SPLIT-RIDGE TECHNIQUE AND GUIDED BONE REGENERATION: CURRENT INDICATIONS AND PREDICTABILITY

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ABSTRACT:

Introduction: Guided bone regeneration (GBR) is the most well documented method of bone augmentation in localized bone defects. Split-ridge technique (SRT) is an alternative option to treat alveolar ridge deficiencies and provide condition for implant placement. Both procedures can be used for implant rehabilitation of partially edentulous patients. Thus, the aim of these case reports is to simplify the current indications and predictability of SRT or GBR in daily clinic.

Case reports: Two patients willing to have implant placement in an atrophic ridge were submitted to two different surgical techniques for bone augmentation. In case one, the patient had SRT performed with a placement of bone substitute and implant placement at the same time of augmentation. Three months after surgery the implant was ready for restoration. The second case, GBR technique with tenting screws and fixation pins were performed associated with bone substitute and resorbable collagen membrane. Six months later implant surgery was done and eight weeks after placement, implants were ready for prosthetic rehabilitation.

Conclusions: The predictability of SRT and GBR procedure in terms of survival and success rates seems to be similar. Proper indication according to location, type and extension of bone defect and surgeons' skills are decisive factors for the indication of one procedure over another.

KEYWORDS:

Guided bone regeneration.

Split-ridge technique.

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INTRODUCTION

Osseointegrated implants have been successfully used for oral rehabilitation in partially and fully edentulous patients.[1] However, insufficient amount of the alveolar bone not only could prevent implant placement in adequate three-dimensional position but even make implant placement impossible, depending upon the level of atrophy. Thus, a successful bone augmentation procedure provides adequate amount of alveolar bone for implant placement and also promote peri-implant tissue stability over time.[2] Several surgical techniques for bone reconstruction are reported in the literature.[3] However, split-ridge technique (SRT) and guided bone regeneration (GBR) are the most documented types of horizontal bone augmentation techniques and both have specific indications for successful outcomes.

Guided bone regeneration refers to the use of barrier membranes (i.e. resorbable or non-resorbable) in the alveolar bone defects to stabilize the blood clot or any particulate grafting materials and provide bone formation.[4-6] These barriers offer protection against premature osteoclastic resorption by blocking the pathway for blood-borne osteoclast precursor cells from the neighboring tissues until neovascularization and new bone formation takes place.[5,6]

Split-ridge/ridge-expansion technique is described as the splitting of the cortical plates, creating a space inside the bone marrow that will be occupy by the implant and/or a biomaterial.[7] This is an alternative technique to enable implant placement in certain bone defects (i.e. narrow ridge/knife-shaped ridges) and is considered effective for correction of moderately resorbed edentulous ridges in selected cases.[7-11] SRT requires the alveolar bone to present two cortical plates separated by a layer of cancellous bone. A basal bone wider than the top of the ridge is also required; therefore, a preoperative cone beam computed tomography (CBCT) examination is strongly recommended.[6,10-12] The main indication for SRT is to expand a narrow ridge in the maxilla/mandible and take advantage of cancellous bone characteristics and its peripheral type of blood perfusion.[10,11,13,14]

Thus, the aim of these cases reports is to illustrate and to simplify indications and predictability of SRT and GBR in partially edentulous patients with significant horizontal bone deficiency.

CASE REPORT 1: SPLIT-RIDGE TECHNIQUE

The adult male patient, non-smoking, without any systemic disease and previously treated of gingivitis was referred to private dentist office to rehabilitate a missing lower teeth (Fig 1A, B). The treatment plan included phase 1: i) one implant at position between tooth 44 and 45 placed following split-ridge technique with bone substitute material (Bio-Oss, Wolhusen, Switzerland, small granules (0.25—1 mm) 0.25 g, Geistlich Pharma AB, Wolhusen, Switzerland). Phase 2: final prosthetic rehabilitation.

Under local anesthesia, mid-crestal incision with mesial and distal releasing incisions were performed. Full-thickness flap was elevated in order to obtain clear view of alveolar bone at both facial and palatal aspects. On the facial aspect, a split thickness flap was elevated beyond the level of the previously elevated flap. Subsequently, one horizontal and two vertical osteotomies were performed to allow adequate expansion of the buccal plate. In case of neighboring dentition, the vertical osteotomies were performed at least 1 mm from the adjacent teeth (Fig 2A). The alveolar bone crest was split with a bone chisel (Aseptic, Woodinville, WA, USA).

A narrow diameter implant (3.3 x 10 mm - Regular Neck SLActive, Basel, Switzerland, Institut Straumann AG, Basel, Switzerland) was placed. A bone substitute material (Bio-Oss, Wolhusen, Switzerland, small granules (0.25—1 mm) 0.25 g, Geistlich Pharma AB, Wolhusen, Switzerland) was placed in the gaps between the buccal and palatal bone walls. The flaps were repositioned and stabilized with interrupted sutures over a transmucosal healing abutment (Fig 2B). Further detailed surgical intervention of SCT and medical prescriptions were previously described by Garcez-Filho and Araújo (2007)[14] and Garcez-Filho et al. (2014)[12]. Three months after implant placement (Fig 3A,B) and SRT surgery the final prosthesis was delivered. A new CBCT was taking showing stability of facial and lingual bone walls (Fig 3C).

