Clinical Trial

IMMEDIATELY LOADED MINI DENTAL IMPLANTS AS OVERDENTURE RETAINERS: HISTOMORPHOMETRIC ANALYSIS OF IMPLANT RETRIEVED FROM MAN

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ABSTRACT

The primary function of the dental implant is to transmit occlusal load to the bone with a non-submerged surgical procedure that provides the patient with a provisional restoration. Immediate loading is a clinical procedure in which the dental implant and prosthesis are placed simultaneously to restore the patient's ability to chew food correctly, smile, and speak. In this case report, we histologically examined an immediately loaded mini-implant used for overdenture. The patient reports receiving two mini dental implants (1.8 mm × 13 mm) in the mandibular interforaminal region two years ago. The implants were immediately loaded with pre-made overdentures. He complains of continuous prosthesis loosening, forcing him to replace the O-rings constantly. The clinical examination showed that the right implant was excessively inclined lingually. After evaluating the different treatment options, a decision is made with the patient to remove the implant and place a new one. Histological samples showed cortical bone with a small medullary space without epithelial cells or connective tissue. Human implants are essential for the long-term evaluation of implants subjected to functional loading. The results confirm clinical findings and help doctors choose the most suitable surgical technique for the patient.

KEYWORDS: *mini-implant, immediate loading, narrow implant, overdenture*

INTRODUCTION

Dental implants have been proven to be highly successful long-term rehabilitation options for edentulous or partial edentulous patients. They are currently the best prosthetic alternative in several clinical indications, with high survival and success rates (1).

Osseointegrated dental implant fruit the osseointegration process discovered by Brånemark and defined as "the structural, functional and direct connection between bone and dental surface" (2). One usually waits for a healing period of

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several months before placing a prosthesis and then loading the implant. The primary function of the dental implant is to transmit occlusal load to the bone with a non-submerged surgical procedure that provides the patient with a provisional restoration. Immediate loading is a clinical procedure in which the dental implant and prosthesis are placed simultaneously to restore the patient's ability to chew food correctly, smile, and speak (3). In most cases, the prosthesis is applied from the patient's tooth within the same day of implant placement or 48 hours, which makes the process quick. Many studies have been conducted in animal models, such as monkeys and dogs (1, 4), to identify the reasons for the success or failure of immediate-loading dental implant treatments.

All these studies make it possible to investigate aspects of peri-implant tissue healing and peri-implant disease development. Still, they have a low quality of evidence, and the results obtained from these studies could be automatically transposed to a human situation. It is unethical to perform randomised studies on men; for this reason, it is essential to evaluate the occasionally retrieved human implants. In some cases, it is necessary to remove the implant for prosthetic complications, prosthetics, misalignment, or other problems or be obtained as part of a research protocol approved by an Ethical Committee. Immediately loaded and removed implants are essential data for understanding the nature of the complex and soft tissues in contact with the implant. In this case report, we histologically examined an immediately loaded mini-implant used for overdenture.

CLINICAL CASE

Material and methods

The patient reports receiving two mini dental implants (1.8 mm × 13 mm) in the mandibular interforaminal region two years ago. The implants were immediately loaded with pre-made overdentures. He complains of continuous prosthesis loosening, forcing him to replace the O-rings constantly. The clinical examination showed that the right implant was excessively inclined lingually (Fig. 1).

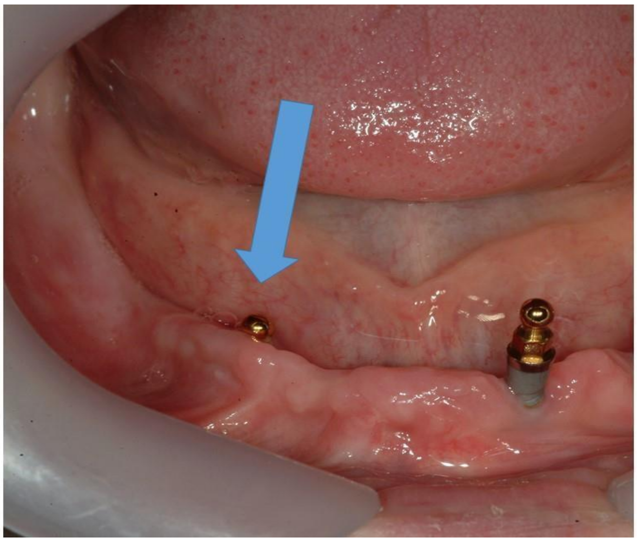

Fig. 1. *The implant was excessively inclined lingually (**Arrow**).*

Unfortunately, the position of the implant resulted in poor retention and premature wear of the O-rings. After evaluating the different treatment options, a decision was made with the patient to remove the implant and place a new one. Preoperatively, the patient was extensively informed concerning the surgical procedures. An attempt was made to unscrew the implant without success, so it was decided to remove it by performing a blok section with ultrasound (Esacrom, Imola-Italy).

Prior to surgery, the subject's mouth was rinsed with a chlorhexidine digluconate solution of 0.2% for 2 min. Local anesthesia was performed by Articaine® (Ubistesin 4% - Espe Dental AG Seefeld, Germany) with epinephrine 1:100.000. The blok section was stored in 10% buffered formalin and processed for histology and histomorphometry at the Implant Retrieval Centre, Dental School, University of Chieti-Pescara, Italy, to obtain thin ground sections with the Scan 1 Automated System (Pescara, Italy). The sample was dehydrated in an ascending series of alcohol rinses and embedded in a glycolmethacrylate resin (Technovit 7200 VLC, Kulzer, Wehrheim, Germany). After completion of the polymerization process, each specimen was sectioned longitudinally along its major axis with a high-precision diamond disc at about 150 µm and ground down to about 30 µm. Three slides were obtained and stained with acid fuchsin and toluidine blue. The nomenclature approved by the American Society of Bone and Mineral Research was used to evaluate bone quality and histomorphometric measurements (5). It was observed in normal transmitted light under a Nikon microscope ECLIPSE (Nikon, Tokyo, Japan). The different hard tissues, medullary space, and biomaterials were carried out by a light microscope connected to a high-resolution video camera (16.25-megapixel) (Digital Sight series microscope cameras), interfaced to a high-definition monitor and a personal computer (Notebook Toshiba Satellite pro r50-c-15w). This optical system was associated with a histometry software package with image-capturing capabilities, then recorded using a Sony α330 digital camera and subjected to morphometric analysis using digital image analysis (NIS-Elements AR 3.0 software, Nikon, Minato, Japan).

Results

At low magnification, the sample showed cortical bone with a small medullary space and without pithelial cells or connective tissue. No gap was observed between the bone and the implant at high magnification.

No pathological inflammatory cell infiltrates or foreign body reactions were evident, and few osteoblasts were present in the specimens evaluated (Fig. 2).

Fig. 2. *Compact bone with small marrow spaces can be observed around the implant perimeter. The bone tissue is also located above the implant shoulder. Acid fuchsin-toluidine blue 40X.*

DISCUSSION

Dental implants have become a successful and good option to enhance the stability and retention of complete dentures over resorbed ridges. Mini dental implants are a valid alternative to standard dental implants due to their small diameter, low primary costs, and avoidance of invasive treatments such as bone augmentation. They are usually used in elderly patients with various diseases or being treated with many drugs. The clinical outcomes of immediately loaded mini dental implants used as retainers for mandibular overdenture were recently investigated by different authors.
Scepanovic et al. reported a 98.3% implant success rate at the 1-year follow-up (6). The results in the present case report confirm the success rate of the mini-implant used for the mandibular overdenture. The outcome showed a high percentage of bone in direct contact with the implant. These histological results justify the high success rates reported by various authors (7, 8).

The initial stability of the mini-implant is important for successful osteointegration and a high success rate. It depends upon the implant design, bone quality, and surgical technique used.

The initial healing period of an implant is the phase of the osseointegration process that is primarily affected by the surface condition of the implant (9).

A cascade of biological events is initiated when an implant is placed into a bone site (10). Osteogenic cells are recruited and migrated to the implant surface. Immediate loading was clinically proposed more than 50 years ago when

Linkow et al. introduced endosseous blade implants (11). Piattelli and colleagues histologically demonstrated that immediately loaded implants achieve a very high BIC (12-16).

CONCLUSIONS

Histological evaluation is extremely important for the long-term evaluation of implants subjected to functional loading. For this reason, it is essential to analyse the removed implants histologically. The results confirm clinical findings and help doctors choose the most suitable surgical technique for the patient. Although we have described only one clinical case, the case report allows us to histologically confirm the validity of immediately loaded mini dental implants as overdenture retainers.

REFERENCES

1. Piattelli A, Paolantonio M, Corigliano M, Scarano A. Immediate loading of titanium plasma-sprayed screw-shaped implants in man: a clinical and histological report of two cases. *J Periodontol.* 1997;68(6):591-597. doi:https://doi.org/10.1902/jop.1997.68.6.591
2. Branemark PI, Adell R, Breine U, Hansson BO, Lindstrom J, Ohlsson A. Intra-osseous anchorage of dental prostheses. I. Experimental studies. *Scand J Plast Reconstr Surg.* 1969;3(2):81-100. doi:https://doi.org/10.3109/02844316909036699
3. Degidi M, Nardi D, Piattelli A. 10-year prospective cohort follow-up of immediately restored XiVE implants. *Clin Oral Implants Res.* 2016;27(6):694-700. doi:https://doi.org/10.1111/clr.12642
4. Blanco J, Linares A, Villaverde G, Perez J, Munoz F. Flapless immediate implant placement with or without immediate loading: a histomorphometric study in beagle dog. *J Clin Periodontol.* 2010;37(10):937-942. doi:https://doi.org/10.1111/j.1600-051X.2010.01608.x
5. Parfitt AM. Bone histomorphometry: standardization of nomenclature, symbols, and units (summary of proposed system). *Bone.* 1988;9(1):67-69. doi:https://doi.org/10.1016/8756-3282(88)90029-4
6. Šćepanović M, Todorović A, Marković A, et al. Immediately loaded mini dental implants as overdenture retainers: 1-Year cohort study of implant stability and peri-implant marginal bone level. *Ann Anat*. 2015;199:85-91. doi:10.1016/j.aanat.2013.12.005
7. Zygogiannis K, Aartman IH, Parsa A, Tahmaseb A, Wismeijer D. Implant Mandibular Overdentures Retained by Immediately Loaded Implants: A 1-Year Randomized Trial Comparing the Clinical and Radiographic Outcomes Between Mini Dental Implants and Standard-Sized Implants. *Int J Oral Maxillofac Implants.* 2017;32(6):1377-1388. doi:https://doi.org/10.11607/jomi.5981
8. Aunmeungtong W, Kumchai T, Strietzel FP, Reichart PA, Khongkhunthian P. Comparative Clinical Study of Conventional Dental Implants and Mini Dental Implants for Mandibular Overdentures: A Randomized Clinical Trial. *Clin Implant Dent Relat Res.* 2017;19(2):328-340. doi:https://doi.org/10.1111/cid.12461
9. Skiba THI, Kalil EC, Piattelli A, Shibli JA. Human Histological Analysis of Early Bone Response to Immediately Loaded Narrow Dental Implants with Biphasic Calcium Phosphate((R)) Grid-Blasted Surface Treatment: A Case Report. *Dent J (Basel).* 2023;11(7):doi:https://doi.org/10.3390/dj11070177
10. Inchingolo F, Inchingolo AM, Latini G, et al. Application of Graphene Oxide in Oral Surgery: A Systematic Review. *Materials (Basel).* 2023;16(18):doi:https://doi.org/10.3390/ma16186293
11. Linkow LI, Miller RJ. Immediate loading of endosseous implants is not new. *J Oral Implantol.* 2004;30(5):314-317. doi:https://doi.org/10.1563/0683.1
12. Piattelli A, Corigliano M, Scarano A, Costigliola G, Paolantonio M. Immediate loading of titanium plasma-sprayed implants: an histologic analysis in monkeys. *J Periodontol.* 1998;69(3):321-327. doi:https://doi.org/10.1902/jop.1998.69.3.321
13. Piattelli A, Corigliano M, Scarano A, Quaranta M. Bone reactions to early occlusal loading of two-stage titanium plasma-sprayed implants: a pilot study in monkeys. *Int J Periodontics Restorative Dent.* 1997;17(2):162-169.
14. Degidi M, Artese L, Piattelli A, et al. Histological and immunohistochemical evaluation of the peri-implant soft tissues around machined and acid-etched titanium healing abutments: a prospective randomised study. *Clin Oral Investig.* 2012;16(3):857-866. doi:https://doi.org/10.1007/s00784-011-0574-3
15. Degidi M, Scarano A, Iezzi G, Piattelli A. Histologic analysis of an immediately loaded implant retrieved after 2 months. *J Oral Implantol.* 2005;31(5):247-254.doi:https://doi.org/10.1563/1548-1336(2005)31[247:HAOAIL]2.0.CO;2
16. Scarano A, Murmura G, Carinci F, Lauritano D. Immediately loaded small-diameter dental implants: Evaluation of retention, stability and comfort for the edentulous patient. *European Journal of Inflammation.* 2021;10(19–23.

Review

ONE OUT OF TEN: WHEN ORAL MEDICINE SHOULD NOT LEAVE BEHIND WOMEN AFFECTED BY REPRODUCTIVE DISORDERS

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ABSTRACT

Female reproductive disorders represent conditions that can significantly impact the overall well-being of women. Research suggests that hormonal changes during menstrual cycles, pregnancy, and menopause can influence the oral environment and contribute to an increased susceptibility to oral diseases, such as periodontitis. Furthermore, polycystic ovary syndrome (PCOS), a common endocrine disorder in women of reproductive age, has been associated with an increased risk of periodontal disease. The underlying hormonal imbalances and inflammatory processes in PCOS may contribute to the higher prevalence and severity of periodontal disease observed in these individuals. Conversely, periodontal disease may have implications for female reproductive health. Evidence suggests a potential link between periodontal pathogens and adverse pregnancy outcomes, including preterm birth, low birth weight, and preeclampsia. The dissemination of oral bacteria and their byproducts into the systemic circulation can trigger an inflammatory response and disrupt the delicate balance essential for a successful pregnancy. This review explores the interrelationship between female reproductive disorders and oral medicine implications, highlighting their potential bidirectional interactions and shared underlying mechanisms. Implementing multidisciplinary approaches combining gynecological and dental care can enhance patient outcomes and improve women's health. Early identification, timely interventions, and preventive measures focused on maintaining oral health through adequate oral hygiene, professional cleanings, and regular dental check-ups are paramount.

KEYWORDS: *PCOS, endometriosis, assisted reproductive technology, periodontitis*

INTRODUCTION

Over the last decades, the scientific community has focused on factors influencing women's health. In particular, the World Health Organization's commitment to "leaving no one behind" is fundamental to achieving the Sustainable Development Goals (SDGs) 3 ("to ensure healthy lives and promote well-being for all at all ages") and SDG 5 ("to achieve gender equality and empower all women and girls") (1-3).

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Women’s reproductive health has recently received considerable research and attention. Reproductive health care is crucial to women's well-being, considering the effects of reproductive physiology on the whole body system (4). Reproductive disorders women encounter during their lifetime, which include hormonal therapy as a solution, are polycystic ovarian syndrome, endometriosis, fibroids, and fertility treatments (5).

Hormones are a class of biomolecules that can be taken or secreted into the bloodstream and whose action is reflected in several areas. Oral health has historically been found to be affected by hormonal effects in women. However, through the years, “gender dentistry” has not seen a proper place in scientific research and clinical application.

The aim of this review, in the attempt to fulfill the WHO commitment to “leaving no one behind”, is to examine polycystic ovarian syndrome, endometriosis, and fertility treatments and their relationship to oral health.

Polycystic Ovarian Syndrome (PCOS) and periodontal disease: what happens when the endocrine-metabolism is altered?

PCOS is an endocrine disorder affecting the reproductive female system and the metabolic asset in the organism (6). PCOS clinical presentation can be classified into phenotypes. The presentation of PCOS can be categorized into separate phenotypes:

a) when hyperandrogenism (HA), ovulatory disorder (OD), and polycystic ovarian morphology (PCOM) exist;
b) when HA and OD occur;
c) HA and PCOM co-exist;
d) OD + PCOM occur (7).

Due to the alteration of the metabolic and, therefore, endocrine assets, patients affected by PCOS can present symptoms affecting the reproductive system, such as menstrual dysfunction, endometrial dysplasia, and infertility, as well as insulin resistance, diabetes, cardiovascular disease, and obesity (8). In addition, the endocrine and metabolic disorder induces low-grade systemic inflammation by raising pro-inflammatory cytokines.

