

Localized ridge augmentation with simultaneous implant placement followed by soft tissue augmentation in the maxillary anterior region: A case report

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Abstract. A deficient alveolar ridge in the maxillary anterior site often warrants ridge augmentation prior to prosthetic rehabilitation, in order to enhance functional and esthetic outcomes. In particular, if implant therapy is planned in a deficient jaw, ridge augmentation is preferred before or simultaneous to implant placement in order to overcome the anatomic limitations of the residual jaw bone crest. Guided bone regeneration (GBR) is the gold standard technique for bone regeneration in patients with atrophic ridges, and it is regarded as one of the most predictable techniques for ridge augmentation. Non-resorbable membranes, such as titanium mesh are preferred in the GBR procedure, due to the enhanced rigidity and microporous structure, facilitating vascularity. However, the most common disadvantage of non-resorbable membranes, when used in vertical augmentation, is the soft tissue dehiscence. However, tissue stability is essential for the long-term successful outcomes of GBR. The present study focuses on the evaluation of the clinical and radiographic outcomes of a patient undergoing GBR using customized titanium mesh and xenograft simultaneous to implant placement in the maxillary anterior region. In addition to the hard tissue augmentation, soft tissue augmentation was performed using injectable platelet-rich fibrin and a collagen membrane. Following 6 months of GBR, the augmentation site exhibited clinically and radiographically significant gain in ridge dimensions, with an average bone gain of 2.8 and 3.1 mm in horizontal and vertical dimensions, respectively with stable soft tissue support.

Introduction

Deficient alveolar bone with horizontal and vertical ridge imperfections encountered due to tooth extraction, advanced periodontitis, dehiscence and window defects, or congenitally missing teeth, present esthetic and functional challenges for implant placement poses a constant challenge (1,2). Therefore, in order to restore function using implant therapy in a prosthetically favorable position, it is necessary to perform ridge augmentation using predictable approaches, such as guided bone regeneration (GBR), prior to, or during implant placement (3). Bone grafting is complicated by bone resorption. The use of bone grafting materials in combination with barrier membranes has been suggested as a strategy with which to mitigate this disadvantage by employing the GBR approach. It involves creating a space beneath the barrier membrane that is then filled with new bone.

For GBR procedures, a variety of resorbable and non-resorbable membranes have been employed (4). Enhancing membrane characteristics, such as biocompatibility, cell occlusiveness (isolation), space maintenance and bio-integration with the surrounding tissue, during osteogenesis can benefit regenerated tissues (5). Although resorbable membranes do not require a second surgical re-entry, their rate of resorption can have a significant impact on the amount of regenerated bone (6). The most often used non-resorbable membranes are polytetrafluoroethylene (PTFE) and titanium mesh (Ti-mesh). These function as a rigid barrier with less risk of complications and tissue biocompatibility (7). Boyne *et al* (8) introduced the Ti-mesh in 1969 for the repair of major osseous defects due to its stiffness and good biocompatibility; hence it is widely employed in a variety of surgical operations (8). For ridge enhancement, von Arx *et al* (9) recommended using the Ti-mesh with autogenous bone. The appropriate stiffness of the mesh maintains room for new bone development, while minimizing graft displacement and mucosal compression. In comparison to resorbable membranes, the Ti-mesh maintains space, enables the three-dimensional restoration of bone deformities due to the enhanced rigidity and microporous structure, facilitating vascularity and is less vulnerable to bacterial contamination (10). The major drawback associated with the Ti-mesh is its exposure, which may lead to complications

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related to bone regeneration (11). While autogenous bone is considered to be the gold standard in alveolar reconstructive procedures, it has a major drawback of limited availability and proclivity for resorption (12). Hence, grafts obtained from other sources, such as xenografts are favored, due to their availability in larger volumes and desired particle size enabling better graft manipulation during the GBR procedure (13). Additionally, properties, such as biocompatibility, scaffold formation (osteoconduction), the moderate resorption rate and the capacity to preserve bone gain volume render xenografts more suitable for use in large reconstructive procedures (14). Evidence from previous studies has demonstrated that ridge augmentation performed using xenografts has been proven to be a more predictable approach for achieving bone regeneration in the deficient alveolar process due to their ability of stable space maintenance (15,16). Hence, GBR performed in extensive alveolar defects using xenografts and non-resorbable membranes has been shown to be associated with successful outcomes (15,16).