A B C

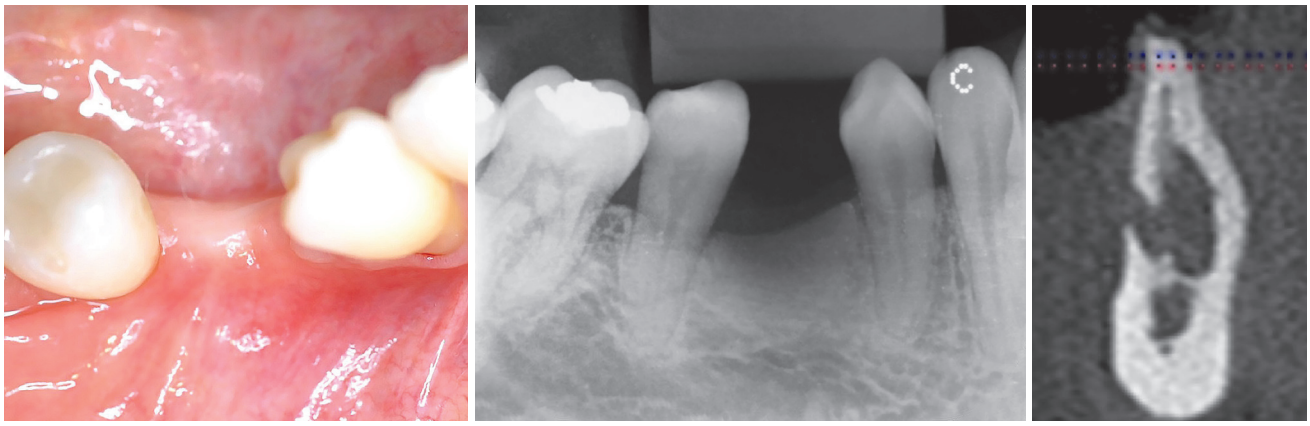


Figure 1:
Clinical (**A**), radiographic (**B**) and cross-section of tomographic image (**C**) of the area submitted to split-ridge technique, an edentulous site between teeth #44 and #45.

A B

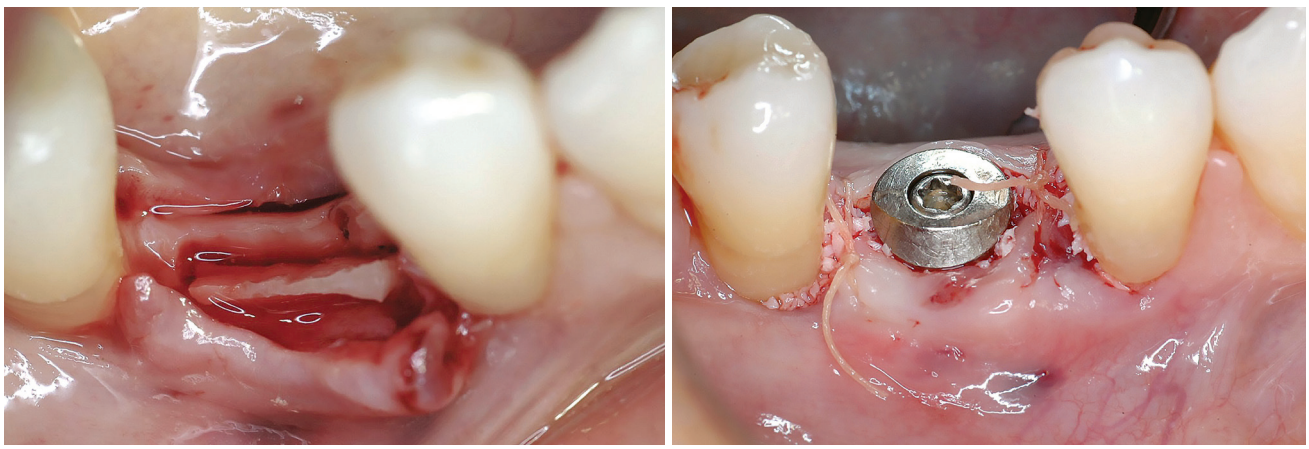


Figure 2:
Clinical photograph of the split-ridge technique after horizontal and vertical osteotomies and adequate expansion of the buccal bone (**A**). Immediate post-surgical photograph after bone grafting and flap reposition (**B**).