These alterations are reflected in saliva and oral microbial composition. Indeed, it has been found that oral microbiota is altered in PCOS patients in response to estradiol levels and cases of insulin resistance and obesity, showing how metabolic disease alters microbial metabolomics (6-8). Clinically, this is reflected in a higher susceptibility of PCOS patients to periodontal diseases. Indeed, the alteration of the endocrine and metabolism of the host is reflected in an alteration of the microbial biofilm (8). In addition, the HA, low estradiol level, and insulin resistance alter both bone metabolism and its resistance to injuries and the susceptibility of gingival epithelial cells to infections (8). The increased level of pro-inflammatory cytokines is reflected in periodontal disease inflammation, which can lead to a worsening of the disease (8).

Endometriosis: a systemic disease with relevant aspects in oral medicine

Endometriosis is an inflammatory disease characterized by endometrial-like tissue outside the uterus (9). Being an endometrial-like tissue, it is estrogen-dependent.

Endometriosis aetio-pathology remains unclear. In 2020, García-Peñarrubia et al. proposed a new model of endometriosis development that includes and correlates prenatal exposure to endocrine disruptors, the anogenital distance, and the dysbiosis in the genital tracts (10). This theory is compatible with those previously proposed and placed at the center of endocrine and microbial alteration (10).

Endometriosis lesions may be located in the pelvis, related organs, and distant organs such as the lungs (11). The pelvic pain symptoms and the menstrual stigma still led to a late diagnosis in women and many undiagnosed cases. Due to the endometriosis nature, and the variety of symptoms, which include bloating or nausea, chronic fatigue, and psychological disorders, it should be considered a systemic disease. If we look at oral medicine, endometriosis has been linked to periodontitis, Temporomandibular Joint Disease (TMD), and occasionally endometrial lesions in the jawbone.

In the case of PCOS, the keyword is inflammation in the linkage between endometriosis and periodontal diseases. Endometrial lesions increase the level of oxidative stress and produce chronic inflammation. The pro-inflammatory cytokine in saliva serum can influence the microbial biofilm community and the immune response to periodontal pathogens (12).

Endometriosis is an estrogen-dependent pathology, and we must recall that the temporomandibular joint cartilage presents estrogen receptors responsible for its normal trophism (13). In 2023, Wójcik et al. achieved a preliminary correlation between pelvic pain symptoms in endometriosis patients and TMJ pain (14). The TMJ pain in these patients must be considered with attention. Indeed, in 2022, Brotskyi et al. reported a patient who complained of pain in the temporomandibular area. The clinical and diagnostic investigations revealed the presence of an endometrial lesion in the temporal bone endometriosis with a consequent TMJ dysfunction (15). Similarly, in 2021, Gala et al. reported an extrapelvic endometriosis lesion in the mandible, initially diagnosed as facial fibroma (16).

Fertility treatment effects on the mineral bone density

The prescription and administration of hormonal therapy in women is becoming frequent to face the systematic effects of menopause and infertility treatments (17). Indeed, fertility in women progressively declines with age until women are no longer able to produce oocytes capable of fertilization well before menopause (17). Menopause is a period strongly associated with bone resorption markers in older women. This phenomenon is probably due to estrogen hormone deficiency and higher follicle-stimulating hormone (FSH) levels in the blood circulation, which increase the risk of osteoporosis up to three times (18). During the menopausal period, an increase in FSH levels and a decrease in estradiol levels will occur, so estradiol does not bind to its receptor in osteoblasts to directly modulate osteoblastic activity and indirectly regulate osteoclast formation (19). As a result, when the estrogen levels decrease, nothing can inhibit the bone resorption process (20). Decreased estrogen will decrease cortical bone matrix production, increase trabecular bone formation, and stimulate bone resorption (20).

Hormonal stimulation is an essential part of modern assisted reproductive technology (ART) (21). Gonadotropin therapy is pivotal in ovarian stimulation. As well acknowledged, whereas FSH is the primary regulator of antral follicular growth, LH enhances steroidogenesis and the development of the leading follicle (21). According to the two-cell two-gonadotropin theory, LH induces androgen production in theca cells, while FSH acts on the proliferation of granulosa cells (GCs) and E_2 synthesis (22). In this context, the main goal of gonadotropin stimulation is to restore adequate E_2 levels. Balanced estradiol levels may determine an improvement in the number and yield of mature oocytes, providing a more physiological pregnancy outcome (23).

There are different applications of gonadotrophic hormones in assisted reproductive technology, and technological advances have led to the production of recombinant forms of human FSH (r-hFSH) and LH (r-hLH) as possible alternatives to the current protocol of therapy (24). Data demonstrated that this gonadotropin stimulation may affect reproductive and bone tissues differently. On the one hand, r-hFSH, used to support ovarian follicle growth in ART, accelerates endometrium maturation, while r-hLH forms improve the follicular environment and insulin sensitivity (25). On the other hand, the use of gonadotropins in ART practice can affect bone health, including the one of the jawbone. As reported by Zhu et al., FSH increases the alveolar bone resorption, activating the cyclooxygenase-2 pathway (26). In addition, FSH up-regulates genes typical of osteoclasts (RANK, MMP-9, and Trap), promoting osteoclast production and alveolar bone resorption. Quantifying the expression of these factors in healthy controls and in patients undergoing ART could provide a more complete view of the effects these treatments can have on patients' oral health years later.

Despite the fact that the hormonal effect of ART has not yet been clinically studied on the alveolar bone changes, few studies evaluate the effect of these hormones on the periodontal state of women who have undergone ART (27, 28). In both studies, gingival and periodontal health worsened after the IVF treatment.

CONCLUSIONS

In conclusion, the interplay between female reproductive disorders and periodontal disease is a complex phenomenon. Understanding the bidirectional relationship between these conditions is vital for healthcare professionals, enabling them to provide comprehensive care that addresses both oral and reproductive health concerns in women. Further research is warranted to elucidate the underlying mechanisms and develop targeted interventions to optimize the health outcomes of affected individuals.

REFERENCES

1. Guidance note on integrating health equity, gender equality, disability inclusion, and human rights in WHO evaluations. In: *World Health Organization*: WHO/DGO/EVL/2023.2; 2023.
2. Country support package for equity, gender, and human rights in ensuring that no one is left behind in the path of universal health coverage. In: *World Health Organization*: WHO/FWC/GER/17.1; 2017.
3. Rural women and girls 25 years after Beijing. In: *UN Interagency Network on Women and Gender Equality*. United Nations 2020.
4. Critchley HOD, Babayev E, Bulun SE, et al. Menstruation: science and society. *Am J Obstet Gynecol.* 2020;223(5):624-664. doi:https://doi.org/10.1016/j.ajog.2020.06.004
5. Vannuccini S, Clifton VL, Fraser IS, et al. Infertility and reproductive disorders: impact of hormonal and inflammatory mechanisms on pregnancy outcome. *Hum Reprod Update*. 2016;22(1):104-115. doi:https://doi.org/10.1093/humupd/dmv044
6. Marquez-Arrico CF, Silvestre-Rangil J, Gutierrez-Castillo L, Martinez-Herrera M, Silvestre FJ, Rocha M. Association between Periodontal Diseases and Polycystic Ovary Syndrome: A Systematic Review. *J Clin Med.* 2020;9(5):doi:https://doi.org/10.3390/jcm9051586

7. Rathi N, Reche A. Risk of Periodontal Diseases in Women With Polycystic Ovary Syndrome: An Overview. *Cureus.* 2023;15(10):e47169. doi:https://doi.org/10.7759/cureus.47169
8. Dou Y, Xin J, Zhou P, et al. Bidirectional association between polycystic ovary syndrome and periodontal diseases. *Front Endocrinol (Lausanne).* 2023;14(1008675. doi:https://doi.org/10.3389/fendo.2023.1008675
9. Becker CM, Bokor A, Heikinheimo O, et al. ESHRE guideline: endometriosis. *Hum Reprod Open.* 2022;2022(2):hoac009. doi:https://doi.org/10.1093/hropen/hoac009
10. Garcia-Penarrubia P, Ruiz-Alcaraz AJ, Martinez-Esparza M, Marin P, Machado-Linde F. Hypothetical roadmap towards endometriosis: prenatal endocrine-disrupting chemical pollutant exposure, anogenital distance, gut-genital microbiota, and subclinical infections. *Hum Reprod Update.* 2020;26(2):214-246. doi:https://doi.org/10.1093/humupd/dmz044
11. Mecha E, Makunja R, Maoga JB, et al. The Importance of Stromal Endometriosis in Thoracic Endometriosis. *Cells.* 2021;10(1):doi:https://doi.org/10.3390/cells10010180
12. Thomas V, Uppoor AS, Pralhad S, Naik DG, Kushtagi P. Towards a Common Etiopathogenesis: Periodontal Disease and Endometriosis. *J Hum Reprod Sci.* 2018;11(3):269-273. doi:https://doi.org/10.4103/jhrs.JHRS_8_18
13. Almeida LE, Doetzer A, Beck ML. Immunohistochemical Markers of Temporomandibular Disorders: A Review of the Literature. *J Clin Med.* 2023;12(3):doi:https://doi.org/10.3390/jcm12030789
14. Wojcik M, Gozdziewicz T, Hudakova Z, Siatkowski I. Endometriosis and the Temporomandibular Joint-Preliminary Observations. *J Clin Med.* 2023;12(8):doi:https://doi.org/10.3390/jcm12082862
15. Brotskyi N, Tatarchuk T, Plaksiieva K, Fetsych A, Ostrianko V. Temporal Bone Endometriosis -A Multidisciplinary Approach. A Clinical Case. *Int Dent Med Res* 2022;15(3):1305-1310.
16. Gala KLC, Rozas MV. Jaw region endometriosis: Case report. *Rev Fac Med Hum.* 2021;21(4):889-895.
17. Velarde MC, Menon R. Positive and negative effects of cellular senescence during female reproductive aging and pregnancy. *J Endocrinol.* 2016;230(2):R59-76. doi:https://doi.org/10.1530/JOE-16-0018
18. Wang J, Zhang W, Yu C, et al. Follicle-Stimulating Hormone Increases the Risk of Postmenopausal Osteoporosis by Stimulating Osteoclast Differentiation. *PLoS One.* 2015;10(8):e0134986. doi:https://doi.org/10.1371/journal.pone.0134986
19. Almeida M, Iyer S, Martin-Millan M, et al. Estrogen receptor-alpha signaling in osteoblast progenitors stimulates cortical bone accrual. *J Clin Invest.* 2013;123(1):394-404. doi:https://doi.org/10.1172/JCI65910
20. Bandeira F, Costa AG, Soares Filho MA, Pimentel L, Lima L, Bilezikian JP. Bone markers and osteoporosis therapy. *Arq Bras Endocrinol Metabol.* 2014;58(5):504-513. doi:https://doi.org/10.1590/0004-2730000003384
21. Filicori M, Cognigni GE, Pocognoli P, Ciampaglia W, Bernardi S. Current concepts and novel applications of LH activity in ovarian stimulation. *Trends Endocrinol Metab.* 2003;14(6):267-273. doi:https://doi.org/10.1016/s1043-2760(03)00085-7
22. Alviggi C, Conforti A, Esteves SC, et al. Recombinant luteinizing hormone supplementation in assisted reproductive technology: a systematic review. *Fertil Steril.* 2018;109(4):644-664. doi:https://doi.org/10.1016/j.fertnstert.2018.01.003
23. Nassar J, Tadros T, Adda-Herzog E, Ayoubi JM, Fanchin R. Steroid hormone pretreatments in assisted reproductive technology. *Fertil Steril.* 2016;106(7):1608-1614. doi:https://doi.org/10.1016/j.fertnstert.2016.09.013
24. Liu X, Qiao P, Jiang A, et al. Paracrine Regulation of Steroidogenesis in Theca Cells by Granulosa Cells Derived from Mouse Preantral Follicles. *Biomed Res Int.* 2015;2015(925691. doi:https://doi.org/10.1155/2015/925691
25. Ezcurra D, Humaidan P. A review of luteinizing hormone and human chorionic gonadotropin when used in assisted reproductive technology. *Reprod Biol Endocrinol.* 2014;12(95. doi:https://doi.org/10.1186/1477-7827-12-95
26. Zhu C, Ji Y, Liu S, Bian Z. Follicle-stimulating hormone enhances alveolar bone resorption via upregulation of cyclooxygenase-2. *Am J Transl Res.* 2016;8(9):3861-3871.
27. Smadi L. Gingival and periodontal changes in patients undergoing in vitro fertilization treatment: A clinical study. *Indian J Dent Res.* 2017;28(6):650-654. doi:https://doi.org/10.4103/ijdr.IJDR_712_16
28. Pavlatou A, Tsami A, Vlahos N, Mantzavinos T, Vrotsos I. The effect of in vitro fertilization on gingival inflammation according to women's periodontal status: clinical data. *J Int Acad Periodontol.* 2013;15(2):36-42.

Review

SAFETY IN DERMAL FILLER INJECTION: ASPIRATION OR CONSTANT NEEDLE MOVING?

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ABSTRACT

Although dermal filler injections are extensively used worldwide, no consensus within the scientific literature determines precise guidelines for reducing the risk of vascular occlusion. This narrative review aims to distinguish whether the risk-reduction maneuvers proposed by the various authors are derived from anecdotal knowledge or based on scientific evidence. To pursue the objectives of the present study, a PubMed search was used using the search string ("aspiration" OR "needle movement" OR "needle motion") AND "filler." Articles were selected based on inclusion criteria. Twenty-five studies were chosen from 58 studies published between 1980 and 2023. Four opinion categories were compiled: 12 studies against retro-aspiration, 1 study in favor of retro-aspiration, 4 articles partially in favor of retro-aspiration, and 8 articles determined that further research is needed. The review shows no clear guidelines on vascular occlusion prevention techniques. This is due to inadequate study designs that reflect clinical reality. Therefore, further research is needed, focusing on realistic study designs applicable to everyday clinical practice.

KEYWORDS: *dermal fillers, injections, aspiration, needle motion*

INTRODUCTION

Dermal filler injections have become very popular nonsurgical facial rejuvenation procedures thanks to the excellent results they consent to achieve, the short recovery times, and their relatively low complication rate. In the past few years, the number of performed procedures has increased significantly, but unfortunately, the number of potential and reported adverse complications has also increased proportionally. These adverse events are, in most cases, mild and self-limiting (bruising, swelling, erythema), but more moderate adverse events can occur (hypercorrection, filler visibility.

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Due to too superficial injection, Tyndall effect, and granulomas), leading even to rare but extremely dangerous complications like vascular occlusion, whose most common sequelae is skin necrosis, while the most devastating one is injection-related visual impairment, which can even lead to blindness (1). This has led to practitioners' need to develop predictable techniques to prevent vascular complications. Before any injection into the body, practitioners have usually been taught to follow two main rules:

- remove the air from the syringe by priming and filling the needle with the solution that is about to be injected;
- perform the “retro aspiration test” by withdrawing the plunger before the injection to ensure the needle is not inside a vessel. The retro aspiration test consists of withdrawing the plunger for a few seconds and checking if blood flows back into the syringe (positive result) or not (negative result).

These principles can be considered valid when the injected solution is fluid, so it can easily pass back through the needle and allow blood to enter the syringe (2). But what about if the materials injected have a higher viscosity and a gel-like consistency? Due to their rheological characteristics, fillers may impede blood flow back into the syringe, giving a false sense of security with potentially devastating consequences.

The HA fillers differ in degree of crosslinking, the type of crosslinker used, hardness, viscosity, gel consistency, total HA concentration, and so forth (3).

In the past few years, some practitioners and researchers have raised many doubts and critical issues about the reliability of aspiration and have begun to investigate and develop different alternative techniques (4). Many of them have hypothesized that constant needle motion could be a safer maneuver compared to the static bolus injection (5-8) with previous retro aspiration.

The purpose of this research is to understand whether the scientific community accords reliability to the most common techniques that are routinely used and taught. The methods considered are the needle motion after insertion in the injecting site and retro aspiration before filler injection (R.A.).

MATERIALS AND METHODS

To conduct this literature review, the PubMed database was searched using the string ("aspiration" OR "needle movement" OR "needle motion") AND "filler". The titles and abstracts of each paper obtained from the results were listed, and full-text manuscripts were retrieved using online resources.

The papers were reviewed, and any study that did not relate to safety measures during tissue filling procedures was excluded. The selection did not take into account the differences between the studies' designs or the methodologies used to determine the accuracy of the scientific opinion on which risk-reducing maneuver is best suited to the tissue-filling procedure.