During the GBR procedure with simultaneous implant placement, it is necessary to create a space between the implant and surrounding soft tissues and it should be maintained for an appropriate duration to prevent the migration of non-osteogenic tissues into the area (17). Multilayered platelet-rich fibrin (PRF) can be used as a membrane for the graft material and it provides a barrier effect for new bone regeneration. There have been various attempts to change the structure of PRFs and create new formulations since its launch in 2001 (18). PRF, which was introduced by Miron *et al* in 2017 (19), is one of the recently created formulations. Injectable-PRF (i-PRF), is a liquid formulation that is prepared using shorter and slower centrifugal speeds, is simple to handle, and can be combined with contemporary biomaterials. Furthermore, circulating stem cells have been discovered in i-PRF, which may improve its regenerative potential (20).

The present case report study focuses on the clinical and radiographic aspects of GBR employing personalized titanium mesh and xenograft in the maxillary anterior region with simultaneous implant placement. Since soft tissue stability is critical for long-term success, i-PRF and collagen membrane was used to augment the soft tissue surrounding the implant during the second surgical exposure.

Case report

A 27-year-old systemically healthy male patient reported at the Department of Periodontology, SRM Dental College, Chennai, Tamil Nadu, India, with mobility in the upper right anterior region with a history of trauma in the upper anterior region 2 years prior. A clinical examination revealed grade III mobility according to the tooth mobility index published by Miller in 1950 (21) in relation to tooth no. 11. The patient was advised for the extraction of tooth no. 11, followed by implant prosthetic rehabilitation. An informed consent was obtained from the patient for the treatment procedure. After 4 weeks of healing, the edentulous site in relation to tooth no. 11 was inspected clinically, which revealed class III Siebert's ridge defect (22) (Fig. 1A). A staged approach for implant placement was planned following hard tissue augmentation using a Ti-mesh and xenograft.

The intraoperative surgical procedures were as follows: Under local anesthesia (Indoco Warren Lignox Lignocaine 2%), a paracrestal incision was performed and the full-thickness mucosal periosteal flap was elevated extending from tooth nos. 12 to 21 (Fig. 1B). The reflection was extended to expose the whole length of the facial cortical plate of the alveolar ridge. The defect site was inspected intraoperatively, an implant (ADIN Dental Implant System Ltd.) of 3.75 mm in width and a length of 13 mm was placed in the edentulous site, primary stability was achieved and the cover screw was placed (Fig. 1C). Cone-beam computed tomography (CBCT) was performed prior to surgery, which revealed defect measurements of 3.6 and 10.9 mm in relation to horizontal and vertical dimensions, respectively (Fig. 2). GBR was performed simultaneous to implant placement, xenograft (Bio-Oss® particles, Geistlich Pharma AG) was used along with rigid customized titanium membrane for ridge augmentation. Depending on the size of the alveolar defect and the future position of the prosthetic crown, the required amount of bone augmentation required was planned and the dimensions of the Ti-mesh was customized according to the defect. The titanium membrane was adapted to the adjacent bone using titanium fixing microscrews to provide the tenting effect (Fig. 3A). The gap between the Ti-mesh and the native bone was then filled with bone graft, the graft was placed in an over contoured fashion to supplement its final resorption. A resorbable collagen membrane (PerioCol®, Eucare Pharmaceuticals Pvt. Ltd.) was placed on a Ti-mesh and covered with PRF membranes (Fig. 3B). The flap was approximated and secured with a 3-0 vicryl suture (Ethicon, Division of Johnson and Johnson Ltd.). The patient was advised to take antibiotics and analgesics, and was also provided instructions on oral hygiene. Since there were no symptoms of infection or inflammation during the 2-week follow-up, the patient was instructed to continue the oral hygiene routine with a soft-bristle toothbrush. The patient was advised to be followed up at 6 weeks and 3 months; however, the patient reported for the review appointment only after 4 months, during which time, membrane exposure was evident (Fig. 3C) in the augmented site, and the patient was advised to use topical antibiotics (Hexidine®-ICPA Health Products Ltd.). The patient was regularly followed-up until the second surgical appointment. Oral hygiene instructions were reinforced. After 5 months, during the second stage of surgery, the Ti-mesh was removed thereby exposing the implant (Fig. 4A). The newly formed hard tissue was evident surrounding the implant (Fig. 4B). A collagen sponge (Periocol™, Eucare Pharmaceuticals Private Ltd.) reinforced with i-PRF was placed covering the buccal and lingual aspects, around the implant, followed by flap advancement and flap closure. Abutment placement was performed and a temporary prosthesis was provided (Fig. 4C). After 3 weeks of soft tissue healing, permanent restoration was provided in relation to tooth no. 11 (Fig. 4D). At 6 months, the implant exhibited satisfactory stability with no major biological complications and post-operative CBCT evaluation revealed a ridge dimension of 6.4 mm horizontally and 14 mm in the vertical dimension of the ridge (Fig. 5). The outcome of ridge augmentation along with implant placement was evident when the bone gain was compared between the pre-operative and post-operative CBCT (Fig. 6).