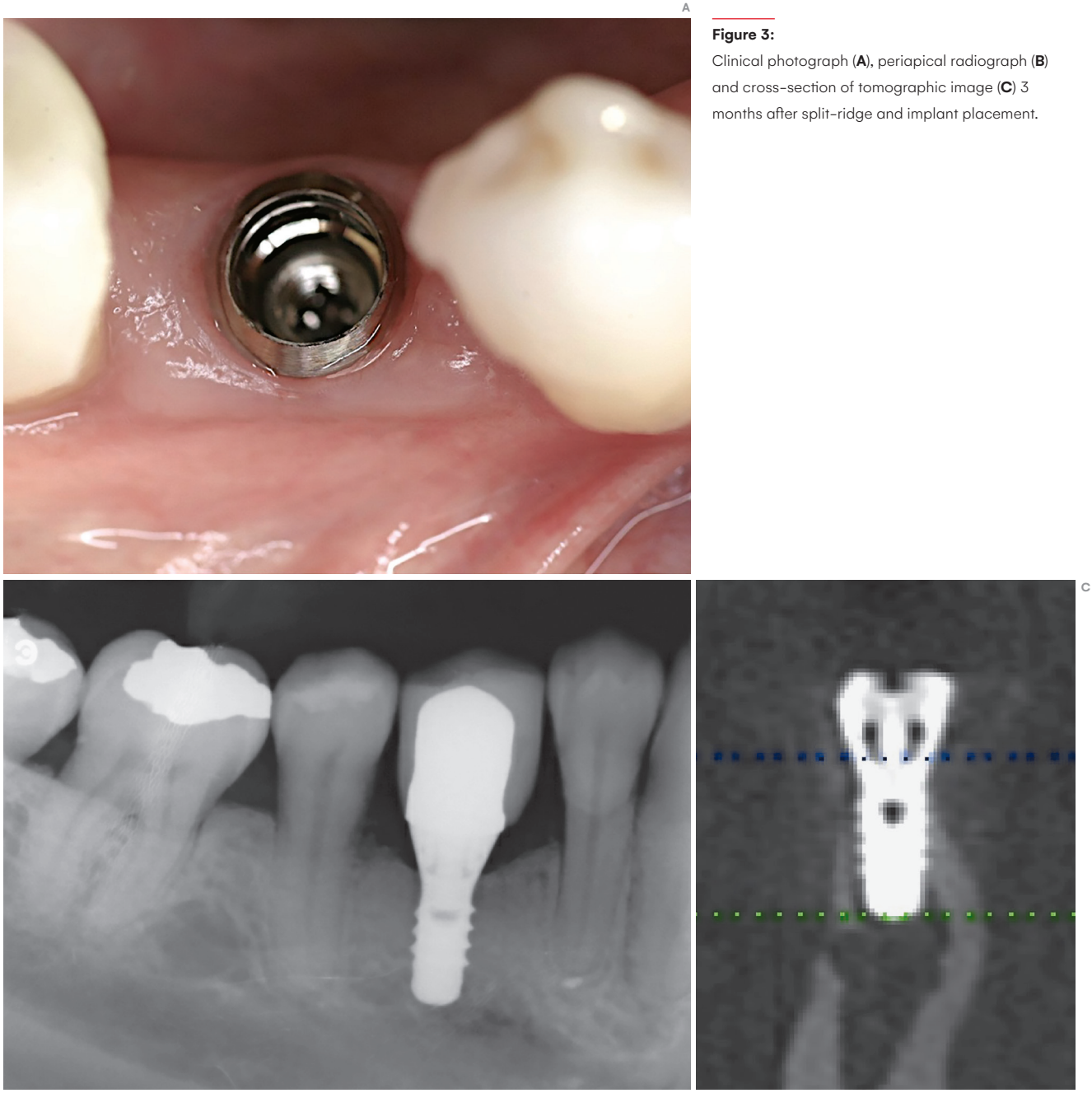
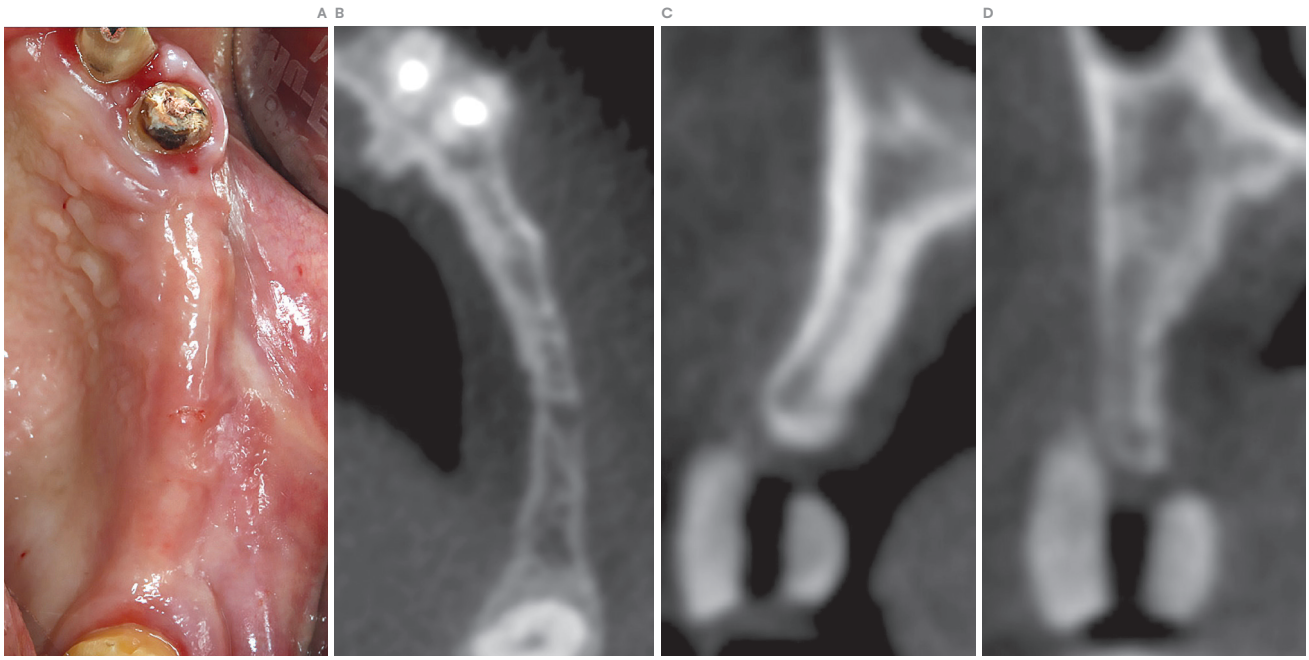


Figure 3:
Clinical photograph (**A**), periapical radiograph (**B**) and cross-section of tomographic image (**C**) 3 months after split-ridge and implant placement.