RESULTS

The PubMed search yielded 58 results published between 1980 and September 2023. This selection left 25 included papers, which were summarized and categorized by type. The 25 selected studies included 6 *in vitro* studies, 2 *in vivo* studies, 3 *in vitro* and *in vivo* studies, 5 literature reviews, 1 descriptive analysis, 1 systematic review and meta-analysis, 1 theoretical investigation, and 6 commentaries or editorials. All of the papers were published between the year 2015 and September 2023. The selected papers are shown in Table I (2, 3, 9-32).

After reviewing the selected papers, 4 different categories of opinions were redacted, and every paper was labeled as belonging to one unique opinion category, as follows:

- 12 papers were AGAINST R.A.
- 1 paper was IN FAVOUR of R.A.
- 4 papers were PARTIALLY IN FAVOUR of R.A. (they added specific conditions to their statement)
- 8 papers stated that FURTHER RESEARCH IS NEEDED.

Table I. *Summary of selected papers.*

AUTHOR	YEAR	JOURNAL	TYPE	SUMMARY
Carey & Weinkle	2015	Dermatologic Surgery	*In vitro*/*in vivo*	Against RA
Casabona	2015	Dermatologic Surgery	*In vitro*/*in vivo*	Partially in favor of RA
Van Longhem et al.	2018	Journal of Cosmetic Dermatology	*In vitro*	Further research is needed
Torbeck et al.	2019	Dermatologic Surgery	*In vitro*	Further research is needed
Albornoz et al.	2020	Journal of Cosmetic Dermatology	Literature review	Further research is needed
Kogan et al.	2020	Journal of Cosmetic Dermatology	*In vitro*	Partially in favor of RA
Wang et al.	2020	Journal of Cutaneous Medicine and Surgery	*In vivo*	Further research is needed
Goodman et al.	2021	Aesthetic Surgery Journal	Commentary	Against RA
Jewell	2021	Aesthetic Surgery Journal	Commentary	Against RA
Kapoor et al.	2021	Dermatologic Therapy	Systematic Review and Meta-Analysis	Further research is needed
Lee et al.	2021	Aesthetic Surgery Journal	Commentary	Against RA
Moon et al.	2021	Aesthetic Surgery Journal	*In vitro*/*in vivo*	Further research is needed
Rivkin	2021	Journal of Cosmetic Dermatology	Literature Review	Against RA
Tseng et al.	2021	Aesthetic Surgery Journal	Descriptive Analysis	Further research is needed
DeLorenzi	2022	Aesthetic Surgery Journal	Commentary	Against RA
Goodman et al.	2022	Aesthetic Surgery Journal	Literature Review	Against RA
Jewell	2022	Aesthetic Surgery Journal	Commentary	Against RA
Lin et al.	2022	Aesthetic Surgery Journal	*In vitro*	Against RA
Rocha et al.	2022	Journal of Cosmetic Dermatology	*In vivo*	Against RA
Sezgin	2022	Aesthetic Surgery Journal	Commentary	Against RA
Wang e Huang	2022	Aesthetic Surgery Journal	Literature Review	Against RA
Gonchar	2023	Journal of Cosmetic Dermatology	Theoretical investigation	Partially in favor of RA
Peng et al.	2023	Journal of Cosmetic Dermatology	*In vitro*	In favor of RA
Zhang et al.	2023	Journal of Plastic, Reconstructive & Aesthetic Surgery	*In vitro*	Partially in favor of RA
James	2023	International Journal of Nursing and Health Care Research	Literature Review	Further research is needed

DISCUSSION

This literature review found few approaches to the topic, and most of them are not supported by precise protocols for evaluating the effectiveness of safety techniques in the context of tissue fillers.

The examined *in vitro* studies focused on reproducing operative conditions using fresh frozen cadaveric preparations or animal models, proposing imaging techniques such as Doppler ultrasonography or ultrasonography in injection assistance, and proposing needle lumen flushing maneuvers with sterile saline before each filler injection.

The examined *in vivo* studies focused on: analysing the statistical occurrence of false negatives when using a retro-aspiration prior to filler injection; analyzing the time offset between the retro-aspiration and the flashback of blood into the syringe; using ultrasonography as an imaging technique in injection assistance; and using needle lumen flushing maneuvers with sterile saline before injections.

The only examined theoretical investigation proposed a mathematical model to describe the risk of injecting into a blood vessel when doing continuous needle movement, compared to retro-aspiration before injection (28).

The only examined systematic review and metanalysis concluded that the efficacy of pre-injection aspiration as a risk-preventing technique could be improved, but only after a deep understanding of the relationship between factors such as the chosen needle gauge, the density and viscoelastic properties of the different fillers. In this review, several parameters that affect the reliability of the aspiration test came out: diameter of the needle and rheological properties of fillers, priming of the needle, speed of plunger pullback, stability of the needle, and planes injected. The needle's inner diameter is one of the main parameters determining the resistance of the filler to the backflow: needles require different strengths and times to aspirate a determined liquid with a specific density, and the smaller the gauge, the higher the strength needed (9).

Using a small gauge needle with a high-viscosity filler may impede the flow back of the filler and, consequently, the entry of the eventual blood inside the syringe, invalidating the procedure (1, 2, 16, 29).

An *in vitro* study from Kogan et al. 2020 showed that aspiration with 29G needles gave all false negatives; using 27G needles gave better results, but the minimum aspiration time was 3.5 sec.

During the aspiration procedure, the needle lumen must first be emptied to allow blood to flow into the syringe. This is straightforward when the needle is filled with air or water. In contrast, emptying the needle is complex, often incomplete, and can distort the test result when the needle is filled with filler.

One way around this problem might be to change the needle each time after a bolus injection, or to change the needle each time after a bolus injection, but with a potential risk of air embolism (since an empty needle contains air), and with definite issues of practicability in daily clinical practice.

An *in vitro* study (3) suggested the priming of the needle as a solution to this problem: the saline solution was used as a priming material because of its low viscosity, and, according to this study, 100% of the aspirations performed with this test were reliable.

Another *in vitro* study (29) from Peng et al. used lidocaine as a priming material, suggesting that it could be a better material than saline solution, as it improves the patient's comfort during the procedure.

Speed of plunger pullback

Most studies investigating the retro aspiration technique, regardless of the conclusions for or against suction, agree that it is necessary to make a slow movement in the pullback of the plunger to increase its reliability. A quick movement (usually done by practitioners) is associated with more false negative results. In addition, it raises the risk of sucking up the vessel and collapsing it, giving a false negative result and a potential intravascular filler placement.

An *in vitro* study by Peng et al. observed that holding the plunger for at least 10 seconds, even if the needle had been misinserted into the vessel, could detect 88% of these misses. They also observed that the waiting time could be shortened as the residual amount of filler in the syringe decreased. Blood appeared instantaneously in the retro aspiration tests performed with 0.1ml filler remaining in the syringe. A human study on the peripheral vein found that the mean time it took blood to appear in the syringe was 3.1 sec (13).

A retrospective case series of 213 positive blood aspiration procedures revealed that almost all positive aspirations were evident within 2 seconds, and the most frequent site was the pyriform fossa (20). The most frequent plane where aspiration was positive was the supra-periosteal plane, and this result is intuitive because this area is also the most frequent plane where aspiration is performed and considered valid since it is almost impossible to firmly maintain the position of the needle while doing aspiration in soft tissue compartments. However, this study is biased because only positive aspirations were considered, so it is impossible to evaluate the incidence of false negatives.

As needle immobility is a prerequisite for successful aspiration testing, an ultrasound study in 2022 (24) investigated the presence of micromovements during aspiration, performed by different physicians with different experiences: in all cases, there was retrograde motion along the axis of needle insertion during plunger retraction and anterograde motion during injection. The aspiration test is therefore most effective when the needle is pointed against the periosteum, thus ensuring stability of position. Any slight movement during aspiration could potentially invalidate the test.

Among the studies in favor of pre-injection aspiration, Peng et al. state that "Aspiration should be considered as a regular procedure before giving an injection", and they suggest doing aspiration "as a must no matter which equipment is used" since aspiration is a simple action that gives a "huge benefit to patients and operators". In addition, priming syringes with lidocaine is suggested to raise aspiration reliability, and tiny needles (29-30G) should be avoided because they slow down the blood flow during aspiration (29).

A different outcome came from the paper by Casabona et al., whose conclusion stated that "the aspiration test for filler application was reliable with 53% syringes and needles tested". Moreover, this paper states that the size and collapsibility of the vessels in the anatomical region of the face negatively influence the reliability of the retrograde aspiration technique as a safety maneuver.

The other safety maneuver considered among the selected papers is the continual movement of the needle or cannula during injection. The reasoning behind the adoption of this technique is that in case of unfortunate intravasal injection, it helps in reducing the chances of complete occlusion of a vessel since the filler injected is more diffused, resulting in lower pressure on the tissues rather than a single, massive static bolus.

The role of pressure in filler delivery is crucial. If the injecting pressure overcomes the patient's systolic pressure, there is a higher risk of causing an embolic bolus if the needle is positioned into a vessel. Since a still and massive bolus can easily reach and overcome the threshold of the patient's systolic pressure, continual needle movement during injection may avoid this risk. However, the theoretical model proposed by Gonchar et al. raises the issue that continual movement could enhance the possibility of hitting a vessel. Although this finding is reasonable, the model described is far from clinical reality.

Some authors firmly take sides against aspiration and say that it should not be relied upon (14). Different authors in commentaries or editorial articles described the procedure of pre-injection aspiration as “unreliable” or “useless”, as it could give “a false sense of security” (19), as it “precludes other important safety measures – those of movement and avoidance of static bolus production”.

None of the examined papers concluded that the retro-aspiration is a recommended maneuver. Still, they all state that further research is needed to assess this technique's validity as a safety-increasing filler administration practice. Some of them suggest implementing this technique with improvements such as saline flashing and ultrasound, which may improve the sensitivity and reliability of aspiration tests. However, conclusive evidence is still lacking (3, 32). A Consensus published in 2020 states that there is no evidence in the literature that aspiration reduces the incidence of blindness or necrosis (4).

The study's limitations are represented by the fact that the only source taken into account was the search engine PubMed. Furthermore, the articles that emerged from the search have very heterogeneous study designs, so there is no comparable data to draw up statistics.

CONCLUSIONS

In conclusion, many factors can influence the reliability of pre-injection aspiration: anatomical area being treated, needle diameter and length, cohesiveness of the product, time of aspiration, and speed of retraction technique. Using air/fluid primed needles with a big diameter (>27G) with a slow pullback of the plunger is associated with fewer false negative tests (2, 10, 18, 20).

REFERENCES

1. Scarano A, Di Carmine MS, Greco Lucchina A, et al. Chronic lip edema and pain secondary to lip augmentation: histological, scanning electron microscopy and X-ray microanalysis evaluation. *Eur Rev Med Pharmacol Sci.* 2023;27(3 Suppl):147-152. doi:https://doi.org/10.26355/eurrev_202304_31334
2. Carey W, Weinkle S. Retraction of the Plunger on a Syringe of Hyaluronic Acid Before Injection: Are We Safe? *Dermatologic Surgery.* 2015;41 (Supplement 1)(S340–346.
3. Kogan I, Korolik P, Cartier H, Adhoute H, Liberzon A. *In vitro* evaluation of aspiration of hyaluronic acid filler with a new saline flashing method. *J Cosmet Dermatol.* 2020;19(10):2513-2518. doi:https://doi.org/10.1111/jocd.13651
4. Goodman GJ, Magnusson MR, Callan P, et al. A Consensus on Minimizing the Risk of Hyaluronic Acid Embolic Visual Loss and Suggestions for Immediate Bedside Management. *Aesthet Surg J.* 2020;40(9):1009-1021. doi:https://doi.org/10.1093/asj/sjz312
5. Signorini M, Liew S, Sundaram H, et al. Global Aesthetics Consensus: Avoidance and Management of Complications from Hyaluronic Acid Fillers-Evidence- and Opinion-Based Review and Consensus Recommendations. *Plast Reconstr Surg.* 2016;137(6):961e-971e. doi:https://doi.org/10.1097/PRS.0000000000002184
6. Kumar N, Swift A, Rahman E. Development of "Core Syllabus" for Facial Anatomy Teaching to Aesthetic Physicians: A Delphi Consensus. *Plast Reconstr Surg Glob Open.* 2018;6(3):e1687. doi:https://doi.org/10.1097/GOX.0000000000001687
7. Funt D, Pavicic T. Dermal fillers in aesthetics: an overview of adverse events and treatment approaches. *Clin Cosmet Investig Dermatol.* 2013;6(295-316. doi:https://doi.org/10.2147/CCID.S50546
8. Heydenrych I, Kapoor KM, De Boulle K, et al. A 10-point plan for avoiding hyaluronic acid dermal filler-related complications during facial aesthetic procedures and algorithms for management. *Clin Cosmet Investig Dermatol.* 2018;11(603-611. doi:https://doi.org/10.2147/CCID.S180904
9. Casabona G. Blood Aspiration Test for Cosmetic Fillers to Prevent Accidental Intravascular Injection in the Face. *Dermatol Surg.* 2015;41(7):841-847. doi:https://doi.org/10.1097/DSS.0000000000000395
10. Van Loghem JA, Fouche JJ, Thuis J. Sensitivity of aspiration as a safety test before injection of soft tissue fillers. *J Cosmet Dermatol.* 2018;17(1):39-46. doi:https://doi.org/10.1111/jocd.12437
11. Torbeck RL, Schwarcz R, Hazan E, Wang JV, Farberg AS, Khorasani H. *In vitro* Evaluation of Preinjection Aspiration for Hyaluronic Fillers as a Safety Checkpoint. *Dermatol Surg.* 2019;45(7):954-958. doi:https://doi.org/10.1097/DSS.0000000000001767
12. Albornoz CA, Jhawar N, Durso TA, Hazan E, Wang JV, Saedi N. Preinjection aspiration for injectable fillers in aesthetic dermatology: Trust or bust? *J Cosmet Dermatol.* 2020;19(5):1063-1064. doi:https://doi.org/10.1111/jocd.13377
13. Wang JV, Hazan E, Hattier G, Torbeck RL, Khorasani H, Saedi N. Utility of Preinjection Aspiration for Hyaluronic Fillers: A Novel *In vivo* Human Evaluation. *J Cutan Med Surg.* 2020;24(4):367-371. doi:https://doi.org/10.1177/1203475420921387
14. Goodman GJ, Magnusson MR, Callan P, et al. Neither Positive Nor Negative Aspiration Before Filler Injection Should Be Relied Upon as a Safety Maneuver. *Aesthet Surg J.* 2021;41(4):NP134-NP136. doi:https://doi.org/10.1093/asj/sjaa215