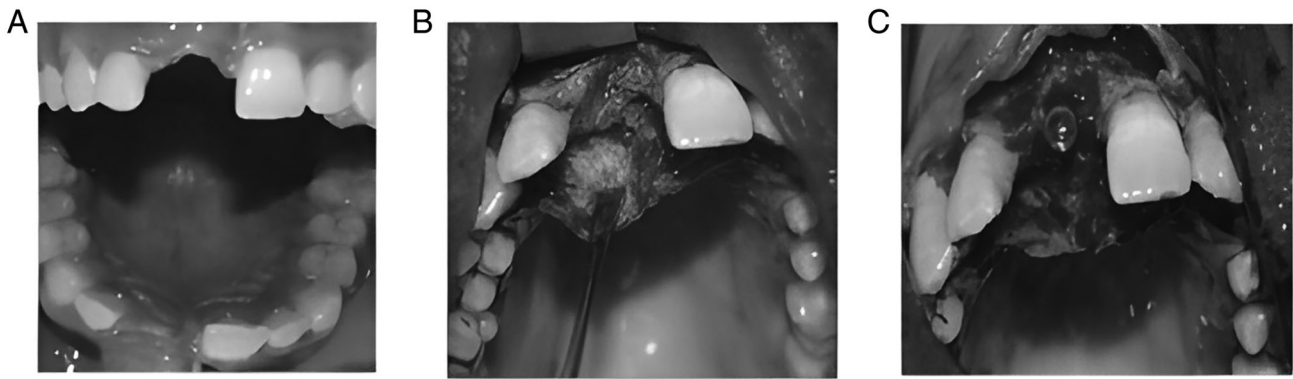


Figure 1. Clinical images illustrating (A) the ridge deficiency preoperatively, (B) the ridge defect after flap reflection, (C) implant placement in relation to the edentulous region.