CASE REPORT 2: GUIDED BONE REGENERATION

A female patient, 40 years-old, was referred to university for oral rehabilitation of atrophic posterior maxilla (Fig 4A). After clinical (Fig 4A) and radiographic (Fig 4B, C, D) examination the treatment plan was chosen and defined in three phases. Phase 1: GBR procedure using resorbable collagen membrane (Bio-Gide, Wolhusen, Switzerland, Geistlich Pharma AB, Wolhusen, Switzerland) and bone substitute material (Bio-Oss, Wolhusen, Switzerland, small granules 0.5 g, Geistlich Pharma AB, Wolhusen, Switzerland). Phase 2: implant placement. Phase 3: prosthetic rehabilitation with implant-assisted removable partial denture.

Figure 4:
Clinical occlusal image (**A**), axial (**B**) and cross-sectional view of tomographic image (**C, D**) of the area submitted to guided bone regeneration procedure extending from tooth #23 to #26.



After local anesthesia, a mid-crestal incision assuring a band of 2 mm of keratinized mucosa on the buccal aspect was performed. Complimentary vertical releasing incisions were done at the mesial and distal aspects of the flap. Subsequently, full-thickness flap was elevated and retracting sutures were placed at the facial and palatal flaps (Fig 5A). All granulation and soft tissue were removed with a bone scrapper and several decortication osteotomies were performed using a round bur to enhance blood supply to the grafting material. Four tenting screws (Titanium Tenting Screw 1.5mm x 8mm, Salvin Dental Specialties, Charlotte, NC, USA) were placed in the facial aspect of the ridge to provide stability for the grafting material. A resorbable collagen membrane (Bio-Gide, Wolhusen, Switzerland, Geistlich Pharma AB, Wolhusen, Switzerland) was stabilized with four tacks (Titanium Bone Tack-3mm, Salvin Dental Specialties, Charlotte, NC, USA) in the apical portion the grafted area (Fig 5B). A xenograft material (Bio-Oss, Wolhusen, Switzerland, small granules 0.5 g, Geistlich Pharma AB, Wolhusen, Switzerland) was mixed with patient's blood collected from the surgical site. The biomaterial was placed in the site of interest (Fig 5C) and covered with double-layer collagen membrane previously stabilized with the tacks (Fig 5D). After proper periosteal releasing incisions, horizontal mattress and interrupted sutures were placed and primary closure was obtained. Post-surgical prescriptions included ibuprofen (600 mg) thrice, for 3 days, amoxicillin (500 mg) thrice daily, for 7 days, and mouthwash with chlorhexidine 0.12%, twice a day, for 15 days.