15. Jewell ML. Commentary on: Aspiration Revisited: Prospective Evaluation of a Physiologically Pressurized Model With Animal Correlation and Broader Applicability to Filler Complications. *Aesthet Surg J.* 2021;41(8):NP1084-NP1085. doi:https://doi.org/10.1093/asj/sjab163
16. Kapoor KM, Murthy R, Hart SLA, et al. Factors influencing pre-injection aspiration for hyaluronic acid fillers: A systematic literature review and meta-analysis. *Dermatol Ther.* 2021;34(1):e14360. doi:https://doi.org/10.1111/dth.14360
17. Lee W, Sundaram H, Moon HJ, Yang EJ. Aspiration Before Filler Injection: Rethinking the Paradigm? *Aesthet Surg J.* 2021;41(12):NP2100-NP2101. doi:https://doi.org/10.1093/asj/sjab264
18. Moon HJ, Lee W, Kim JS, Yang EJ, Sundaram H. Aspiration Revisited: Prospective Evaluation of a Physiologically Pressurized Model With Animal Correlation and Broader Applicability to Filler Complications. *Aesthet Surg J.* 2021;41(8):NP1073-NP1083. doi:https://doi.org/10.1093/asj/sjab194
19. Rivkin AZ. Aspiration: I don't do it and neither should you. *J Cosmet Dermatol.* 2021;20(4):1042-1043. doi:https://doi.org/10.1111/jocd.13989
20. Tseng FW, Bommareddy K, Frank K, et al. Descriptive Analysis of 213 Positive Blood Aspiration Cases When Injecting Facial Soft Tissue Fillers. *Aesthet Surg J.* 2021;41(5):616-624. doi:https://doi.org/10.1093/asj/sjaa075
21. DeLorenzi C. Commentary on: Is Aspiration Prior to Filler Injection Beneficial in Preventing Inadvertent Vascular Adverse Events? *Aesthet Surg J.* 2022;42(6):NP437. doi:https://doi.org/10.1093/asj/sjab428
22. Goodman GJ, Magnusson MR, Callan P, et al. Aspiration Before Tissue Filler-An Exercise in Futility and Unsafe Practice. *Aesthet Surg J.* 2022;42(1):89-101. doi:https://doi.org/10.1093/asj/sjab036
23. Jewell ML. Commentary on: Aspiration Before Tissue Filler-An Exercise in Futility and Unsafe Practice. *Aesthet Surg J.* 2022;42(1):102-105. doi:https://doi.org/10.1093/asj/sjaa408
24. Lin F, Goodman GJ, Magnusson M, et al. Movement of the Syringe During Filler Aspiration: An Ultrasound Study. *Aesthet Surg J.* 2022;42(10):1109-1116. doi:https://doi.org/10.1093/asj/sjac032
25. Rocha PS, Guerra TA, Teixeira DA. Description of a safe doppler ultrasound-guided technique for hyaluronic acid filler in the face-A method to avoid adverse vascular events. *J Cosmet Dermatol.* 2022;21(7):2783-2787. doi:https://doi.org/10.1111/jocd.14492
26. Sezgin B. Commentary on: Movement of the Syringe During Filler Aspiration: An Ultrasound Study. *Aesthet Surg J.* 2022;42(10):1117-1118. doi:https://doi.org/10.1093/asj/sjac047
27. Wang YH, Huang YL. Is Aspiration Prior to Filler Injection Beneficial in Preventing Inadvertent Vascular Adverse Events? *Aesthet Surg J.* 2022;42(6):NP434-NP436. doi:https://doi.org/10.1093/asj/sjab404
28. Gonchar IV, Alfertshofer M, Nikolis A, Hong WJ, Biesman B, Cotofana S. Is constant needle motion during soft tissue filler injections a safer procedure? A theoretical mathematical model for evaluating patient safety. *J Cosmet Dermatol.* 2023;22(11):2964-2970. doi:https://doi.org/10.1111/jocd.15998
29. Peng YP, Lin YW, Yang YY. Aspiration before tissue filling with hyaluronic acid-safety enhancement by using a lidocaine-primed syringe. *J Cosmet Dermatol.* 2023;22(9):2457-2463. doi:https://doi.org/10.1111/jocd.15759
30. Zhang L, Zhao Y, Gu Q, et al. A roadmap for safety during facial filler injections: A fresh frozen cadaver study. *J Plast Reconstr Aesthet Surg.* 2023;86(155-164. doi:https://doi.org/10.1016/j.bjps.2023.06.029
31. James H. A Critical Literature Review Analysing the Evidence Base for the Efficacy of Aspiration Prior to Injection of Dermal Filler as A Safety Measure to Reduce the Risk of Vascular Complications. *Int J Nurs Health Care Res* 2023
32. Schelke LW, Decates TS, Velthuis PJ. Ultrasound to improve the safety of hyaluronic acid filler treatments. *J Cosmet Dermatol.* 2018;17(6):1019-1024. doi:https://doi.org/10.1111/jocd.12726

Case report

TREATMENT OF GINGIVAL RECESSION WITH TUNNEL TECHNIQUE: A 13-YEAR FOLLOW-UP CASE REPORT

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ABSTRACT

The periodontium is a complex structure that plays a crucial role in oral health. It has been studied extensively, and its understanding is essential for preventing and treating periodontal diseases. Periodontal disease is a pervasive inflammatory disorder that negatively impacts the supporting structures of the dentition, culminating in progressive attachment loss and alveolar bone resorption. A prevalent clinical manifestation of periodontal disease is gingival recession. Various factors, including chronic inflammatory periodontal disease, occlusal trauma, aggressive tooth brushing, and periodontal treatment, can cause it. Multiple gingival recessions can be treated through various surgical techniques. The choice of surgical technique to adopt depends on the anatomical characteristics, the surgical objectives, the predictability data of root coverage present in the literature, and finally, the aesthetic requests of the patient. The tunnel technique (TUN) is used when there is not enough apical keratinized tissue to cover the root, and at the same time, there are well-represented papillae that allow tunneling. TUN is a minimally invasive method that doesn't require vertical releasing incisions and preserves the interdental papillae. A connective graft collected from the palate is inserted in a tunnel of the papilla to cover the roots of the teeth. The following work presents a case report. Furthermore, literature is discussed.

KEYWORDS: *gingival recession, coronally advanced flap, tunnel technique, connective tissue graft*

INTRODUCTION

Gingival recession is characterized by the downward movement of the gingival line beyond the cement-enamel junction, leading to the root surface being exposed to the oral environment (1, 2). This condition can be triggered by chronic inflammatory periodontal disease, occlusal trauma, chronic trauma, particularly aggressive tooth brushing, and periodontal treatment. Factors such as tooth anatomy and position, reduced alveolar bone crest thickness, bone dehiscence, soft tissue thickness, frenulum traction, or orthodontic treatment can contribute to its development (3-6).

Recently, Cairo et al. proposed a new classification based on the interproximal clinical attachment loss: while Recession Type 1 (class RT1) includes gingival recession with no loss of interproximal attachment, Recession Type 2 (class RT2) is associated with interproximal attachment loss less than or equal to the buccal bone site and Recession Type 3 (class RT3) shows higher interproximal attachment loss than the buccal site (4).

Two surgical techniques are commonly used to achieve complete root coverage: the coronal advanced flap and the tunnel technique (7, 8). The coronally advanced flap is a conventional surgical method to achieve total root coverage for single, multiple, continuous, or neighboring gingival recessions (6). This procedure makes two oblique cuts that start from the distal and medial aspects of the affected teeth and extend toward the alveolar mucosa. A partial thickness flap

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dissection is performed from the oblique interdental incisions. The periosteum is incised to eliminate muscle tension in the apical portion of the flap. The mobilized flap should be able to reach the enamel-cement junction passively. The sutures are positioned to fit the flap advanced coronally precisely.

However, an alternative treatment for gingival recessions is the latest tunnel technique, a minimally invasive method that doesn't require any vertical releasing incisions and preserves the interdental papillae (8, 9). This technique performs partial lateral incisions in the mucosa surrounding adjacent teeth affected by periodontal recession. Papillae are not thoroughly dissected, so a connective graft collected from the palate can be inserted in a papilla tunnel to cover the teeth' roots in the vestibular site. The graft is secured with two interrupted sutures. Suspensory sutures are recommended to advance the mucosal flap in the coronal direction over the exposed portions of the connective tissue graft. Soft pressure is applied to the graft for a few minutes to improve the graft's adaptation to the root surface (9). The following work presents a case report using the tunnel technique. Then, the literature is discussed.

CASE REPORT

A 17-year-old patient came to our clinic in January 2010 for an orthodontic evaluation. She had a gingival thin phenotype that did not present any periodontal disease. A gingival recession was noted at elements 2.3 and 2.4, with sensitivity to thermal variations (Fig. 1).

Fig. 1. *Initial intraoral photos.*

The patient reported aesthetic discomfort; she would like to cover these recessions. Before surgery, complete oral hygiene and a radiological examination were performed (Fig. 2).

Fig. 2. *Radiological examination (dental panoramic tomograph).*

The integrity of the interproximal periodontal support is fundamental in obtaining complete root coverage. This specific case of the patient's recession was classified as Miller class I. Therefore, this case's potential for root coverage was 100% complete. Before proceeding with the surgery, the thickness of the palatal fibro-mucosa was evaluated to quantify the amount of graft that would be collected (Fig. 3).

Fig. 3. *Measurement of the thickness of the palatal fibro-mucosa using an anesthesia needle and an endodontic stop.*

A 0.8-1.0 mm graft was needed to cover recessions on natural elements. Local anesthesia with adrenaline was performed at the palatal and vestibular levels. Tetracycline was used to condition the root surface. This agent eliminates the dentinal mud that accumulates inside the dentinal tubules after root planning. The elimination of dentinal mud allows the exposure of the collagen fibrils within the dentinal tubules, which can thus interact with the fibrin network of the clot that forms between the root and soft tissues. Consequently, the adhesion of the clot to the root surface was accomplished (Fig. 4).

Fig. 4. *Tetracycline eliminates dentinal mud on the root surface of elements 2.3 and 2.4.*

At this point, the graft was taken from the palate with the following technique (Fig 5):

- a linear incision of half thickness was done parallel to the molar and premolar teeth;
- a second incision was parallel to the first line (0.5 -1.0 mm);
- the graft was free with two vertical incisions and one horizontal apical.

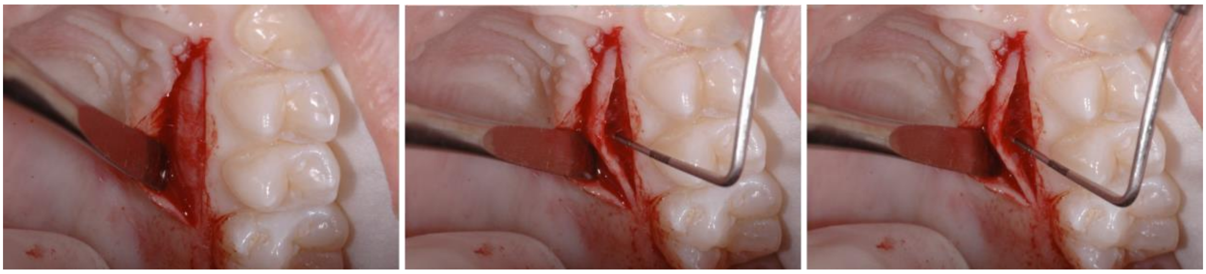

Fig. 5. *Technique used to collect connective tissue.*

The receiving bed was prepared at the vestibular level of teeth with gingival recession, and a tunnel technique was performed. The tunnel technique involves splitting the papilla between 2.3 and 2.4 without detaching it. Then, an incision was done distally to 2.4 and mesially to 2.3, and then the incision was performed apically on the two teeth, 2.3 and 2.4. This way, a receiving envelope was created without the papilla being detached. A periodontal probe was used to check that there was no adhesion inside the receiving bed. In such a way, the graft lodged passively. Subsequently, the graft was positioned and secured with a suture point. After a week, the sutures were removed (Fig. 6, 7).

Fig. 6. *Intraoperative photos.*

Fig. 7. *Healing one week after the surgery.*

The patient was discharged and subjected to therapy with a chlorhexidine-based mouthwash and a painkiller (as needed). A control was performed after a month (Fig. 8).

Fig. 8. *The first picture shows the initial stage, and the second picture shows the clinical status one month after the surgery.*

A 13-year follow-up shows the effectiveness of the tunnel technique (Fig. 9).

Fig. 9. *Intraoral photo taken 13 years later.*

DISCUSSION

The tunnel technique consists of creating a supra-periosteal "envelope" or "pouch" "envelope" at the gingival margins, allowing flap elevation and insertion of a connective tissue graft. In this procedure, minor side cuts are made in the mucosa around neighboring teeth suffering from a periodontal recession. Extreme caution must be exercised to not split the interdental papilla, allowing for a connective tissue graft harvested from the palate to be placed in a papillary tunnel. The graft is anchored with interrupted sutures. Suspensory sutures should be employed to shift the mucosal flap coronally over the exposed sections of the connective tissue graft. Light, digital pressure is exerted on the graft for a short duration to enhance the graft's adaptation to the root surface and to maximize the graft surface in contact with the root (9).

For each case, several factors should be considered when selecting the surgical technique to achieve root coverage, for example, the arch form of the soft tissue, the position of the tooth, the depth and width of the recession, the thickness and quality of the apical and lateral tissue to the recession, aesthetic needs and compliance of the patient. From an aesthetic point of view, the coverage of the exposed root surface with soft tissues must be in harmony with the adjacent tissues. Therefore, a pedunculated graft is preferable because the gingiva color is a better match (9).

The coronally advanced flap technique consists of an intrasulcular incision made at the buccal aspect of the treated tooth and extended 3 mm horizontally in the mesial and distal interdental gingiva. Two oblique, divergent releasing incisions followed, extending beyond the mucogingival junction. A trapezoidal partial-thickness flap is then raised beyond the mucogingival junction to allow a passive coronal displacement of the flap, completely covering the cement-enamel junction. A sling suture stabilizes the flap in a coronal position, and interrupted sutures are placed on the releasing incisions (10).

The tunnel technique is specifically designed to address multiple and extensive gingival recessions typically found in jaw areas where achieving root coverage is challenging. Moreover, it aids in maintaining sufficient and steady blood flow to ensure optimal graft adaptation in the recipient area (11).

Both root coverage methods can use various graft types. The connective tissue graft is the most commonly used and is considered the gold standard for enhancing keratinized soft tissue gums. However, its main drawback is the need for a donor site, which may lead to postoperative complications (12).

In addition, many authors in the scientific community, such as Cairo et al. (13), Pini-Prato et al. (14), and Zucchelli et al. (15), confirm that the addition of connective tissue graft enhanced the clinical outcomes of the coronally advanced flap in terms of complete root coverage, providing a better long-term clinical outcome compared to coronally advanced flap alone.

The literature is not unanimous in comparing the coronally advanced flap and tunnel techniques. In fact, Toledano-Osorio et al. (16) state that the coronally advanced flap is more effective than the tunnel technique in terms of root coverage percentage; on the contrary, Mayta-Tovalino et al. (17) argue that the tunnel technique had similar primary and secondary outcomes compared to the coronally advanced flap.

Cairo et al. (18) confirm that both the tunnel technique and coronally advanced flap procedure with connective tissue graft showed the highest overall aesthetic performance for root coverage. However, graft integration might impair soft tissue color and appearance. Also, Gobbato et al. (19) demonstrated that both treatments with a subepithelial connective tissue graft had similar clinical efficacy regarding root coverage. In conclusion, our report shows that the tunnel technique has a long-term outcome in selected cases.

REFERENCES

1. Pini-Prato G, Baldi C, Pagliaro U, et al. Coronally advanced flap procedure for root coverage. Treatment of root surface: root planning versus polishing. *J Periodontol.* 1999;70(9):1064-1076. doi:https://doi.org/10.1902/jop.1999.70.9.1064
2. Naomi R, Ardhani R, Hafiyyah OA, Fauzi MB. Current Insight of Collagen Biomatrix for Gingival Recession: An Evidence-Based Systematic Review. *Polymers (Basel).* 2020;12(9):doi:https://doi.org/10.3390/polym12092081
3. Jati AS, Furquim LZ, Consolaro A. Gingival recession: its causes and types, and the importance of orthodontic treatment. *Dental Press J Orthod.* 2016;21(3):18-29. doi:https://doi.org/10.1590/2177-6709.21.3.018-029.oin
4. Cairo F, Nieri M, Cincinelli S, Mervelt J, Pagliaro U. The interproximal clinical attachment level to classify gingival recessions and predict root coverage outcomes: an explorative and reliability study. *J Clin Periodontol.* 2011;38(7):661-666. doi:https://doi.org/10.1111/j.1600-051X.2011.01732.x
5. Tavelli L, Barootchi S, Nguyen TVN, Tattan M, Ravida A, Wang HL. Efficacy of tunnel technique in the treatment of localized and multiple gingival recessions: A systematic review and meta-analysis. *J Periodontol.* 2018;89(9):1075-1090. doi:https://doi.org/10.1002/JPER.18-0066
6. Kasaj A. Etiology and Prevalence of Gingival Recession. In: *Gingival Recession Management*. Cham, Switzerland: Springer International Publishing; 2018. pp. 19–31.
7. Kassab MM, Cohen RE. The etiology and prevalence of gingival recession. *J Am Dent Assoc.* 2003;134(2):220-225. doi:https://doi.org/10.14219/jada.archive.2003.0137
8. Zuhr O, Rebele SF, Vach K, et al. Tunnel technique with connective tissue graft versus coronally advanced flap with enamel matrix derivate for root coverage: 2-year results of an RCT using 3D digital measuring for volumetric comparison of gingival dimensions. *J Clin Periodontol.* 2020;47(9):1144-1158. doi:https://doi.org/10.1111/jcpe.13328
9. Lang NP, Lindhe J. *Parodontologia Clinica e Implantologia orale*. Milan: Edi-Ermes; 2016.
10. Kuis D, Sciran I, Lajnert V, et al. Coronally advanced flap alone or with connective tissue graft in the treatment of single gingival recession defects: a long-term randomized clinical trial. *J Periodontol.* 2013;84(11):1576-1585. doi:https://doi.org/10.1902/jop.2013.120451
11. Parween S, George JP, Prabhuji M. Treatment of Multiple Mandibular Gingival Recession Defects Using MCAT Technique and SCTG With and Without rhPDGF-BB: A Randomized Controlled Clinical Trial. *Int J Periodontics Restorative Dent.* 2020;40(2):e43-e51. doi:https://doi.org/10.11607/prd.4505