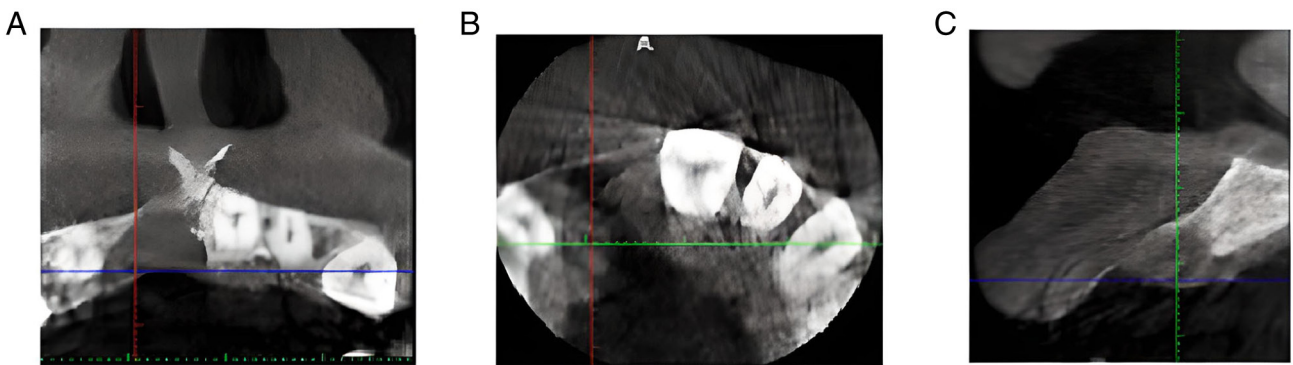


Figure 2. Cone-beam computed tomography image illustrating (A-C) pre-operative ridge assessment performed prior to implant placement in all the three planes.

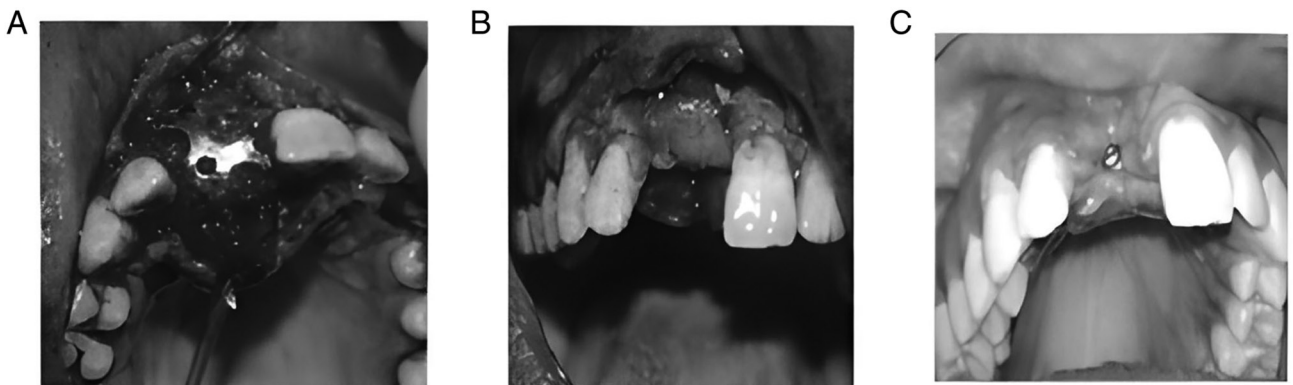


Figure 3. Clinical photographs illustrating (A) the application of the customized titanium mesh, (B) the placement of the platelet-rich fibrin membrane, and (C) membrane exposure after 4 weeks.

Discussion

Over the past decade, longitudinal studies have emphasized that GBR is a successful and predictable technique for clinicians to achieve vertical and horizontal ridge enhancement (16). Using titanium mesh in severely deficient alveolar ridges may provide a tenting effect and stability for the graft structure and rigidity, used in this case would provide the minimization of soft tissue in-growth into the micro-perforation and maintain the permeability of nutrients, thus promoting the attachment,

migration and proliferation of bone-forming cells involved in bone regeneration (23). Previous research has demonstrated that alveolar defects, both vertical and horizontal ridge defects, treated with titanium mesh exhibit predictable regenerative results (7). However, the major drawback of the Ti-mesh is the membrane exposure that may occur due to its rigidity (11,24). The majority of studies have not revealed any undesired regeneration results following mesh placement (25,26). Xenografts were used due to the need for a larger bone volume to fill the defect. A previous systematic review reported that the implant