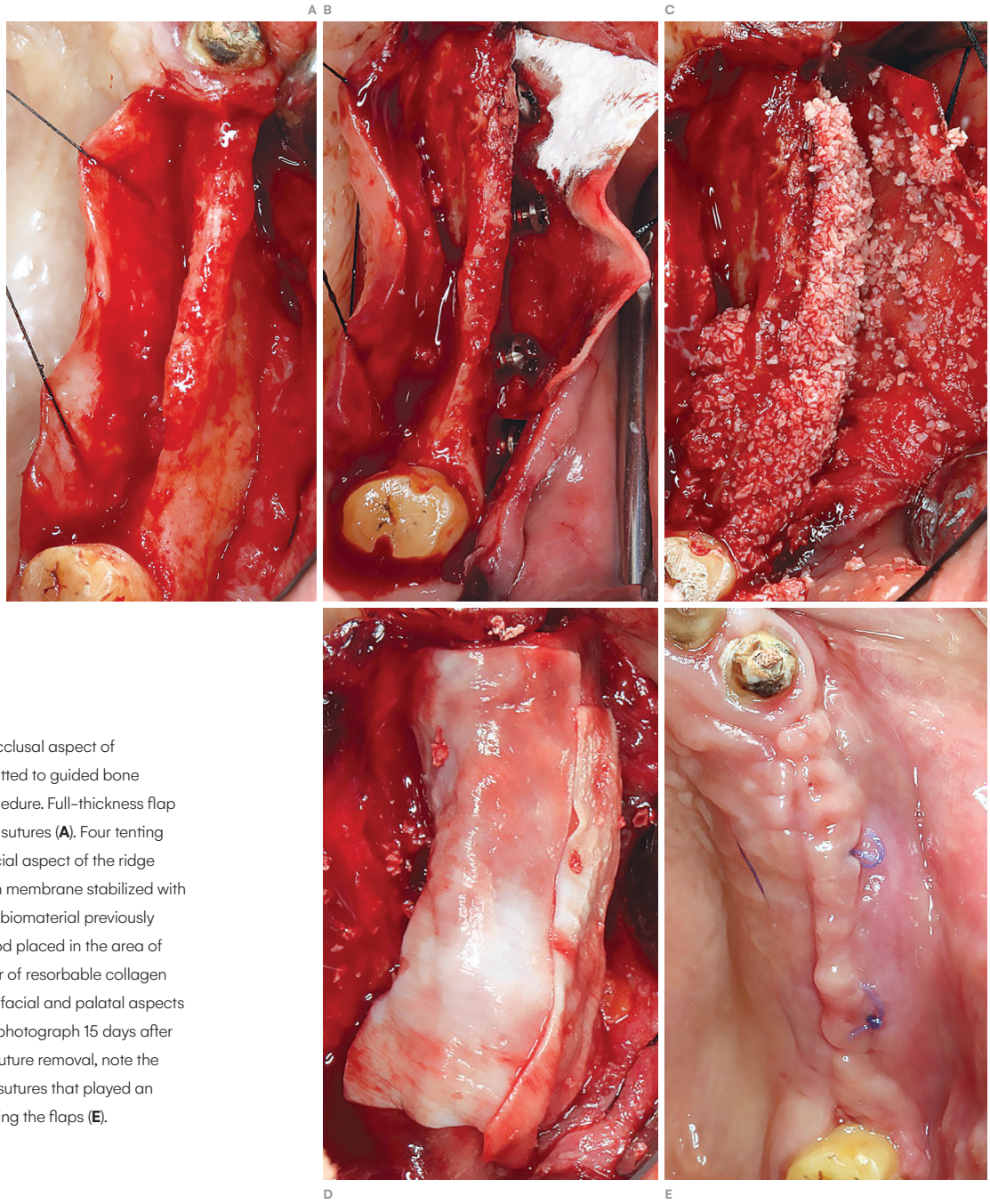


Figure 5:
Clinical images of the occlusal aspect of the maxillary area submitted to guided bone regeneration (**GBR**) procedure. Full-thickness flap elevation and retraction sutures (**A**). Four tenting screws placed at the facial aspect of the ridge and resorbable collagen membrane stabilized with four tacks (**B**). Xenograft biomaterial previously mixed with patient's blood placed in the area of interest (**C**). Double-layer of resorbable collagen membrane covering the facial and palatal aspects of the ridge (**D**). Clinical photograph 15 days after GBR procedure during suture removal, note the two horizontal mattress sutures that played an important role in stabilizing the flaps (**E**).

Two weeks after GBR surgery, the surgical site healed uneventfully (Fig 5E). Six months after the grafting procedure a re-entry surgery was performed for implant placement (Fig 6A). A new CBCT image was taken and a significant bone gain was observed (Fig 7A, B) Two bone level tapered (BLT) implants were placed (Fig 6B, 7C), one 4.1 x 8 mm — NC and one 3.3 x 10 mm (SLActive, Basel, Switzerland, Institut Straumann AG, Basel, Switzerland), in a submerged healing (Fig 6C). Eight weeks after surgery implants were ready for prosthetic rehabilitation (Fig 6D).

