A Contemporary Approach for Treatment Planning of Horizontally Resorbed Alveolar Ridge: Ridge Split Technique with Simultaneous Implant Placement using Platelet Rich Fibrin Membrane Application in Mandibular Anterior Region

Abstract
Treatment of edentulous sites with horizontal atrophy represents a clinical situation in which the positioning of endosseous implants might be complex or sometimes impossible without a staged regenerative approach. This case report presents management of horizontally deficient mandibular anterior ridge with a contemporary approach to treatment planning and application of platelet-rich fibrin membrane for ridge split technique and simultaneous implant placement. Implants in anterior mandibular area are considered to be most predictable, stable, with high success rate and patients’ satisfaction with implant esthetics. In contrast to traditional ridge augmentation techniques, ridge splitting allows for immediate implant placement following surgery and eradicates the possible morbidity from a second surgical site.

Keywords: Cone beam computed tomography, horizontal ridge resorption, mandibular anterior implants, platelet rich fibrin membrane, ridge-split technique

Introduction
Atrophic edentulous jaws can represent a significant challenge to the successful use of endosseous implants. The horizontal and vertical ridge resorption occurs at differential rates that vary among individuals and at different sites in the same person. However, there is greater extent of horizontal resorption that would make the implant positioning a complex task. Several implant driven treatment techniques have been proposed for horizontal defects such as monocortical block bone grafting, guided bone regeneration, ridge splitting procedures, and alveolar distraction osteogenesis. The complexity of such augmentation procedures warrants informed treatment planning that implies the aid of three-dimensional (3D)/volumetric evaluation of bone using cone beam computed tomography (CBCT). This case report describes a case of horizontally resorbed mandibular anterior ridge, which was treated with ridge split technique and simultaneous implant placement.

Case Report
A 40-year-old female patient reported to the outpatient department with a chief complaint of missing lower front teeth region for the past 4 months. The patient was systemically healthy and reveals a history of extraction of lower mandibular anterior teeth due to the advanced periodontal disease before 4 months. On intraoral examination, reduced lower vestibular depth and Siebert’s class III alveolar defects were noticed. A complete case history with preoperative procedures including oral prophylaxis was performed. This was followed by investigations including routine blood screening, conventional orthopantomogram (OPG), and ridge mapping. Ridge mapping showed ridge width of <4 mm and radiograph showed a ridge height of >10 mm, which was inconclusive to plan the treatment. Hence, CBCT was advised in relation to the edentulous span with the note that the patient was more concerned about esthetic outcome and reduced treatment time.

Cone beam computed tomography analysis
The edentulous span necessitates placement of three implants to maintain the inter-implant distance of 3 mm to counteract bone loss [Figure 1]. Three implants were planned at equidistance,
and CBCT sagittal slice was taken at site A (Implant 1), B (Implant 2), and C (Implant 3) [Figure 2 and Table 1]. According to Tolstunov’s classification of alveolar ridge defect, this particular case of horizontal deficiency falls under moderate resorption class [Table 2].

The treatment planning was done using Romexis software in 3D visual reconstruction of CBCT image [Figure 3]. The treatment was planned for ridge split technique with an intention to increase the local bone volume along with simultaneous implant placement in the mandibular anterior edentulous area and the procedure was explained to the patient completely, and duly written consent was obtained. The interpositional space was intended to be filled with bone graft. Platelet-rich fibrin (PRF) was prepared preoperatively after collection of 10 ml intravenous blood drawn and centrifuged at 2700 rpm for 10 min without the addition of anticoagulant. The fibrin clot portion was then separated and sandwiched between two sterile glass plates to remove the acellular plasma. Fibrin matrix rich in growth factors (platelet-derived growth factor, Epidermal derived growth factor (EDGF), Insulin-like growth factor (IGF), transforming growth factor-β, thrombospondin) accelerates healing by altering the metabolism of epithelial cells and fibroblasts and promotes microvascularization.

### Surgical technique

After administration of local anesthesia (2% lidocaine with 1:200,000 adrenaline) by mental nerve block, a crestal incision was given to elevate a mucoperiosteal flap [Figure 4].

### Table 1: Preoperative measurements from cone beam computed tomography analysis showing the ridge width in relation to site A, B, and C at 3 mm apical to crest and 6 mm below the crest

| Implant site | Preoperative width |
|--------------|--------------------|
|              | At 3 mm below the crest | At 6 mm below the crest |
| A*           | 3.81                | 6.60                |
| B$           | 4.20                | 7.00                |
| C#           | 5.26                | 6.23                |

Implant osteotomy sites: *Implant 1, $Implant 2, #Implant 3
The crestal incision was given about 2 mm lingual to the mid-crestal line for the following reasons: (1) the lower labial vestibular depth was shallow, (2) after ridge splitting and implant placement, close approximation of the flaps would be difficult, and (3) besides to attain increased width of keratinized tissue around the implant. During mucoperiosteal flap elevation, the mentalis muscle attachment was found to be present at a higher level in the symphysis region, and the muscular attachment was preserved with the intention to support the labial cortical bone after lateralization.