12. Pazmino VFC, Rodas MAR, Caceres CDB, et al. Clinical Comparison of the Subepithelial Connective Tissue versus Platelet-Rich Fibrin for the Multiple Gingival Recession Coverage on Anterior Teeth Using the Tunneling Technique. *Case Rep Dent.* 2017;2017(4949710. doi:https://doi.org/10.1155/2017/4949710
13. Cairo F, Pagliaro U, Nieri M. Treatment of gingival recession with coronally advanced flap procedures: a systematic review. *J Clin Periodontol.* 2008;35(8 Suppl):136-162. doi:https://doi.org/10.1111/j.1600-051X.2008.01267.x
14. Pini-Prato G, Nieri M, Pagliaro U, et al. Surgical treatment of single gingival recessions: clinical guidelines. *Eur J Oral Implantol.* 2014;7(1):9-43.
15. Zucchelli G, Mounssif I, Mazzotti C, et al. Coronally advanced flap with and without connective tissue graft for the treatment of multiple gingival recessions: a comparative short- and long-term controlled randomized clinical trial. *J Clin Periodontol.* 2014;41(4):396-403. doi:https://doi.org/10.1111/jcpe.12224
16. Toledano-Osorio M, Munoz-Soto E, Toledano M, et al. Treating Gingival Recessions Using Coronally Advanced Flap or Tunnel Techniques with Autografts or Polymeric Substitutes: A Systematic Review and Meta-Analysis. *Polymers (Basel).* 2022;14(7):doi:https://doi.org/10.3390/polym14071453
17. Mayta-Tovalino F, Barboza JJ, Pasupuleti V, Hernandez AV. Efficacy of Tunnel Technique (TUN) versus Coronally Advanced Flap (CAF) in the Management of Multiple Gingival Recession Defects: A Meta-Analysis. *Int J Dent.* 2023;2023(8671484. doi:https://doi.org/10.1155/2023/8671484
18. Cairo F, Barootchi S, Tavelli L, et al. Aesthetic-And patient-related outcomes following root coverage procedures: A systematic review and network meta-analysis. *J Clin Periodontol.* 2020;47(11):1403-1415. doi:https://doi.org/10.1111/jcpe.13346
19. Gobbato L, Nart J, Bressan E, Mazzocco F, Paniz G, Lops D. Patient morbidity and root coverage outcomes after the application of a subepithelial connective tissue graft in combination with a coronally advanced flap or via a tunneling technique: a randomized controlled clinical trial. *Clin Oral Investig.* 2016;20(8):2191-2202. doi:https://doi.org/10.1007/s00784-016-1721-7

Case Report

SPLIT CREST TECHNIQUE: A 16-YEAR FOLLOW-UP CASE REPORT

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ABSTRACT

In most cases, alveolar atrophy is a result of tooth loss. To rehabilitate those areas, bone volume must be increased before inserting implants. The alveolar bone's width must be adequate to the optimally planned implant diameter. Several methods can be performed for bone augmentation, such as autogenous block or Guided Bone Regeneration (GBR). In addition to these methods, the Split Crest Technique (SCT) is a valid option for increasing bone width in atrophic alveolar crests, and it has several advantages. The present work describes a clinical case using the SCT and reviews the literature until now.

KEYWORDS: *mandible, jaw, split, crest, alveolus, graft*

INTRODUCTION

In long-time edentulous alveolar ridge segments, horizontal and vertical bone resorptions occur. Numerous studies have revealed that once a tooth is lost, the horizontal dimension of the alveolar bone significantly decreases. According to these studies, the alveolar ridge can reduce its width by 50%, corresponding to 5 to 7 mm (1-3). Today, there is general agreement that implant placement requires a minimal amount of 3 mm of surrounding bone. Simple fixture insertion is impossible when there is a mismatch between the alveolar bone's horizontal dimension and the implant's diameter.

Oral rehabilitation in areas with insufficient bone width is complex because dental implant osseointegration is highly predictable only when implants are surrounded by adequate bone (4). To achieve a predictable outcome, the crest's optimal width should allow at least a 1.5 mm bone frame after the implant is placed (5). If the width of the alveolar bone is not adequate to the optimally planned implant diameter, the case requires bone volume augmentation treatments.

Several methods can be performed for bone augmentation, such as autogenous block grafts obtained from intraoral sites or extraoral sites (6-9) or Guided Bone Regeneration (GBR) (10). These two methods present some disadvantages. For example, in the case of GBR, there are increased treatment costs, delay of implant placement, and, in some cases, exposure of the membrane with consequential infection. In the case of bone grafting, it is necessary to have a second surgery site to collect bone, a 6-month delay of implant placement to allow grafting material to heal, and a higher risk of dehiscence.

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An alternative approach to bone grafting and GBR has been developed to treat narrow alveolar ridges, called Split Crest Technique (SCT). It was first described by Nentwig in 1986 (11) and studied by G.B. Bruschi and A. Scipioni, who described the Edentulous Ridge Expansion technique (ERE) (12). This bone inlay grafting and implant placement technique consists of horizontal and vertical osteotomies to distance cortices (vestibular and palatal/lingual). This procedure allows for implant placement and introduction of biomaterials - such as bovine origin bone covered with collagen membrane. One of the main advantages is the reduction in the number of surgical procedures and the total treatment time for the patients. The closure is indeed by first intent, and this technique does not require a second surgical area to harvest bone grafts. Here, a clinical case is reported, and recent literature is discussed.

CASE REPORT

The patient was a healthy, non-smoking 64-year-old woman. Her dental history included a recent failure of a removable partial denture rehabilitation due to psychological and functional reasons. She complained of chewing difficulty because of a partial mandibular edentulism (missing teeth: 4.5, 4.6, 4.7) (Fig. 1).

The patient asked for functional rehabilitation and agreed to undergo bone regenerative therapy and the placement of a fixed prosthesis using endosteal fixtures.

Fig. 1. *Pre-op intraoral photography.*

The patient was rehabilitated with a bridge at the time of the visit. During clinical examination, a ridge defect with a reduction in the thickness of bone, which appeared to be thin, was diagnosed.

The Cone Beam Computed Tomography (CBCT) scan showed the horizontal defect (Fig. 2): in site 4.5, the thickness of the crest was 1-2 mm; in site 4.6, the same parameter was 1-2 mm, and in site 4.7 it was 2 mm.

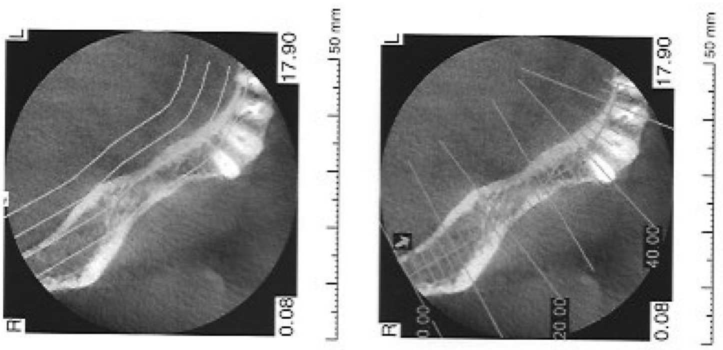

Fig. 2. *CT scan shows the horizontal defect.*

The panoramic X-ray showed the edentulous sites and a deep alveolar pocket on element 4.8. (Fig. 3).

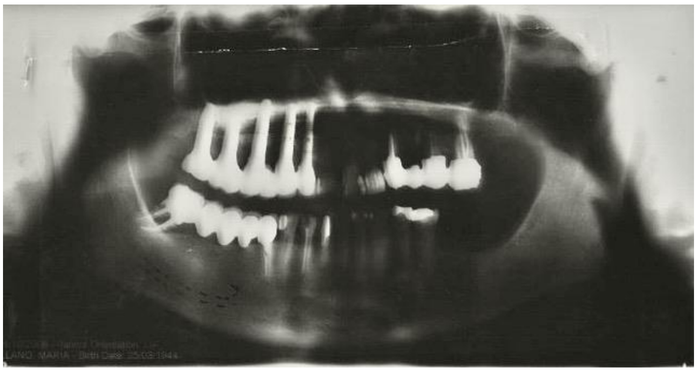

Fig. 3. *Panoramic X-ray.*

Severe horizontal bone defects in this location can be treated using techniques such as GBR or autogenous block grafts. For this patient, the best option seemed to be the SCT, which used ultrasonic devices and immediate implant placement.

The patient was treated with local anesthetics with adrenaline. A full-thickness mid-crest flap was incised with a vertical distal and mesial releasing incision to mobilize the flap (Fig. 4).

Fig. 4. *Mid-crest flap.*

The crestal osteotomy was executed using an ultrasonic device to a depth of 10 mm (Fig. 5). The CBCT showed that the mandibular canal was located at 13 mm. Two vertical osteotomies were also executed distally and mesially (Fig. 6). An apical osteotomy was also executed to avoid the fracture of the bone block during its mobilization (Fig. 7).

Fig. 5. *Horizontal osteotomy.*

Fig. 6. *Vertical osteotomy.*

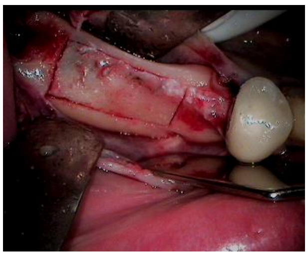

Fig. 7. *Apical osteotomy.*

Once the bone block was moved horizontally, the implant site was prepared to guarantee primary stability to the implants in their apical portions. In this case, the three implants placed were Replace Tapered (Nobel Biocare ®) conical implants (4,3 × 13 mm) with a Ti Unite surface. These implants were positioned in sites 4.6, 4.7, and 4.8 (previously extracted) (Fig. 8, 9).

The primary stability of the implants was excellent at 20 N. Filling materials between the lingual and vestibular pieces was unnecessary because the bone morphology created was a four-wall type: the clot was sufficient for bone regeneration.

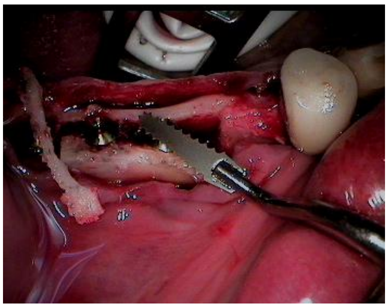

Fig. 8. *Implant placement*

Fig. 9. *Result after implant placement*

To obtain a passive closure with no tension, horizontal incisions of the periosteum were executed. Before this surgical procedure, it was essential to isolate the mental nerve.

The flap was sutured using the Glottlow technique (Fig. 10).

Fig. 10. *Glottlow technique.*

A control X-ray was executed (Fig. 11), and the patient was dismissed.

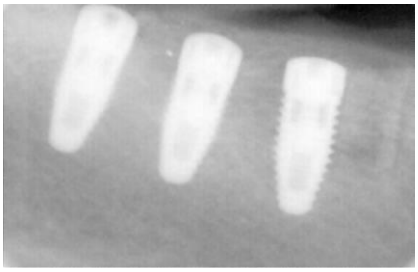

Fig. 11. *Control X-ray.*

The post-operative therapy was done with antibiotics (amoxicillin and clavulanic acid), chlorhexidine mouthwash, and painkillers. Three months later, healing caps were inserted (Fig. 12-14).

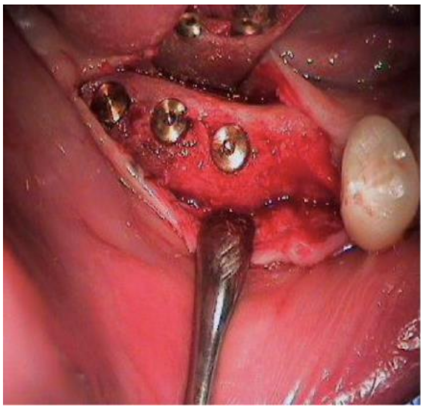

Fig. 12. *Elevation of the flap.*

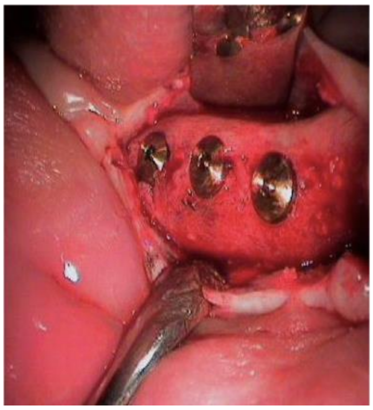

Fig. 13. *Regenerated alveolar.*

Fig. 14. *Closure with healing caps.*

A metal-ceramic prosthesis with an extension on element 4.5 was delivered (Fig.15). Since a lack of keratinized tissue was observed (Fig. 16), tissue grafting surgery was planned.

Fig.15. *Metal-ceramic prosthesis.*

Fig. 16. *Lack of keratinized tissue.*

Indeed, soft tissue grafting procedures result in more favorable peri-implant health: (i) for the gain of keratinized mucosa using autogenous grafts with a more significant improvement of bleeding indices and higher marginal bone levels; (ii) for the gain of mucosal thickness using autogenous grafts with significantly less marginal bone loss (13). First, the receiving site was prepared (Fig. 17). The connective graft (Fig. 18) was harvested from the palate (Fig. 19).

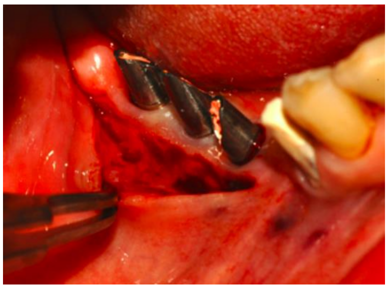

Fig. 17. *Receiving site.*

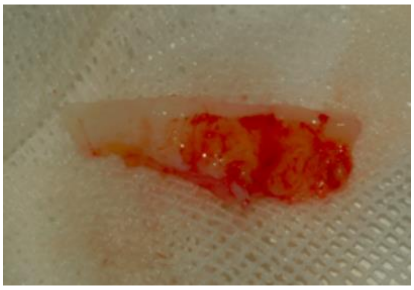

Fig. 18. *Connective graft.*

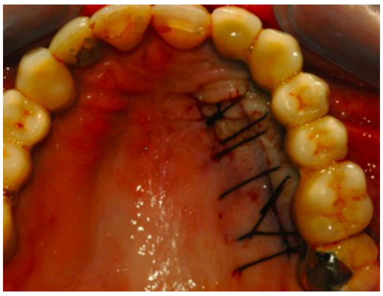

Fig. 19. *Palate.*

After placing the connective graft on the receiving site, a suture was performed (Fig. 20). The results one month later are reported in Fig. 21.

Fig. 20. *Suture.*

Fig. 21. *Results after one month.*

A 16-year follow-up demonstrated good results over time (Fig. 22, Fig. 23).

Fig. 22. *Intra-oral follow-up.*

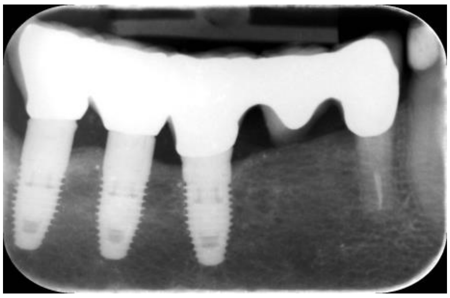

Fig. 23. *X-Ray follow-up.*

DISCUSSION

Many techniques have been developed in implantology to rehabilitate areas where bone width is insufficient due to bone atrophy. Among these, autogenous grafts are still considered the gold standard. Still, many studies have shown that SCT has numerous advantages, such as lower operating times, no need for a second surgical site, lower overall costs, no need for a second surgical time to insert implants, and lower patient complication risks.

The SCT proved viable and predictable, enabling a significant increase in ridge thickness and a high percentage of implant survival (14). It is recommended to treat width augmentation in areas of bone atrophy where the remnant thickness is around 3.0 mm (in such cases, the bone is easier to expand, and there is a lower fracture risk since it is more pliable).

Studies have also shown that this technique is especially useful for distal segments of the mandible (15). However, the mandible is the most affected area when it comes to unintended fracture of the vestibular segment (16). This can be attributed to the fact that the mandibular cortex is thicker and more brittle, so it is harder to split, resulting in a higher risk of fracture. The bone lacks elasticity when bone quality is reduced because the medullary layer is very thin. This can lead to fractures responsible for the loss of primary stability of implants (17). To prevent fracture, a longitudinal basal notch can be created on the surface of the vestibular bone. Even if a fracture occurred in the SCT, sufficient volume of the alveolar bone could be obtained without any rigid fixation of a free bone segment, and the dental implants placed within the fracture area showed a good prognosis (16). In addition, studies have shown that SCT with inlay bone block grafts promotes both the augmentation of hard tissues and the augmentation of soft tissues.