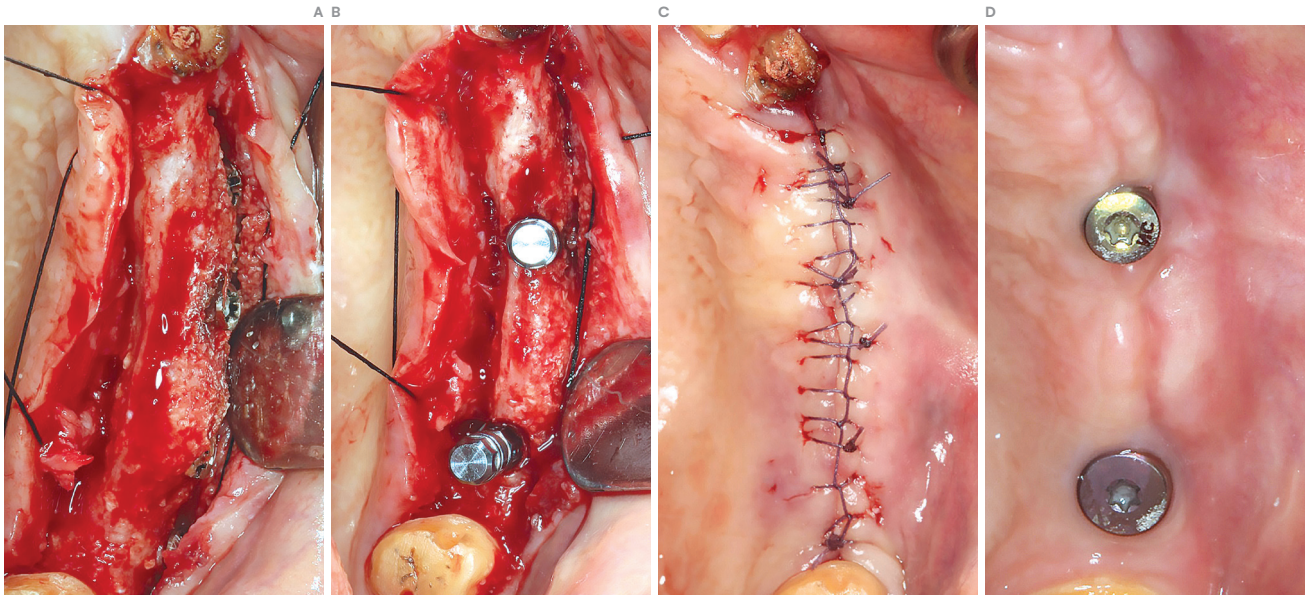
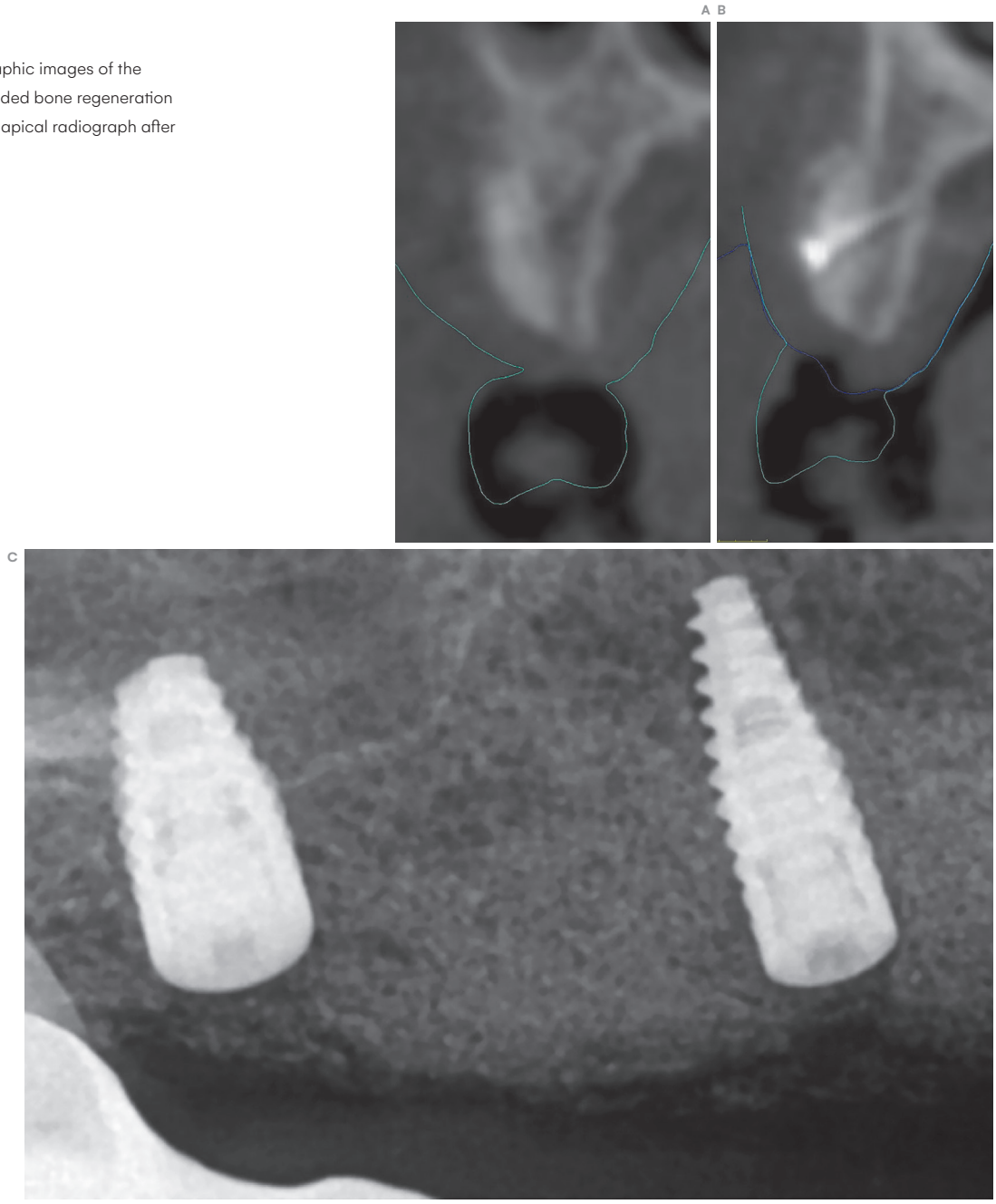


Figure 6:
Clinical images of the area previously submitted to guided bone regeneration procedure. Full-thickness flap elevation, tenting screws and tacks removed (**A**). Two bone level tapered (**BLT**) implants placed (**B**) and flaps repositioned with primary closure (**C**). Clinical photograph eight weeks after implant placement with transmucosal healing abutments (**D**).

Figure 7:
Cross-sectional tomographic images of the areas of interest after guided bone regeneration procedure (**A, B**) and periapical radiograph after implant placement (**C**).



DISCUSSION

Different types of surgical interventions present advantages and disadvantages; therefore, the priority should be given to those less invasive, with less morbidity, simpler to perform and to solve the patient's complaint.[3,11] These case reports summarized the most important aspects to be taken into consideration in the decision between SRT and GBR, as described on Table 1.