Initially, mid-crestal cut was placed using uni-beveled chisel (2 mm) with bevel facing the labial bone and mallet to guide the further ridge-split. Further deepening of the cortical cut into the cancellous bone was performed using calibrated chisel. The depth of the ridge-split was determined in this case based on the CBCT measurements. Preoperatively, the ridge width at the level of 6 mm below the crest was 6.39, 7.0, and 6.55 mm at implant site A, B, and C respectively, that was ideal for 3.3 mm diameter implant to achieve 1 mm bone around the implant. Hence, the ridge splitting was performed up to a depth of 5 mm. Following crestal ridge splitting, two lateral cortical cut were placed on either side of the edentulous span using bone-cutting carbide bur. The lateral cuts were then connected with the horizontal crestal cut to afford for the ridge expansion. Once the targeted depth was reached, chisels of increasing thickness were used with lever and wedge movements to gradually mobilize the lateral cortical bone. All attempts to avoid fracture of the buccal and lingual cortical bone were taken during mobilization of the cortical bone by providing adequate support, and also the lingual flap was not elevated apical to the crest. Furthermore, the ridge was carefully expanded to prevent fenestration and off-axis loading after implant placement.

Osteotomy site was prepared in relation to A, B, and C, to place three implants of dimensions 3.3 mm × 10 mm single piece using pilot drill followed by 2.8 mm diameter drill. The paralleling was checked, and self-tap implants were placed in the osteotomy bed. The interpositional space between the cortical plates was filled with particulate grafts – demineralized bone matrix (DMBM - Osseograft™), and PRF membrane was placed. The flap was closely approximated using 3-0 black silk sutures. Temporization was done on the day of surgery [Figure 5]. The temporary bridge was cemented and the excess cement was removed meticulously. The postoperative instructions and ice pack were given. Antibiotics (Augmentin, BD for 5 days) and analgesics (acelofenac + paracetamol, BD for 3 days) were prescribed. 0.2% chlorhexidine rinse was prescribed to use every 3 h for 1 week and twice daily for following 2 weeks postoperatively. The suture removal was done on the 15th day after surgery.

| Table 2: Tolstunov’s classification of alveolar ridge width |
|----------------|----------------|-----------------|-----------------|-----------------|
| Class | Alveolar ridge width in mm based on CBCT scan | Alveolar ridge deficiency | Indications for Surgery | Immediate Implant Insertion |
|------|---------------------------------|-----------------|-----------------|-----------------|
| 0    | 6.55 >10 | No deficiency | Hard tissue surgery is not indicated. Occasionally, alveolar width (buccal convexity) can be improved for esthetic reasons with a soft tissue graft | Yes |
| I    | 6-8     | Minimal | Hard tissue surgery is rarely indicated. Occasionally, alveolar width can be improved by particulate bone graft or palatal soft tissue graft for esthetic and prosthetic reasons | Yes/no, depends on presence of apical bone for primary implant stability |
| II   | 4-6     | Moderate | Particulate (GBR) grafting or ridge - split is often needed to improve labial bone projection and proper occlusal implant position | Yes/no, depends on presence of apical bone for primary implant stability |
| III  | 2-4     | Severe | An ideal width for the ridge-split procedure that can be done in a single- or two-stage approach [Figure 3]. Block graft or GBR can also be done | No |
| IV   | <2      | Extreme | Ridge-split or block bone graft is a graft of choice (surgeon’s experience) | Not recommended |
| V    | 6-10/2-4 | “Hourglass” (undercut) (buccal or lingual) | GBR at the mid ridge level can be done | Yes/no, depends on the severity of the undercut |
| VI   | 2-4/6-10 | “Bottleneck” | Ridge reshaping or GBR at the top of the ridge can be done | Usually yes, can depend on the morphology of the top portion of the ridge |

CBCT=Cone beam computed tomography, GBR=Guided bone regeneration
Clinical outcome

The ridge splitting technique performed in this case allowed a gain in width of 3 mm uniformly throughout the edentulous span. The postoperative OPG taken on the 15th day after surgery showed the healing phase bone following the implant placement. The follow-up CBCT was taken on the 15th day showing ridge expansion of 6.62 mm, 7.61 mm, 7.35 mm, respectively, at implant site A, B, C [Figure 6 and Table 3]. The final restoration (DMLS – PFM direct metal laser sintered porcelain fused to metal) was given 3 months following implant placement.