A low keratinized mucosa exposes a high risk of gingival recession and crestal bone loss. On the other hand, a correct amount of keratinized mucosa guarantees the maintenance of long-term stability, the aesthetic results of the implant, and an optimal blood supply. The correct blood supply is essential for wound healing without infections, and proper wound healing means keratinized mucosa gain (18).

According to the literature, the survival rate of implants installed in sites where the SCT was conducted varies from 93% to 100% (12).

SCT can be performed with many different instruments. One of the most advantageous is piezoelectric surgery. Its benefits are reduced bone consumption (≤ 0.5 mm) and selective cuts (i.e. bone can be cut, whereas soft tissues, including blood vessels, nerves, and mucosal tissues, remain unharmed) (19). In addition, the cavitation effect of piezoelectric devices increases visibility, and the vibrating tip can penetrate up to 12 mm of bone without risk of bone overheating (when gentle coming and going movements are performed) (20). A case report published in 2008 demonstrated that piezoelectric surgery used to perform SCT allowed a 4.8 mm ridge augmentation and contextual insertion of 3 implants with a safe and comfortable procedure (17). In 2005, an article that analyzed 230 clinical sites was published, demonstrating that the SCT with ultrasonic devices was highly predictable as 99.1% of the planned implants were successfully placed (20). In 2016, a systematic review (21) demonstrated that SCT effectively increases bone thickness; the average bone gain is 3.8 mm, independent of the surgical instruments used to cut bone.

The results of this case report agree with the literature, as the SCT performed using an ultrasonic device was successful, and the follow-up 16 years after the implants were placed shows that they are still stable.

REFERENCES

1. Johnson K. A study of the dimensional changes occurring in the maxilla following tooth extraction. *Aust Dent J.* 1969;14(4):241-244. doi:https://doi.org/10.1111/j.1834-7819.1969.tb06001.x
2. Pietrokovski J, Massler M. Alveolar ridge resorption following tooth extraction. *J Prosthet Dent.* 1967;17(1):21-27. doi:https://doi.org/10.1016/0022-3913(67)90046-7
3. Schropp L, Wenzel A, Kostopoulos L, Karring T. Bone healing and soft tissue contour changes following single-tooth extraction: a clinical and radiographic 12-month prospective study. *Int J Periodontics Restorative Dent.* 2003;23(4):313-323.
4. Branemark PI, Adell R, Breine U, Hansson BO, Lindstrom J, Ohlsson A. Intra-osseous anchorage of dental prostheses. I. Experimental studies. *Scand J Plast Reconstr Surg.* 1969;3(2):81-100. doi:https://doi.org/10.3109/02844316909036699
5. Nedir R, Bischof M, Briaux JM, Beyer S, Szmukler-Moncler S, Bernard JP. A 7-year life table analysis from a prospective study on ITI implants with special emphasis on using short implants. Results from private practice. *Clin Oral Implants Res.* 2004;15(2):150-157. doi:https://doi.org/10.1111/j.1600-0501.2004.00978.x
6. Felice P, Pistilli R, Lizio G, Pellegrino G, Nisii A, Marchetti C. Inlay versus onlay iliac bone grafting in atrophic posterior mandible: a prospective controlled clinical trial for comparing two techniques. *Clin Implant Dent Relat Res.* 2009;11 Suppl 1(e69-82. doi:https://doi.org/10.1111/j.1708-8208.2009.00212.x
7. Misch CM. Comparison of intraoral donor sites for onlay grafting prior to implant placement. *Int J Oral Maxillofac Implants.* 1997;12(6):767-776.
8. Pikos MA. Block autografts for localized ridge augmentation: Part I. The posterior maxilla. *Implant Dent.* 1999;8(3):279-285. doi:https://doi.org/10.1097/00008505-199903000-00009
9. Pikos MA. Block autografts for localized ridge augmentation: Part II. The posterior mandible. *Implant Dent.* 2000;9(1):67-75. doi:https://doi.org/10.1097/00008505-200009010-00012
10. Melcher AH. On the repair potential of periodontal tissues. *J Periodontol.* 1976;47(5):256-260. doi:https://doi.org/10.1902/jop.1976.47.5.256
11. Nentwig GH. [Technic of bone splitting for alveolar recession in anterior maxillary region]. *Quintessenz.* 1986;37(11):1825-1834.
12. Scipioni A, Bruschi GB, Calesini G, Bruschi E, De Martino C. Bone regeneration in the edentulous ridge expansion technique: histologic and ultrastructural study of 20 clinical cases. *Int J Periodontics Restorative Dent.* 1999;19(3):269-277.
13. Thoma DS, Naenni N, Figuero E, et al. Effects of soft tissue augmentation procedures on peri-implant health or disease: A systematic review and meta-analysis. *Clin Oral Implants Res.* 2018;29 Suppl 15(32-49. doi:https://doi.org/10.1111/clr.13114
14. de Souza CSV, de Sa BCM, Goulart D, Guillen GA, Macedo FGC, Noia CF. Split Crest Technique with Immediate Implant to Treat Horizontal Defects of the Alveolar Ridge: Analysis of Increased Thickness and Implant Survival. *J Maxillofac Oral Surg.* 2020;19(4):498-505. doi:https://doi.org/10.1007/s12663-020-01332-z
15. Agabiti I, Botticelli D. Two-Stage Ridge Split at Narrow Alveolar Mandibular Bone Ridges. *J Oral Maxillofac Surg.* 2017;75(10):2115 e2111-2115 e2112. doi:https://doi.org/10.1016/j.joms.2017.05.015
16. Shibuya Y, Yabase A, Ishida S, Kobayashi M, Komori T. Outcomes and treatments of mal fractures caused by the split-crest technique in the mandible. *Kobe J Med Sci.* 2014;60(2):E37-42.
17. Belleggia F, Pozzi A, Rocci M, Barlattani A, Gargari M. Piezoelectric surgery in mandibular split crest technique with immediate implant placement: a case report. *Oral Implantol (Rome).* 2008;1(3-4):116-123.
18. Guo Z, Chen L, Ning Y, et al. Split-crest technique with inlay bone block grafts for narrow posterior mandibles: a retrospective clinical study with a 3-year follow-up. *Am J Transl Res.* 2020;12(8):4628-4638.
19. Stubinger S, Robertson A, Zimmerer KS, Leiggener C, Sader R, Kunz C. Piezoelectric harvesting of an autogenous bone graft from the zygomaticomaxillary region: case report. *Int J Periodontics Restorative Dent.* 2006;26(5):453-457.

20. Blus C, Szmukler-Moncler S. Split-crest and immediate implant placement with ultra-sonic bone surgery: a 3-year life-table analysis with 230 treated sites. *Clin Oral Implants Res.* 2006;17(6):700-707. doi:https://doi.org/10.1111/j.1600-0501.2006.01206.x
21. Waechter J, Leite FR, Nascimento GG, Carmo Filho LC, Faot F. The split crest technique and dental implants: a systematic review and meta-analysis. *Int J Oral Maxillofac Surg.* 2017;46(1):116-128. doi:https://doi.org/10.1016/j.ijom.2016.08.017

Case Report

POST-EXTRACTIVE IMPLANT INSERTION, XENOGRAFT, AND PALATAL CONNECTIVE GRAFT FOR REHABILITATION OF POSTERIOR MANDIBULAR RIDGE

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ABSTRACT

Endodontic disease occurs when the dental pulp becomes infected and inflamed. During the progression, inflammation in the periapical area and periodontal ligament leads to tooth loss. In all cases of tooth loss, alveolar bone volume is lost. Various surgical treatments use bone graft material to recover the ridge bone volume. Graft material can be obtained from the patient's body (autologous graft), animals (xenograft), human cadavers (allograft), and synthetic materials (alloplastic bone graft). Xenograft material is derived from equine, porcine, or bovine and is deproteinized and further processed. Here, we report a case of a post-extractive implant insertion with a xenograft and palatal connective graft to rehabilitate the posterior alveolar crest of the mandible. Moreover, the literature is discussed.

KEYWORDS: *connective, tissue, graft, mandible, lower jaw, implant*

INTRODUCTION

Osteoclasts and osteoblasts are the main components responsible for the highly dynamic equilibrium between bone resorption and formation. The association between the tooth and periodontium also increases the complexity of alveolar bone remodeling. Pathogen invasion from the oral environment or hematogenous spread, mechanical stress from orthodontic treatments, medication, and systemic pathological factors can induce inflammation, which dictates the activities of osteoclasts and osteoblasts in alveolar bone, shifting the balance of bone homeostasis to increase bone resorption and decrease bone formation (1). Endodontic disease occurs when the dental pulp becomes infected and inflamed. During the progression, inflammation in the periapical area and periodontal ligament leads to tooth loss.

The volumetric reduction of the maxillary and mandibular bone, caused by tooth loss, imposes limitations on dental implants, constituting a key challenge in implantology. Guided Bone Regeneration (GBR) is a suitable therapeutic option to address this issue (2). Bone volume loss, ranging from 29% to 63% horizontally and 11% to 22% vertically six months after tooth loss, has led to the development of various techniques and biomaterials to correct these discrepancies.

Different approaches have been suggested for horizontal gain, including autologous and allogeneic block bone grafts, particulate autologous, xenogeneic, and alloplastic grafts, alveolar ridge expansion, and GBR. For vertical loss, alternatives such as short implants (less than 7 mm), lateralization of the inferior alveolar nerve, autologous bone grafting, distraction osteogenesis, growth factors usage, tissue engineering, and GBR have been described (3).

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Among these techniques, GBR stands out for its ability to reduce morbidity, unpredictability, and surgical complications. Autologous block bone grafts, while osteogenic, often require a second surgical site, increasing morbidity. Homogeneous, heterogeneous, and synthetic grafts exhibit osteoconductive properties, but when combined with autologous bone or growth factors, they promote the adherence and proliferation of osteoprogenitor cells. Therefore, limitations associated with autologous block bone grafts, such as surface resorption, limited bone availability, and morbidity, have led to adopting GBR, which overcomes these obstacles.

GBR, based on barrier membrane use, is a technique that promotes predictable and stable alveolar bone gain. The fundamental principle involves isolating the surgical site with a mechanical barrier, allowing the proliferation of osteogenic cells and bone formation. A successful procedure is based on four basic principles that must be ensured during surgery and throughout the healing process, according to Wang and Boyapati (4): primary closure, angiogenesis, space maintenance, and wound stability, known as the PASS principle (Primary Closure, Angiogenesis, Space Creation/Maintenance, Stability).

The bone gain associated with GBR protocols that combine bone grafts, Platelet-Rich Fibrin (PRF), and membranes for vertical and horizontal bone augmentation are particularly interesting. Recently, the association of PRF with regenerative procedures has been proposed, showing an increase in the concentration of growth factors and other molecules involved in tissue regeneration (5, 6). The results of recent studies have indicated that the use of PRF improves graft manipulation and stability, promotes soft tissue healing, and reduces complications such as membrane exposure (3).

Soft tissue grafting procedures are increasingly performed for various indications in conjunction with dental implant therapy, considering that the primary goal of implant therapy is to ensure long-term peri-implant health based on stable dimensions of peri-implant soft tissues, low bleeding indices, and stable levels of marginal bone (7).

The main clinical indications for soft tissue grafting include coverage of recessions, a gain of keratinized tissue (KT), and an increase in soft tissue volume. These periodontal surgical interventions are recommended to achieve favorable biological, functional, and aesthetic outcomes in the short and long term (7).

Plastic periodontal procedures to increase KT and augment soft tissue volume are well-documented (8). These interventions are indicated to establish biological and functional stability around teeth and implants, especially in conjunction with reconstructive therapies. The question of whether KT is necessary to maintain periodontal health around teeth and peri-implant health in dental implants has been a subject of controversy in the literature, citing various parameters to consider: stabilization and maintenance of biological health, prevention of recession, aesthetic aspects, and ease of cleaning the reconstruction (9).

For dental implants, previous reviews suggest that the lack of keratinized mucosa (KM) may not be crucial for maintaining the health of peri-implant soft tissues, may not be correlated with increased bone loss, or that, despite the presence of KM, peri-implantitis may occur (8). On the contrary, more recent clinical studies have concluded that a broader zone of KM may better preserve the stability of soft and hard tissues, may be more favorable for the long-term maintenance of dental implants, and that the lack of KM may lead to poorer oral hygiene (10), a higher risk of peri-implant alveolar bone loss, as well as clinical attachment loss and increased soft tissue recession (10).

Previous studies have highlighted that implant sites without an adequate band of KM exhibit increased susceptibility to inflammation and adverse peri-implant soft and hard tissue reactions (10). Furthermore, there is evidence that the width of peri-implant KM influences the immune response against external irritations (plaque accumulation) (10). This has led to a clinical recommendation of a 2 mm KM width, similar to the recommended keratinized gingiva zone as adequate around teeth (8). Therefore, surgical interventions to increase soft tissue volume are recommended, especially in aesthetically critical areas, to compensate for volume loss after tooth extraction and during implant therapy with immediate or delayed placement (7).

There are various effective methods and materials to increase KM at implant sites, yielding superior aesthetic results in peri-implant tissue color, maintenance or improvement of mucosal margin height, and preservation of papillae (8). This intervention can be performed before implant placement, simultaneously with the second surgical phase, or after the insertion of the final reconstruction (8). In general, there are two main methods to increase peri-implant soft tissue: 1. enlargement of KM width using an apically positioned flap/vestibuloplasty (in combination with a free gingival graft (FGG) or an allogeneic or xenogeneic graft material); 2. increase in soft tissue volume using a subepithelial connective tissue graft (SCTG) or soft tissue replacement grafts (10).

Four different time points can be distinguished to increase KM width or mucosal thickness around dental implants: (a) before implant placement, (b) during implant placement, (c) during the second surgical phase (re-entry), or (d) after the implant is osseointegrated, uncovered, and eventually already loaded (10). The first three protocols seem to lead to more predictable clinical outcomes, while the fourth may be challenged by aesthetic problems or complications such as mucositis or peri-implantitis (10).

Here we present a case of tooth extraction, implant insertion, xenograft placement, and palatal connective tissue graft is described, and the literature is discussed.

CASE REPORT

A 51-year-old woman presented with a vestibular lesion in element 4.4 and a swelling visible in Fig. 1. Elements 4.4, 4.5, and 4.6 presented good hygiene and a metal-ceramic prosthesis.

Fig. 1. *Intraoral photo of the fourth quadrant: visible vestibular swelling.*

Element 4.4 featured a metal-ceramic prosthesis and had a vestibular probing of 10mm. Nevertheless, the patient did not report pain on percussion, and the element had no mobility. As seen in Fig. 2, an endo-buccal X-ray was performed, highlighting appropriate root canal treatment with sealing of the root apex and reconstruction using a metal abutment pin. An area of radicular rarefaction was observed where the stump pin ended.

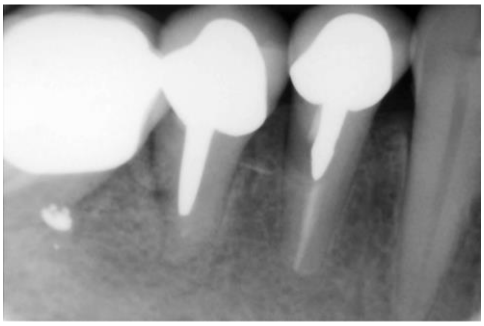

Fig. 2. *The Endobuccal X-ray included elements 4.3, 4.4, 4.5, and 4.6. Elements 4.4, 4.5, and 4.6 had a metal-ceramic prosthesis. In element 4.4, we saw a congruous root canal treatment is visible, with sealing of the root apex and a reconstruction using a metal abutment pin, with an area of root rarefaction where the abutment pin ended.*

Element 4.4 was difficult to recover as it presented an endodontic lesion, which manifested itself with a vestibular swelling. As seen in the X-ray, there was a rarefaction where the abutment pin ended. Furthermore, the lesion caused bone resorption at the vestibular level. For this reason, it was decided to extract the 4.4. The treatment plan was communicated to the patient, and element 4.4 was extracted and replaced with an implant. The metal-ceramic prosthesis on elements 4.5 and 4.6 were no longer suitable, and replacement was advised. The patient decided to proceed with the treatment of element 4.4 only.

The operation began with local plexus anesthesia with adrenaline. A full-thickness ridge flap was incised with a vertical mesial release incision at the level of 4.3. The flap was detached, and granulation tissue on the vestibular wall was noted (Fig. 3). Again, a bone lesion was observed at the vestibular level, highlighting a root perforation once the granulation tissue was removed. The extraction of element 4.4 was carried out to not damage the socket further (Fig. 4-6).