Table 1:

Main indications of techniques to treat ridge deficiencies. SRT: split ridge technique; GBR: guided bone regeneration

	SRT	GBR
Maxilla	X	X
Mandible	X	X
Vertical defects		X
Width defects	X	X
Esthetic areas	X	X
Faster procedures	X	
Low cost procedures	X	
Less morbidity	X	
High surgeon skills	X	X
Immediate implant installation	X	X

Both techniques have similar frequency of success/survival rates when compared with implants placed in native bone.[2,3,8,15] The two cases reported illustrate how it is possible to ensure safety and efficacy to rehabilitate partially edentulous patients presenting horizontal bone defects, considering: i) correct indications; ii) biological limitations and; iii) treatment planning. A classification of these bone defects was reported by Hämmerle and Jung (2008)[4] to illustrate how the hard tissue morphology can be determinant to decide the best technique to treat this type of bone deficiencies (for review see Hämmerle & Jung 2008).[4] According to this classification, SRT and GBR are better indications to treat defects class III and IV, which are, essentially, horizontal defects. One of the requirement for SRT to be performed is the presence of alveolar bone crest with at least 3 mm between buccal and lingual/palatal cortical plates, thus, a prior CBCT image examination is important.[6,10-12,14,16]

Some authors[2,3,6,10] reported that split ridge osteotomy can result in a higher risk of vertical resorption of the outer bone lamella by lowering blood supply to that structure and due the fracture of the buccal bone plate during the ridge expansion. However, Ella et al. (2014)[11] in a 3-year follow-up clinical study to determine the necessity to fill the gap between cortical plates after split ridge expansion and immediate fixture installation observed no implant loss and maintenance of buccal bone volume using a bone substitute. Some studies also reported an undesirable facial implant inclination with SRT.[3,10] As implants facially positioned can directly impact on rehabilitation of esthetic areas, GBR procedure would be more adequate when this scenario is predicted at implant planning.

The most common complication of SCT is the fracture of the buccal plate,[3] which could potentially result in facial bone reabsorption if not properly managed.[10] In this scenario, implant placement at the same time of SCT is not recommended and GBR technique might be required. A frequent complication in GBR procedure is flap dehiscence and, consequently, barrier exposure. Membrane barrier exposure could lead to loss of bone graft and, as a consequence, increase the chances for site infection and impact in amount of new bone formation.[17]

In general, a GBR procedure requires a wider flap elevation and sometimes a second surgical site to harvest autogenous bone, what can potentially increase patient's morbidity and is frequently indicated as a staged procedure.[6] In addition, GBR has a significant financial impact on patient's treatment and is expected to extend the overall treatment time.[9,17,18] Flap dehiscence and barrier membrane exposure is a common complication of GBR procedures, affecting the amount of bone regeneration achieved.[2,19] However, GBR is extremely indicated in clinical situations which are of paramount importance obtaining bone augmentation in horizontal as well as in vertical direction[5,6] and when the bone deficiency expands to lingual/palatal aspect.

Some authors[1,3,13,18] suggest that SRT is an easier technique, less technical sensitive with a reduced learning curve compared to GBR procedure. However, on the other hand, Terheyden & Cordaro (2014)[6] and Misch (2014)[10] suggested that the surgeon should have a higher level of surgical skills and experience to perform SRT over a GBR procedure. The technique of the last procedure can vary significantly depending upon the extension, type of barrier membrane, use of fixation pins and/or tenting screws as well as the type of bone grafting material (i.e. autograft versus xenograft).

Variations of SRT have been suggested to enhance the outcomes of ridge augmentation, such as: i) staged approach;[7] ii) the use of piezoelectric instruments;[13,18] iii) one staged SRT and immediate implant placement;[11,12] iv) platform switching implant associated with morse connection;[20] v) filling the gap with bone substitutes;[11,12] v) narrow diameter implants immediate with SRT;[12] and vii) association with GBR.[11]

Success and survival rates of implants placed following SRT are reported in the literature mostly from retrospective studies.[21-25] Survival rates range from 86.2%[25] to 100%.[11,20,23] with a follow-up up to 10-years.[12] The cumulative survival rate of implants placed with simultaneous GBR in fenestration and dehiscence defects varied from 96.1% at 5 years post-implantation[26] to a significantly reduced survival rate of 76.8% for the maxilla and 83.8% for the mandible.[27] However, most authors agree that implant placement in grafted areas seems to present similar success and survival rates compared to implants placed in pristine bone.[5] Donos et al. (2008),[2] in a systematic review, suggested that staged GBR presents higher success rates than simultaneous GBR procedures.

CONCLUSION

The predictability of SRT and GBR procedure in terms of survival and success rates seems to be similar. Proper indication according to location, type and extension of bone defect and surgeons' skills are extremely important for indication of one procedure over another. However, when properly indicated, SRT can be a less invasive with lower cost surgical alternative compared to GBR. Both surgical techniques present advantages and disadvantages and must be taken into consideration at the time of surgical planning, preferably using a CBCT image with a reference of the future prosthesis outlines.

