal plane. To a certain degree, the appliance altered the relationship between the maxilla and the mandible by bringing the posterior occlusal plane into a better functional position, and thus balancing the face. Although, his study noticed slight skeletal changes that happened by functional repositioning of the condyle in the temporomandibular complex and which was confirmed by positive change in the ANB angle after the treatment, which we did not notice in our case, where most of the bigger changes were dentoalveolar.

The study of McNamaraet al.[16] analyzed 32 patients with Class III molar relationship, CVM stage greater than stage 4(minimally growing/non-growing). Statistically significant differences were observed in all dentoalveolar comparisons which correspond with our findings. No statistically significant or clinically relevant changes were noticed in the sagittal position of the maxilla. Only slight changes were observed in the position of the mandible. There was a mild decrease in the SNB angle (less than 1 degree) during the CM3 phase. The improvement in the facial aesthetics, looking at the Z angle and the decrease in the distance from the chin point at Pogonion to the Nasion perpendicular of 2.1 mm, noted in our study, was confirmed with the previous findings of McNamara.

Our study confirmed what the previous literature described, the Carriere Motion Class III appliance is an effective and efficient method of resolving occlusal problems in minimally growing Class III patients. Primary treatment effects are dentoalveolar in nature with minimal skeletal alterations that are not worth considering.

The patient was reluctant to undergo surgery, and he demonstrated a very compliant attitude toward the treatment demands, which is one of the most important factors contributing to the success of the treatment. The obtained satisfactory occlusal and aesthetic results were due to significant dentoalveolar compensation and excellent patient

compliance with elastics. The changes contributing most to the correction were maxillary incisor proclination, as well as the extrusion and bodily retrusion of the mandibular incisors with concurrent alveolar remodeling. These changes produced a counterclockwise rotation of the occlusal plane as expected.

Despite the limited articles about the effects of the CM3 appliance, the literature contains many studies[11,12,13] about compensational Class III therapy with lower bilateral bicuspid exraction. The achieved results have notable dentoalveolar changes, with significantly increased lower incisor reroinclination. No skeletal effect was noted and also no change in the functional occlusal plane as it can be seen in the final results achieved after the treatment with CM3 appliance. Also, the total treatment time for closing extraction spaces is greater than the total CM3 appliance followed by fixed braces. The great success of Class III correction, using the CM3, is due to establishing a Class I relationship at the beginning of treatment when patient compliance is high and before initiating the correction of the position and alignment of individual teeth with fixed appliances.

Conclusion

In undertaking the decision to treat Class III condition with means of dentoalveolar compensation, the clinician must carefully weigh the benefits and costs of this choice. Considering the reluctance of the patient to undergo surgery, difficult decision must be made in selecting the most suitable compensating treatment plan for the patient, based on its individual values and diagnosis. Every compensation procedure has its benefits and costs as well as a restrictive factor. If extraction of lower teeth is contraindicated, and the benefits outweigh the costs, the treatment option of using Carriere Motion III appliance can be chosen. Otherwise, it would be better not to engage in orthodontic treatment in which a satisfactory result cannot be predicted.

The Carriere Motion Class III appliance is an effective and efficient adjunct to fixed appliances in the management of Class III malocclusion in mature patients. As shown in our study and observed in other studies, referring to the effects of the treatment with Carriere Motion III appliance, most of the treatment effects produced by the CM3 appliance were dentoalveolar in nature, with minimal skeletal adaptations observed. A counterclockwise rotation of the occlusal plane was evident. With good patient compliance using elastic wear, in minimally growing Class III patients, surgery can be avoided.

Reference

1) Zere E, Chaudhari P K, Jitendra Sh, Dhingra K, Tiwari N. Developing Class III malocclusions: challenges and solutions.Clin Cosmet Investig Dent. 2018;10:99–116.
2) Nanda R. Biomechanics and esthetic strategies in clinical orthodontics: Elsevier Health Sciences; 2005.
3) Thilander B, Myrberg N. The prevalence of malocclusion in Swedish schoolchildren. European Journal of Oral Sciences 1973;81(1):12-20.
4) Tschill P, Bacon W, Sonko A. Malocclusion in the deciduous dentition of Caucasian children. European Journal of Orthodontics 1997;19(4):361-67.
5) Lew KKK, Foong WC. Horizontal skeletal typing in an ethnic Chinese population with true Class III malocclusion. British Journal of Orthodontics 1993;20:19-23.
6) Chan GK-H. Class III malocclusion in Chinese (Cantonese): etiology and treatment. American Journal of Orthodontics and Dentofacial Orthopedics 1974;65(2):152-57.
7) MermigosJ, Full C A, Andreasen G. Protraction of the maxillofacial complex. Am J Orthod Dentofacial Orthop 1990;98(1):47-55
8) Proffit WR. Contemporary Orthodontics. 5th Ed. St. Louis, MO, Elsevier Mosby, 2013.
9) Yang Ch, Tseng Y. The orthodontic treatment of class III malocclusion with anterior cross bite and severe deep bite. Taiwanese Journal of Orthodontics 2019;31(1):53-63.
10) Proffit W.R. Ackerman J.L. A systematic approach to orthodontic diagnosis and treatment planning in Current Orthodontic Concepts and Techniques, 3rd ed., ed. T.M. Graber and B.F. Swain, C.V. Mosby, St. Louis, 1985.
11) Janson G, De Souza JE, Alves Fde A, Andrade P Jr, Nakamura A, de Freitas MR, Henriques JF. Extreme dentoalveolar compensation in the treatment of Class III malocclusion. Am J Orthod Dentofacial Orthop 2005;128(6):787-94.
12) Moullas, A.T., Palomo, J.M., Gass, J.R. Amberman, B.D. White, J. and Gustovich, D. Nonsurgical treatment of a patient with a Class III malocclusion, Am. J. Orthod. 2006;129:111-118.
13) Park JH, Emamy M, Hope Lee S. Adult skeletal Class III correction with camouflage orthodontic treatment, American Journal of Orthodontics and Dentofacial Orthopedics 2019;156(6):858-869.
14) Kim-Berman H, McNamara JA Jr, Lints JP, McMullen C, Franchi L. Treatment effects of the Carriere Motion 3D appliance for the correction of Class II malocclusion in adolescents. Angle Orthod. 2019;89(6):839-846.
15) Carrière L. Nonsurgical Correction of Severe Skeletal Class III Malocclusion. Journal of Clinical Orthodontics 2016;50(4):228-230.
16) McNamara JA, Franchi L, McClatchey LM, Kowalski SE, Cheeseman CC. Evaluation of adolescent and adult patients treated with the Carriere Motion Class III appliance followed by fixed appliances. Angle Orthod. 2021;91(2):149-156.