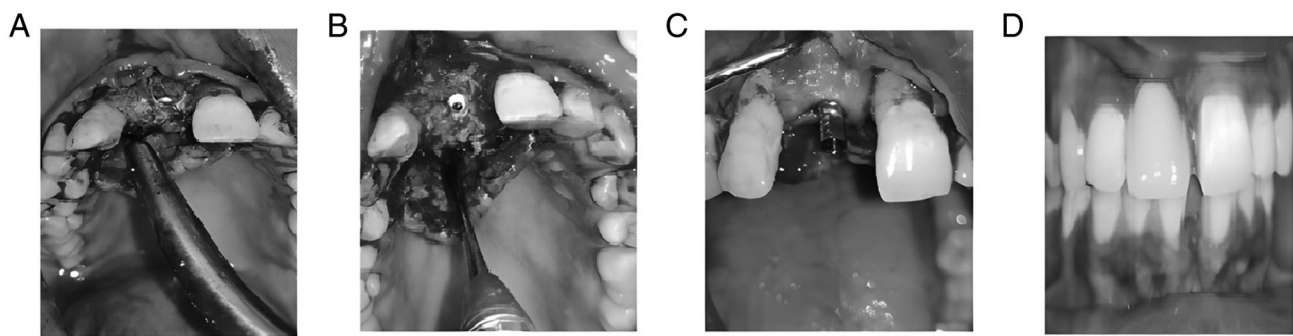


Figure 4. Clinical photographs illustrating (A) second stage surgery, titanium mesh exposure, (B) titanium mesh removed and implant exposure performed, (C) abutment placed, collagen membrane placement performed surrounding the augmented ridge, and (D) prosthesis given in relation to tooth no. 11.

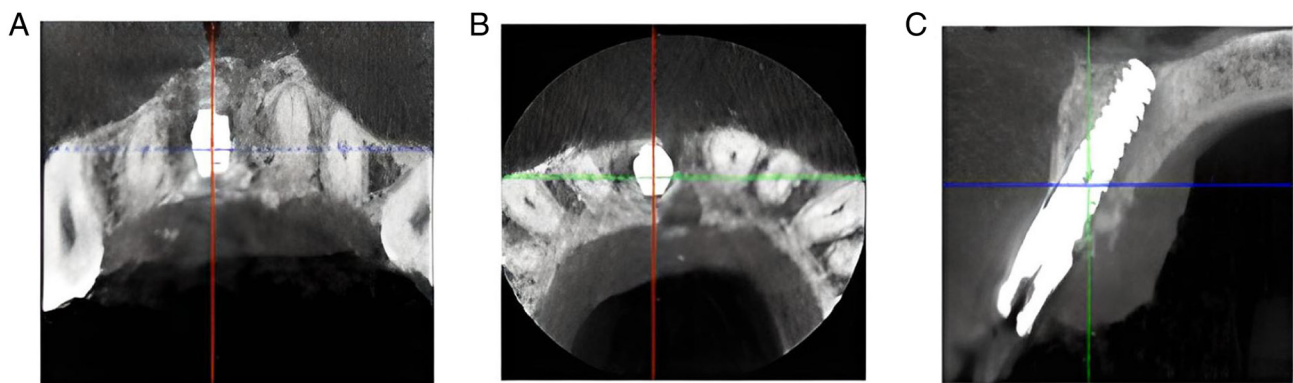


Figure 5. Cone-beam computed tomography image illustrating (A-C) post-operative assessment, 6 months after implant placement in all the three planes.