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REFERENCES:

1. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long term efficacy of currently used dental implants: A review and proposed criteria of success. Int J Oral Maxillofac Implants. 1986 Summer;1(1):11-25.
2. Donos N, Mardas N, Chadha V. Clinical outcomes of implants following lateral bone augmentation: systematic assessment of available options (barrier membranes, bone grafts, split osteotomy). J Clin Periodontol. 2008 Sept;35(8 Suppl):173-202.
3. Chiapasco M, Casentini P. Horizontal bone-augmentation procedures in implant dentistry: prosthetically guided regeneration. Periodontol 2000. 2018 June;77(1):213-40.
4. Hämmerle CHF, Jung RE. Ridge augmentation procedures. In: Lang NP, Lindhe J. Clinical Periodontology and Implant Dentistry. New Jersey: Wiley-Blackwell; 2008, v. 2. chap 49. p. 1083-98.
5. Benic GI, Hämmerle CH. Horizontal bone augmentation by means of guided bone regeneration. Periodontol 2000. 2014 Oct;66(1):13-40.
6. Terheyden H, Cordaro L. Methods for ridge augmentation. In: Cordaro L, Terheyden H. Ridge augmentation procedures in implant patients. A staged approach. ITI Treatment Guide. Batavia: Quintessence; 2014. v. 7, p. 29-90.
7. Anitua E, Begoña L, Orive G. Two-stage split-crest technique with ultrasonic bone surgery for controlled ridge expansion: a novel modified technique. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2011 Dec;112(6):708-10.
8. Chen ST, Beagle J, Jensen SS, Chiapasco M, Darby I. Consensus statements and recommended clinical procedures regarding surgical techniques. Int J Oral Maxillofac Implants. 2009;24 Suppl:272-8.
9. Demetriades N, Park JI, Laskarides C. Alternative bone expansion technique for implant placement in atrophic edentulous maxilla and mandible. J Oral Implantol. 2011 Aug;37(4):463-71.
10. Misch CM. Implant site development using ridge splitting techniques. Oral Maxillofac Surg Clin North Am. 2004 Feb;16(1):65-74
11. Ella B, Laurentjoye M, Sedarat C, Coutant JC, Masson E, Rouas A. Mandibular ridge expansion using a horizontal bone-splitting technique and synthetic bone substitute: an alternative to bone block grafting? Int J Oral Maxillofac Implants. 2014 Jan-Feb;29(1):135-40.
12. Garcez-Filho J, Tolentino L, Sukekava F, Seabra M, Cesar-Neto JB, Araújo MG. Long-term outcomes from implants installed by using split-crest technique in posterior maxillae: 10 years of follow-up. Clin Oral Implants Res. 2015 Mar;26(3):326-31.
13. 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 Dec;17(6):700-7.
14. Garcez-Filho J, Araújo MG. Modificação da técnica de expansão do rebordo alveolar atrófico seguida da instalação imediata de implantes Straumann: acompanhamento de 10 casos clínicos observados durante 1 ano. Rev Dental Press Period Implantol. 2007;1(2):84-97.

15. Mestas G, Alarcón M, Chambrone L. Long-term survival rates of titanium implants placed in expanded alveolar ridges using split crest procedures: a systematic review. Int J Oral Maxillofac Implants. 2016 May-June;31(3):591-9.
16. Cortes AR, Cortes DN. Nontraumatic bone expansion for immediate dental implant placement: an analysis of 21 cases. Implant Dent. 2010 Apr;19(2):92-7.
17. Esposito M, Grusovin MG, Felice P, Karatzopoulos G, Worthington HV, Coulthard P. The efficacy of horizontal and vertical bone augmentation procedures for dental implants - a Cochrane systematic review. Eur J Oral Implantol. 2009 Autumn;2(3):167-84.
18. 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 Dec;17(6):700-7.
19. Al-Nawas B, Schiegnitz E. Augmentation procedures using bone substitute materials or autogenous bone - a systematic review and meta-analysis. Eur J Oral Implantol. 2014 Summer;(7 Suppl 2):S219-34.
20. Sammartino G, Cerone V, Gasparro R, Riccitiello F, Trosino O. The platform switching approach to optimize split crest technique. Case Rep Dent. 2014;2014:850470.
21. Simion M, Baldoni M, Zaffe D. Jawbone enlargement using immediate implant placement associated with a split-crest technique and guided tissue regeneration. Int J Periodontics Restorative Dent. 1992;12(6):462-73.
22. Scipioni A, Bruschi GB, Calesini G. The edentulous ridge expansion technique: a five-year study. Int J Periodontics Restorative Dent. 1994 Oct;14(5):451-9.
23. Basa S, Varol A, Turker N. Alternative bone expansion technique for immediate placement of implants in the edentulous posterior mandibular ridge: a clinical report. Int J Oral Maxillofac Implants. 2004 July-Aug;19(4):554-8.
24. Sethi A, Kaus T. Maxillary ridge expansion with simultaneous implant placement: 5-year results of an ongoing clinical study. Int J Oral Maxillofac Implants. 2000 July-Aug;15(4):491-9.
25. Engelke WG, Diederichs CG, Jacobs HG, Deckwer I. Alveolar reconstruction with splitting osteotomy and microfixation of implants. Int J Oral Maxillofac Implants. 1997 May-June;12(3):310-8.
26. Blanco J, Alonso A, Sanz M. Long-term results and survival rate of implants treated with guided bone regeneration: a 5-year case series prospective study. Clin Oral Implants Res. 2005 June;16(3):294-301.
27. Becker W, Dahlin C, Lekholm U, Bergstrom C, van Steenberghe D, Higuchi K, et al. Five-year evaluation of implants placed at extraction and with dehiscences and fenestration defects augmented with ePTFE membranes: results from a prospective multicenter study. Clin Implant Dent Relat Res. 1999;1(1):27-32.

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» Patients displayed in this article previously approved the use of their facial and intraoral photographs.