Discussion

Following tooth extraction, the horizontal resorption hits the ridge with dissimilar yet certain patterns. There is accelerated bone loss in the labial wall of maxilla termed as centrifugal resorption, whereas lingual wall of mandible tend to resorb faster known as centripetal resorption.[3] The nonextraction cause of ridge atrophy involves denture-induced atrophy, trauma, periodontal disease, congenital alveolar defects, and tumor resection. Alveolar ridge width deficiency can be due to either cortical plate or cancellous bone resorption. However, cortical plate deficiency affects the implant survival to a greater degree because subsequently it can cause implant dehiscence after implant insertion and enhanced bone loss following implant loading.[4]

A variety of classifications have been proposed to address the horizontal, vertical, and combination defects and their treatment needs based on clinical evaluation or radiographic evaluation.[5-8] A clinically relevant implant-driven classification of the alveolar ridge width was proposed by Tolstunov,[1] with the goal to assist an operator in choosing the proper bone augmentation technique. This classification projected eight classes to match the specific ridge topography and width with an appropriate surgical technique that can be used to that particular case of ridge width. Comparing the many techniques that were advocated

| Implant site | Postoperative width - at 3 mm below the crest |
|--------------|-----------------------------------------------|
| A*           | 6.62                                          |
| B*           | 7.61                                          |
| C*           | 7.35                                          |

Implant osteotomy sites: *Implant 1, ¹Implant 2, ²Implant 3

for implant placement in horizontally deficient ridge, ridge-split provides several advantages such as predictable ridge expansion of 2–4 mm, graft stability and decreased postoperative graft exposure, lack of donor site morbidity as with Onlay block grafting, and remarkably allows immediate implant insertion.[1]

Simion et al. in 1992, first introduced the ridge split technique to provide implant driven treatment for horizontally resorbed ridges.[9] Following that several modifications to original technique have been proposed. The staged approach of ridge expansion followed by implant placement after 2–4 months is recommended for maxilla that has more elastic bone whereas mandible has more dense cortical bone, which is best suited for crestal ridge split and green-stick fracture on the lingual plate.[10] Minimum ridge width required for ridge split is 3–4 mm and an adequate ridge height of >10 mm is required to achieve primary stability during immediate implant placement.[11] In this case, the patient had an initial ridge width of <4 mm, and hence ridge splitting was planned anticipating an increase of 3 mm ridge width. Ridge split creates a 4-wall defect with cortical envelope and simulates an extraction socket.[1] An internal coagulum that forms with the placement of interpositional grafting helps in healing and woven bone formation. This technique provides excellent protection to the graft from exposure and displacement, also delivers vascularization from both the cortices and basal bone by internal perfusion throughout the whole healing process. Compared to maxillary soft tissue (palatal), mandibular soft tissue is more elastic and expands for the increase in ridge width to achieve a close approximation of flap.
The PRF membrane acts as a healing material accelerates wound closure by acting as a fibrin bandage.[2] The leukocytes concentrated in the PRF scaffold holds anti-infectious properties. The Platelet concentrates secrete the growth factors which are protected from proteolysis by the fibrin network, the growth factors promote cell migration and matrix remodeling during healing period.[12] The demineralized bone matrix material has a potential osteoinductive property which influences the osteoblastic behavior toward new bone formation.[13]

In a study conducted by Yoon et al., the implant survival rate after ridge-split procedure during an average follow-up period of 4.2 ± 2.1 years was 100% regardless of the implant system and complications.[14] Likewise, another study showed that the mean loss of the alveolar bone height was 0.542 mm.[15] Thus in the present case, the crestal ridge split technique provided a predictable outcome and allowed reduced treatment duration by cutting off the waiting time for the second surgery. However, the limitation of the technique used in this case was a discomfort to the patient because of malleting that could have been averted by the use of the rotary instruments with surgical bone cutting burs and piezosurgery instruments. Furthermore, there is a risk of buccolingual bone fracture when excessive force is delivered which makes the procedure technique sensitive.[15] Despite the risk, the present case showed no such complication and the patient was satisfied with the final outcome after a follow-up period of 6 months.

**Conclusion**

Implants in anterior mandibular area are considered to be the most predictable and stable with high success rate and patient’s satisfaction with implant esthetics. In contrast to traditional ridge augmentation techniques, ridge split technique allows for immediate implant placement following surgery and eradicates the possible morbidity from a second surgical site. Further long-term follow-up studies of several cases are needed to ensure the predictability of the procedure.

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**Conflicts of interest**

There are no conflicts of interest.

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