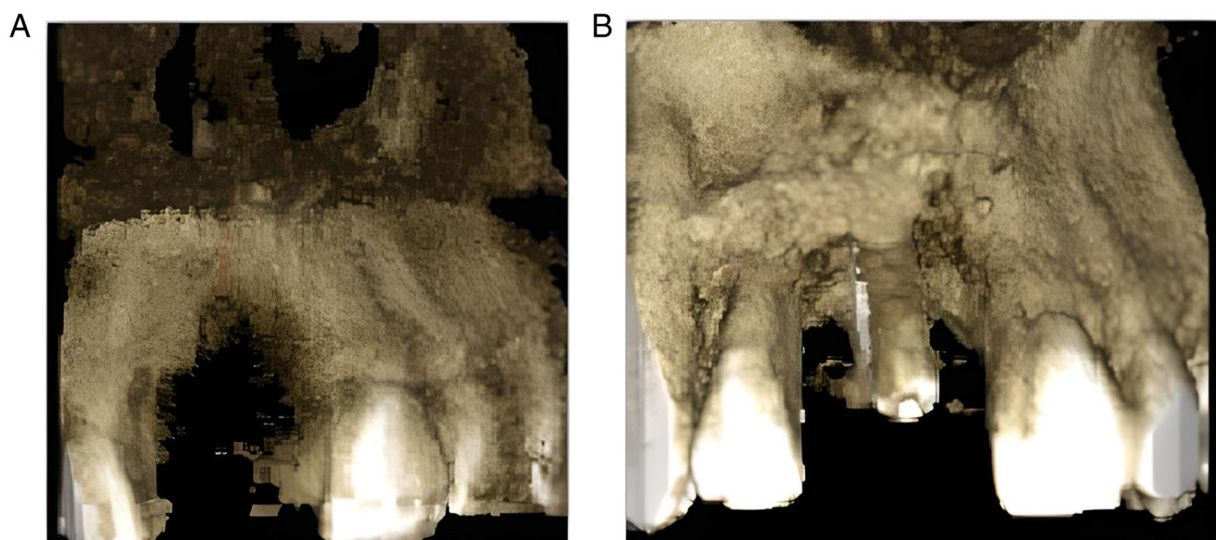


Figure 6. Comparison between (A) pre-operative and (B) post-operative CB cone-beam computed tomography images.

survival for GBR was 95.5%, while that for autologous grafts was 75% (16). In the present study, since simultaneous implant placement along with GBR was performed, implant dimensions were selected according to the available bone, so that an implant insertion torque of 40 Ncm could be achieved. After 5 months, the newly formed bone was clinically evident, the implant was stable in position and CBCT revealed sufficient

horizontal and vertical dimensions. A previous histological analysis revealed that xenografts can promote osteoblast proliferation in its porous structure, facilitating angiogenesis and early bone formation (27).

In the present case report study, the authors attempted to perform ridge augmentation along with implant placement using a rigid non-resorbable membrane primarily to enhance the

outcomes of GBR in cases of severe ridge deficiency and optimal outcomes were successfully achieved in terms of bone gain when comparing the pre-operative and post-operative CBCT. Additionally, the augmentation of soft tissue was also considered during the second surgical procedure to provide adequate soft tissue support for the augmented ridge and to improve the esthetic outcomes (23). Recent research on i-PRF has revealed its ability to improve soft tissue thickness and volume (20) with emphasis on preventing peri-implant disease in the future. In the study by Aprajita (28), GBR was performed in the deficient maxillary anterior site using i-PRF and bone graft simultaneously with implant placement; however, non-resorbable membrane-like titanium was not used. Melek and Taalab (29) evaluated the effects of using i-PRF as an adjunct to bone graft and collagen membrane for the management of contained ridge defect at the time of extraction before implant placement; i-PRF with its high growth factor content may contribute to more favorable and predictable bone formation at the grafted site. In conclusion, severe alveolar defects must be treated with GBR prior to or simultaneous to implant placement depending upon the remaining bone support and amount of soft tissue thickness present.

To the best of our knowledge, the present case report is the first of its kind to attempt an innovative strategy of soft tissue augmentation by the placement of a collagen sponge infused with i-PRF in the GBR site that employed a Ti-mesh and xenograft. This augmentation technique appears to be a therapeutically viable method of restoring soft and hard tissue deficiencies for implant placement in severely resorbed ridges. However, long-term radiographic and histological studies evaluating xenograft in conjunction with rigid membrane-like Ti-mesh are warranted to assess bone quality and final implant treatment outcomes.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

GK was involved in the conception and design of the study, as well as in the acquisition, analysis and interpretation of the patient's data. HP was involved in the analysis, interpretation of the patient's data for the study and in the drafting of the study. DP was involved in the conception of the study and in the acquisition of patient data. GK and HP confirm the authenticity of all the raw data. All authors have read and approved the final manuscript.

Ethics approval and consent to participate

Written informed consent was obtained from the patient for inclusion in the study and investigations were carried out following the rules of the Declaration of Helsinki of 1975.

Patient consent for publication

The patient provided written informed consent for the publication images related to his case.

Competing interests

The authors declare that they have no competing interests.

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