Fig. 3. *Full-thickness ridge flap with a vertical mesial release incision at the level of 4.3. There was granulation tissue with a bone lesion at the vestibular level.*

Fig. 4. *Granulation tissue was removed, and a root perforation was oberved.*

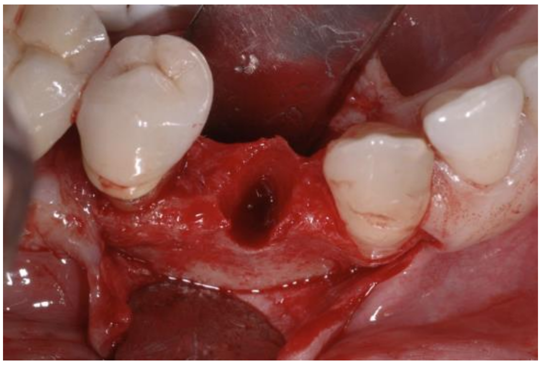

Fig. 5. *Post-extraction socket with a bone lesion in the vestibular wall.*

Fig. 6. *Element 44 with the metal-ceramic prosthesis.*

Immediately after the extraction, a 16 mm long conical implant with a 4.3 diameter from Nobel Biocare was inserted (Fig. 7).

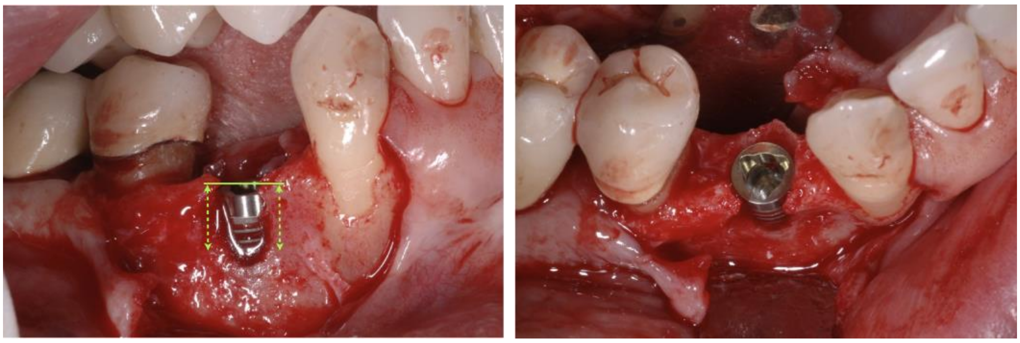

Fig. 7. *Intraoral photos of the positioned implant: On the left, the vestibular view highlighted the exposed part of the implant due to the bone lesion, and on the right, the implant from the occlusal point of view.*

The patient decided not to replace the prostheses in elements 4.5 and 4.6 yet; therefore, it was decided to submerge the implant and not carry out immediate loading. The bone lesion on the vestibular wall of element 4.4 was reconstructed with a xenograft of bovine origin stabilized with platelet derivatives (PRF) (Fig. 8).

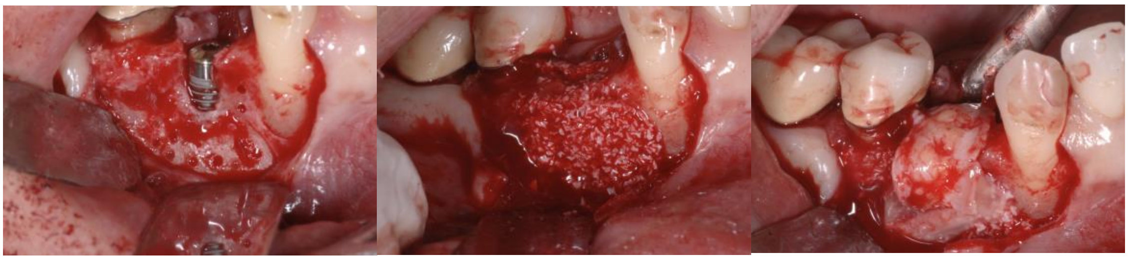

Fig. 8. *Reconstruction of the vestibular wall 4.4 with a xenograft of bovine origin stabilized with PRF*.

The aim was to close the alveolus without mobilizing the vestibular flap to avoid decreasing the depth of the vestibule and obtaining passive closure of the wound. For this reason, it was decided to add subepithelial connective tissue, which connects the lingual flap to the vestibular flap, to guarantee the primary intention of healing the wound.

A connective tissue sample was taken from the palate positioned over the fixture and sutured with the buccal and lingual flap (Fig. 9).

Fig. 9. *Subepithelial connective tissue was taken from the palate, positioned over the implant fixture, and sutured with the buccal and lingual flap.*

One month after the operation, the area of the fourth quadrant affected by the operation is visible. In Fig. 10, a good amount of keratinized gum has completely closed the wound by primary intention.

Fig. 10. *Healing after a month: a good amount of keratinized gum completely closed the wound by primary intention.*

After two months, the implant was uncovered, and a cemented metal-ceramic crown was made. For control, an endobuccal X-ray was performed, and an intraoral photo was taken (Fig. 11, 12).

Fig. 11. *Endobuccal X-ray after placing a cemented metal-ceramic crown on the implant in position 4.4. The old prostheses on elements 4.5 and 4.6 was still visible.*

Fig. 12. *Intraoral photo after treatment.*

DISCUSSION

Alveolar bone atrophy is a challenging problem in implantologists' daily practice. Several options are available to restore the alveolar crest. All aim to restore bone quantity and keratinized gingival amount around the fixture in order to guarantee long-term clinical success. Consequently, bone, membrane, and autologous tissue are managed to reach an appropriate alveolar ridge restoration.

Recent systematic reviews conducted on vertical augmentation with GBR and bone grafts have found that in patients with vertical atrophy of the mandibular ridges undergoing onlay-type bone augmentation, GBR with particulate grafting leads to greater bone gain and less superficial bone resorption compared to intraoral autologous bone grafts. This assessment was initially based on measurements of bone gain and resorption rates, followed by an examination of complications, implant survival, success, and peri-implant marginal bone loss through radiographic analysis (2). Despite its limitations, GBR appears to be the most effective technique for bone regeneration, achieving greater bone gain with less superficial resorption and fewer complications.

The choice of membranes in GBR is crucial for treatment success, with current efforts focused on creating new membranes using natural materials or tissue engineering principles. Once bone particles can support space maintenance and stability of the fibrin clot formed at the surgical site, membranes are typically used over the grafted material. A recent study suggests that the membrane is a bioactive compartment facilitating cell attraction, releasing signals and growth factors for remodeling, regeneration, and vascularization (11).

Membranes are classified as resorbable or non-resorbable based on the type of material used: synthetic (polymer-derived) or animal-derived. The most commonly used resorbable membranes are obtained from type I collagen or a combination of type I and III collagens from bovine tendons, bovine dermis, sheepskin, or porcine dermis. The most used non-resorbable membranes are high-density polytetrafluoroethylene (PTFE-d) with or without titanium reinforcement, providing effective barrier function, supporting space maintenance, and being biocompatible. Still, they need to be removed, resulting in the disadvantage of a second surgical intervention (3).

Some studies (12) comparing bone gain after GBR procedures in sites with and without membrane exposure reveal that sites without membrane exposure achieved significantly more horizontal bone gain in edentulous ridges and a more significant reduction in peri-implant bone dehiscence compared to sites with exposed membranes. In GBR, grafts are combined with a barrier that can be either a non-resorbable membrane (13) or a resorbable membrane (14). One such technique uses a block bone graft (9) and a ridge-split technique (15). Subsequently, the use of distraction osteogenesis to increase the edentulous crest was proposed (16, 17), and recently, the "sandwich" technique has been described to regenerate horizontal and vertical bone defects in peri-implant sites (18). Furthermore, a novel strategy of this surgery was introduced to improve unsuccessful attempts to correct severely resorbed mandibles: soft tissue matrix expansion grafting, otherwise known as “tent pole graft”. The problem was the inadequate soft tissue volume, which contracts following surgical expansion when a graft is introduced.

Onlay grafts underwent physiological resorption due to the remodeling process, resulting in a net loss of bone caused by the soft tissue's contraction around the graft. With Tent Pole technique, bone grafts consolidate and maintain their volume with dental implants, creating a tenting effect. This offers a predictable long-term reconstruction of the severely resorbed mandible without the complications observed with other approaches (19).

Long-term follow-up studies have confirmed the stability of grafts and their ability to maintain bone height. In a report, 64 cases of bone grafts utilizing the tenting graft concept were described, each with a minimum 3-year follow-up. No fractures occurred, and all bone grafts maintained their height, exhibiting increased radiographic density over time. Of these 64 cases, 356 dental implants were placed, with 354 (99.5%) successfully osseointegrated and laoded (20). The authors have highlighted the effectiveness of the tenting graft in various situations, including implant site preparation and reconstruction of severely resorbed mandibles. In conclusion, this method involves a surgical expansion of soft tissue, preventing contraction around grafts and ensuring a stable increase in vertical bone height over time (20).

In addition to bone graft, thick, soft tissues play a crucial role: thicker soft tissues have a greater volume of extracellular matrix and collagen and increased vascularity, which promotes the elimination of toxic products and enhances the immune response. Therefore, it has been demonstrated that thicker soft tissues respond more favorably to wound healing, flap management, and restorative trauma, especially in implant surgery (21-24). Therefore, surgical procedures to increase soft tissue volume are recommended, especially in aesthetically critical areas, to compensate for volume loss after tooth extraction and during implant therapy (7).

Techniques for soft tissue augmentation using different materials, such as subepithelial connective tissue grafts, xenogeneic collagen matrix, or acellular dermal matrix, are discussed. Various studies compare the effectiveness of these techniques in improving peri-implant tissue parameters, such as buccal tissue thickness, mid-buccal gingival level, marginal bone loss, KT width, and Pink Esthetic Score. Subepithelial connective tissue grafts and immediate or delayed implant placement have shown significant improvement in buccal tissue thickness (24).

Furthermore, subepithelial connective tissue can be used not only to increase the quantity and quality of soft tissues around natural teeth or implants but also to close flaps passively without resorting to apical repositioning of the flap, with possible consequences of decreasing vestibular depth and scarring of vertical incisions, which can be aesthetically challenging, especially in the anterior areas where aesthetics plays a crucial role.

CONCLUSIONS

In conclusion, rehabilitating edentulism through bone reconstructions, soft tissue grafts, and osseointegrated implants has transformed dentistry and improve patients' quality of life.

REFERENCES

1. Li Y, Ling J, Jiang Q. Inflammasomes in Alveolar Bone Loss. *Frontiers in Immunology*. 2021;12. doi:https://doi.org/10.3389/fimmu.2021.691013
2. Robert L, A. Aloy-Prósper, S. Arias-Herrera. Vertical augmentation of the atrophic posterior mandibular ridges with onlay grafts: Intraoral blocks vs. guided bone regeneration. Systematic review. *Journal of Clinical and Experimental Dentistry*. 2023;15(5):e357-365. doi:https://doi.org/10.4317/jced.60294
3. Amaral Valladão CA, Freitas Monteiro M, Joly JC. Guided bone regeneration in staged vertical and horizontal bone augmentation using platelet-rich fibrin associated with bone grafts: a retrospective clinical study. *International Journal of Implant Dentistry*. 2020;6(1). doi:https://doi.org/10.1186/s40729-020-00266-y
4. Wang HL, Boyapati L. "PASS" Principles for Predictable Bone Regeneration. *Implant Dentistry*. 2006;15(1):8-17. doi:https://doi.org/10.1097/01.id.0000204762.39826.0f
5. Miron RJ, Fujioka-Kobayashi M, Bishara M, Zhang Y, Hernandez M, Choukroun J. Platelet-Rich Fibrin and Soft Tissue Wound Healing: A Systematic Review. *Tissue Engineering Part B: Reviews*. 2017;23(1):83-99. doi:https://doi.org/10.1089/ten.teb.2016.0233
6. Al-Hamed FS, Mahri M, Al-Waeli H, Torres J, Badran Z, Tamimi F. Regenerative Effect of Platelet Concentrates in Oral and Craniofacial Regeneration. *Frontiers in Cardiovascular Medicine*. 2019;6(1). doi:https://doi.org/10.3389/fcvm.2019.00126
7. Thoma DS, Naenni N, Figuero E, et al. Effects of soft tissue augmentation procedures on peri-implant health or disease: A systematic review and meta-analysis. *Clinical Oral Implants Research*. 2018;29:32-49. doi:https://doi.org/10.1111/clr.13114
8. Thoma DS, Buranawat B, Hämmerle CHF, Held U, Jung RE. Efficacy of soft tissue augmentation around dental implants and in partially edentulous areas: a systematic review. *Journal of Clinical Periodontology*. 2014;41:S77-S91. doi:https://doi.org/10.1111/jcpe.12220
9. Misch CM. Comparison of intraoral donor sites for onlay grafting prior to implant placement. *The International Journal of Oral & Maxillofacial Implants* . 1998;12(6):767-776.
10. Bassetti RG, Stähli A, Bassetti MA, Sculean A. Soft tissue augmentation around osseointegrated and uncovered dental implants: a systematic review. *Clinical Oral Investigations*. 2016;21(1):53-70. doi:https://doi.org/10.1007/s00784-016-2007-9
11. Elgali I, Omar O, Dahlin C, Thomsen P. Guided bone regeneration: materials and biological mechanisms revisited. *European Journal of Oral Sciences*. 2017;125(5):315-337. doi:https://doi.org/10.1111/eos.12364
12. Garcia J, Dodge A, Luepke P, Wang HL, Kapila Y, Lin GH. Effect of membrane exposure on guided bone regeneration: A systematic review and meta-analysis. *Clinical Oral Implants Research*. 2018;29(3):328-338. doi:https://doi.org/10.1111/clr.13121
13. Buser D, Bragger U, Lang NP, Nyman S. Regeneration and enlargement of jaw bone using guided tissue regeneration. *Clinical Oral Implants Research*. 1990;1(1):22-32. doi:https://doi.org/10.1034/j.1600-0501.1990.010104.x
14. Mellonig JT, Nevins M. Guided bone regeneration of bone defects associated with implants: an evidence-based outcome assessment. *The International Journal of Periodontics & Restorative Dentistry* . 1995;15(2):168-185.
15. Simion M, Baldoni M, Zaffe D. Jawbone enlargement using immediate implant placement associated with a split-crest technique and guided tissue regeneration. *The International Journal of Periodontics & Restorative Dentistry*. 1992;12(6):462-473.
16. Chiapasco M, Romeo E, Vogel G. Vertical distraction osteogenesis of edentulous ridges for improvement of oral implant positioning: a clinical report of preliminary results. *The International Journal of Oral & Maxillofacial Implants*. 2001;16(1):43-51.
17. Chin M. Distraction osteogenesis for dental implants. *Atlas of the Oral and Maxillofacial Surgery Clinics of North America*. 1999;7(1):41-63.
18. Wang HL, Misch C, Neiva RF. "Sandwich" bone augmentation technique: rationale and report of pilot cases. *The International Journal of Periodontics & Restorative Dentistry*. 2004;24(3):232-245.
19. Marx RG, Shellenberger TD, Wimsatt JI, Correa P. Severely resorbed mandible: Predictable reconstruction with soft tissue matrix expansion (tent pole) grafts. *Journal of Oral and Maxillofacial Surgery*. 2002;60(8):878-888. doi:https://doi.org/10.1053/joms.2002.33856
20. Daga D, Mehrotra D, Mohammad S, Singh G, Natu SM. Tentpole technique for bone regeneration in vertically deficient alveolar ridges: A review. *Journal of Oral Biology and Craniofacial Research*. 2015;5(2):92-97. doi:https://doi.org/10.1016/j.jobcr.2015.03.001
21. Chappuis V, Araújo MG, Buser D. Clinical relevance of dimensional bone and soft tissue alterations post-extraction in esthetic sites. *Periodontology 2000*. 2016;73(1):73-83. doi:https://doi.org/10.1111/prd.12167
22. BY. Herrera-Serna, OP. López-Soto, T. Chacón, AM. Montoya-Gómez, D. Agudelo-Flórez, OH. Zuluaga-López. Relationship between the gingival biotype and the results of root covering surgical procedures: A systematic review. *Journal of Clinical and Experimental Dentistry*. 2022;14(9):e762-e768. doi:https://doi.org/10.4317/jced.59783
23. Younes F, Eghbali A, Raes M, De Bruyckere T, Cosyn J, De Bruyn H. Relationship between buccal bone and gingival thickness revisited using non-invasive registration methods. *Clinical Oral Implants Research*. 2016;27(5):523-528. doi:https://doi.org/10.1111/clr.12618
24. Aldhohrah T, Qin G, Liang D, et al. Does simultaneous soft tissue augmentation around immediate or delayed dental

implant placement using sub-epithelial connective tissue graft provide better outcomes compared to other treatment options? A systematic review and meta-analysis. Al-Moraissi E, ed. *PLOS ONE*. 2022;17(2):e0261513. doi:https://doi.org/10.1371/journal.pone.0261513

Original Article

HISTOLOGICAL ASPECTS OF AUTOLOGOUS BONE UNDER BONE LAMINA

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ABSTRACT

Autologous bone appears to be the most predictable and successful material available. The main problem concerning its use is its availability, but with autologous bone, there are no immunologic reactions or risks of disease transmission. The authors present a histological study of autologous bone used in ridge augmentation associated with bone lamina. Twenty patients participated in this study, and all gave their informed consent. In all patients, autologous bone was obtained during implant bed preparation in association with bone lamina in lateral and vertical ridge augmentation procedures. After 12 months, a small biopsy of the regenerated tissues was carried out. Histologically, almost all particles of autologous bone were surrounded by newly formed bone; all particles had been surrounded by new bone or undergoing remodeling. In conclusion, we observed that autologous bone used in ridge augmentation procedures under bone lamina membranes presented excellent osteoconductive properties: all the particles were surrounded by newly formed bone.

KEYWORDS: *autologous bone, bone lamina, bone regeneration, remodeling*

INTRODUCTION

Insufficient bone amount of bone is one of the most significant clinical challenges in dental implantology (1). Alveolar distraction osteogenesis, guided bone regeneration (GBR), and onlay grafting have been described to augment the horizontal and vertical bone volume (2). Trauma, surgery for tumors, or periodontal pathologies cause resorption of the alveolar process or, in severe cases, resorption of native bone may produce insufficient bone volume or unfavorable vertical, transverse, and/or sagittal inter-arch relationships for dental implant placement (3).

Various graft materials have been effectively used for bone regeneration, including xenografts, alloplasts, and allografts, but autologous bone is considered a gold standard. Autologous bone (AB) grafting is the gold-standard technique and appears to be the best type of graft used in bone regeneration (4), and is the most predictable and successful material

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available (5-8). In implant surgery, the reported benefits of AB graft include accelerated wound healing and the regeneration of new bone and soft tissue following tissue injury because it contains viable osteogenic cells, intrinsic growth factors, and a scaffold that collectively promotes new bone formation (9). However, autologous bone graft can present various disadvantages, including limited grafted bone and procedure time. Moreover, a year after the regenerative procedure, bone reabsorption happens in 40% (10).

Usually, the intraoral area is the main site of autologous bone donation, including maxillary tuberosity, mandibular symphysis, and ascending ramus of the mandible. Also, the iliac crest graft and calvarial graft have been used in major surgeries because of the large amount of donated bone (11). The autologous harvested bone contains cortical bone and cancellous bone. Cancellous bone is rapidly revascularized, and this type of bone is resorbed and replaced by creeping substitution, while cortical bone appears to be revascularized very slowly (12).

The main problems concerning the use of autologous bone are its availability (13), infections, a limited amount of donor bone tissue, the need for a second surgery site for bone graft harvest, bleeding, and chronic pain. For this reason, many other types of materials have been used as substitutes for autologous bone (2, 13-15).

However, autologous bone remains the gold standard in bone regeneration due to its osteogenic, osteoinductive, and osteoconductive properties (16), growth factors, and the fact that it does not cause immunogenic reactions (17). Autologous bones are classified according to their intraoral or extraoral origin and endochondral or membranous according to their embryologic origin. In implantology, the most frequently used intraoral donor sites are the chin and body or ramus of the mandible; the main disadvantage is their high number of postoperative complications (18, 19).

The present study aimed to perform a histologic study in man to analyze the healing features and remodeling patterns of autologous bone used under bone lamina membranes in ridge augmentation procedures.

MATERIALS AND METHODS

Twenty patients participated in this study (mean age 48; range 32 to 72). All gave their informed consent. In all patients, autologous bone was obtained during implant bed preparation in association with Bone Lamina (OsteoBiol by Tecnoss, Italy) in lateral and vertical ridge augmentation procedures (Fig. 1, 2).

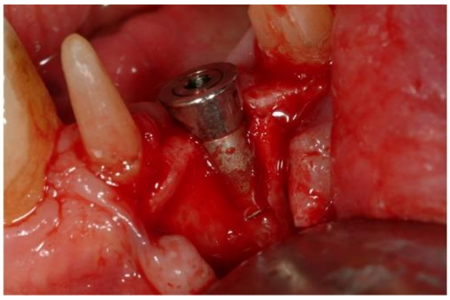

Fig. 1. *Vestibular bone defect.*

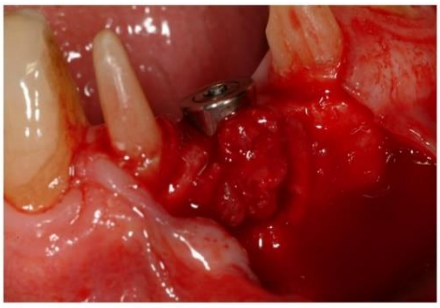

Fig. 2. *Bone defect treated with autologous bone before placement of the bone lamina.*

After 12 months, a small biopsy of the regenerated tissues was carried out at implant insertion. The specimens were retrieved, washed in saline solution, and immediately fixed in 4% paraformaldehyde and 0.1% glutaraldehyde in 0.15 M cacodylate buffer al 4°C and pH 7.4 to be processed for histology. The specimens were processed to obtain thin ground sections with the Precise 1 Automated System (Assing, Rome, Italy) (20). The specimens were dehydrated in an ascending series of alcohol rinses and embedded in a glycolmethacrylate resin (Technovit 7200 VLC, Kulzer, Germany). After polymerization, the specimens were sectioned with a high-precision diamond disc at about 150 μm and ground down to about 30 μm. The slides were stained with basic fuchsin, toluidine blue, and von Kossa. The histochemical analysis of acid and alkaline phosphatases was carried out according to a previously described protocol (21).

RESULTS

In many histological samples, it was possible to see that almost all particles of autologous bone were surrounded by newly formed bone. In some fields, it was possible to see that this newly formed bone was lined by a rim of osteoblasts that was positive for alkaline phosphatase. No osteoclasts or macrophages positive to acid phosphatase were present. A resorption phenomenon was present. In many areas, it was possible to observe the presence of compact, mature cortical bone that could be easily differentiated from the newly formed bone. The grafted bone presented different structure and maturation features from the regenerated bone: it had a lesser affinity for dyes and a basic fuchsin-positive, highly stained line, similar to the cementing lines, divided the grafted from the regenerated bone (Fig. 3).

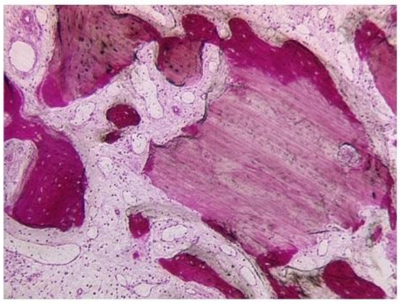

Fig. 3. *Autologous bone is easily recognized due to its lesser staining affinity than newly formed bone. Basic fuchsin-toluidine blue 100 X.*

These lines had higher staining than the cementing lines observed in normal bone. The biological fluid colonized the bone plate, which was also present, and in several areas, it was in direct contact with the new bone.

DISCUSSION

The present study shows that all particles of autologous bone were always surrounded by newly-formed bone, and several areas showed a resorption process. The underlying cellular mechanisms that trigger graft resorption remain to be elucidated. In the present study, we show graft resorption could plausibly be compared to bone resorption during physiological remodeling (22). Much remains elusive with regard to the underlying cellular mechanisms that trigger graft resorption. The old or damaged bone is resorbed by osteoclast during bone remodeling. This is a desirable effect because resorption is coupled with bone formation during physiological bone remodeling.

Autogenous bone is currently the only osteogenic material available (23). The biology and biomechanics of bone healing are complex and currently considered that successful bone healing requires the presence of viable osteogenic cells and appropriate connective tissue matrix, adequate vascularity, the presence of multiple growth factors that have both temporal and particular specificity within the fracture site, and appropriate degree of mechanical stability (24). Viable bone cells have been found in borings collected from implant cavities (25).

Autogenous bone from the iliac crest appears to be the best material for sinus-lift procedures (24), treatment of dehiscences and fenestrations around dental implants (24), and vertical ridge augmentation around dental implants (3). Autologous bone is inert, does not produce immunologic reactions, is replaced by osteoclastic resorption and bone formation, presents cell viability and a decreased time for revascularization, resorption, and replacement, and has no risks of disease transmission (26).

Our histological results show a very high osteoconductivity of the autologous bone: all the particles were always surrounded by newly formed bone, and the latter was firmly attached to the former (27, 28). It was possible to find a regular cement line at the interface between the autologous and the newly formed bone (28). These lines occasionally had a crenated appearance, which osteoclastic resorption could explain this phenomena before bone formation. The bone regeneration with autologous bone had the most significant bone regeneration (26). Cortical bone becomes revascularized much slower than cancellous bone (26, 28).

The cortical portion is revascularized slowly through the Haversian system and remodeled by cortical bone-modeling units (28). Allografts, on the other hand, are replaced slowly. There is a host immune response, and the failure of all forms of allografts is significantly higher than that of autografts (26). Autologous bone can be mixed with platelet concentrates to improve bone healing (29).

CONCLUSIONS

In conclusion, we observed that autologous bone used in ridge augmentation procedures under bone lamina membranes was excellently osteoconductive: all the particles were surrounded by newly formed bone.

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REFERENCES

1. Malchiodi L, Scarano A, Quaranta M, Piattelli A. Rigid fixation using titanium mesh in edentulous ridge expansion for horizontal ridge augmentation in the maxilla. *Int J Oral Maxillofac Implants.* 1998;13(5):701-705.
2. Simion M, Dahlin C, Trisi P, Piattelli A. Qualitative and quantitative comparative study on different filling materials used in bone tissue regeneration: a controlled clinical study. *Int J Periodontics Restorative Dent.* 1994;14(3):198-215.
3. Scarano A, Carinci F, Assenza B, Piattelli M, Murmura G, Piattelli A. Vertical ridge augmentation of the atrophic posterior mandible using an inlay technique with a xenograft without miniscrews and miniplates: case series. *Clin Oral Implants Res.* 2011;22(10):1125-1130. doi:https://doi.org/10.1111/j.1600-0501.2010.02083.x
4. Becker W, Dahlin C, Becker BE, et al. The use of e-PTFE barrier membranes for bone promotion around titanium implants placed into extraction sockets: a prospective multicenter study. *Int J Oral Maxillofac Implants.* 1994;9(1):31-40.
5. Triplett RG, Schow SR. Autologous bone grafts and endosseous implants: complementary techniques. *J Oral Maxillofac Surg.* 1996;54(4):486-494. doi:https://doi.org/10.1016/s0278-2391(96)90126-3
6. Bell RB, Blakey GH, White RP, Hillebrand DG, Molina A. Staged reconstruction of the severely atrophic mandible with autogenous bone graft and endosteal implants. *J Oral Maxillofac Surg.* 2002;60(10):1135-1141. doi:https://doi.org/10.1053/joms.2002.34986
7. Sethi A, Kaus T. Ridge augmentation using mandibular block bone grafts: preliminary results of an ongoing prospective study. *Int J Oral Maxillofac Implants.* 2001;16(3):378-388.
8. Behneke A, Behneke N, d'Hoedt B. Treatment of peri-implantitis defects with autogenous bone grafts: six-month to 3-year results of a prospective study in 17 patients. *Int J Oral Maxillofac Implants.* 2000;15(1):125-138.
9. Chen X, Wang H, Wang Y, Shi Y, Wang Z. Enhanced osteogenesis by addition of cancellous bone chips at xenogenic bone augmentation: In vitro and in vivo experiments. *Clin Oral Implants Res.* 2023;34(1):42-55. doi:https://doi.org/10.1111/clr.14017
10. Stricker A, Jacobs R, Maes F, Fluegge T, Vach K, Fleiner J. Resorption of retromolar bone grafts after alveolar ridge augmentation-volumetric changes after 12 months assessed by CBCT analysis. *Int J Implant Dent.* 2021;7(1):7. doi:https://doi.org/10.1186/s40729-020-00285-9
11. Valentini V, Cassoni A, Marianetti TM, Romano F, Terenzi V, Iannetti G. Reconstruction of craniofacial bony defects using autogenous bone grafts: a retrospective study on 233 patients. *J Craniofac Surg.* 2007;18(4):953-958. doi:https://doi.org/10.1097/scs.0b013e3180690123
12. OT J. Guided bone graft augmentation. *Guid Bone Regen Implant Dent.* 1994;235–264.
13. Simion M, Trisi P, Piattelli A. Vertical ridge augmentation using a membrane technique associated with osseointegrated implants. *Int J Periodontics Restorative Dent.* 1994;14(6):496-511.
14. Simion M, Trisi P, Piattelli A. GBR with an e-PTFE membrane associated with DFDBA: histologic and histochemical analysis in a human implant retrieved after 4 years of loading. *Int J Periodontics Restorative Dent.* 1996;16(4):338-347.
15. Camelo M, Nevins ML, Lynch SE, Schenk RK, Simion M, Nevins M. Periodontal regeneration with an autogenous bone-Bio-Oss composite graft and a Bio-Gide membrane. *Int J Periodontics Restorative Dent.* 2001;21(2):109-119.
16. Schwarz N, Schlag G, Thurnher M, Eschberger J, Dinges HP, Redl H. Fresh autogeneic, frozen allogeneic, and decalcified allogeneic bone grafts in dogs. *J Bone Joint Surg Br.* 1991;73(5):787-790. doi:https://doi.org/10.1302/0301-620X.73B5.1894667
17. Clarke B. Normal bone anatomy and physiology. *Clin J Am Soc Nephrol.* 2008;3 Suppl 3(Suppl 3):S131-139. doi:https://doi.org/10.2215/CJN.04151206
18. Inchingolo AM, Patano A, Di Pede C, et al. Autologous Tooth Graft: Innovative Biomaterial for Bone Regeneration. Tooth Transformer((R)) and the Role of Microbiota in Regenerative Dentistry. A Systematic Review. *J Funct Biomater.* 2023;14(3):doi:https://doi.org/10.3390/jfb14030132

19. Inchingolo AD, Inchingolo AM, Bordea IR, et al. The Effectiveness of Osseodensification Drilling Protocol for Implant Site Osteotomy: A Systematic Review of the Literature and Meta-Analysis. *Materials (Basel).* 2021;14(5):doi:https://doi.org/10.3390/ma14051147
20. Scarano A, Quaranta M, Piattelli A. Bone sectioning using the precise 1 automated cutting system. *Handb Histol Methods Bone Cartil.* 2003;265-269.
21. Borges FL, Dias RO, Piattelli A, et al. Simultaneous sinus membrane elevation and dental implant placement without bone graft: a 6-month follow-up study. *J Periodontol.* 2011;82(3):403-412. doi:https://doi.org/10.1902/jop.2010.100343
22. Andersen TL, Abdelgawad ME, Kristensen HB, et al. Understanding coupling between bone resorption and formation: are reversal cells the missing link? *Am J Pathol.* 2013;183(1):235-246. doi:https://doi.org/10.1016/j.ajpath.2013.03.006
23. Misch CE, Dietsh F. Bone-grafting materials in implant dentistry. *Implant Dent.* 1993;2(3):158-167. doi:https://doi.org/10.1097/00008505-199309000-00003
24. Wheeler SL, Holmes RE, Calhoun CJ. Six-year clinical and histologic study of sinus-lift grafts. *Int J Oral Maxillofac Implants.* 1996;11(1):26-34.
25. Lauer G, Schili W. Collected Implant Cavity Borings Used as Peri-Implant Osseous Augmentation Material. *Int J Oral Maxillofac Implants.* 1994;9
26. Becker W, Becker BE, Polizzi G, Bergstrom C. Autogenous Bone Grafting of Bone Defects Adjacent to Implants Placed Into Immediate Extraction Sockets in Patients: A Prospective Study. *Int J Oral Maxillofac Implants.* . 1994;9(4):
27. Schenk R. Bone regeneration: biologic basis. *Guid Bone Regen Implant Dent.* 1994;
28. Buser D, Sennerby L, De Bruyn H. Modern implant dentistry based on osseointegration: 50 years of progress, current trends and open questions. *Periodontol 2000.* 2017;73(1):7-21. doi:https://doi.org/10.1111/prd.12185
29. Ucer C, Khan RS. Alveolar Ridge Preservation with Autologous Platelet-Rich Fibrin (PRF): Case Reports and the Rationale. *Dent J (Basel).* 2023;11(10):doi:https://doi.org/10.3390/dj11100244