Ridge Split Techniques: A Literature Review

Mohit Das[1], Abhaya Chandra Das[2], Sourav Panda[3], Rashmita Nayak[2], Rinkee Mohanty[2], Anurag Satpathy[2]

[1]Post Graduate Trainee, [2]Professor, [3]Reader, Department of Periodontics and oral Implantology, Institute of Dental Sciences, Siksha 'O' Anusandhan, (Deemed to be University), Bhubaneswar, Odisha, India

Abstract

Extraction of teeth leads to loss of alveolar bone in several patterns. The bone loss can occur in a horizontal or vertical direction or a combination of both. Horizontal ridge width deficiency possesses a challenge for the clinician to obtain primary stability during loading and there is risk of fracture of bone segment. Therefore different techniques have been described to gain the ridge width. One of the techniques used is ridge split technique which was first described by Simion et al in 1992. It is a technique of bone manipulation in such a way that it becomes a site for implant placement without removing any bone. Various types of techniques like 3 staged approach, one staged approach etc are described for various sites and situation that help in obtaining an adequate width for loading. This article specifically deals with the different types of ridge split techniques and its description in a simplified manner.

Keywords*: Alveolar bone, Horizontal ridge width, and Ridge split technique*

Introduction

The architecture of the alveolar bone is completely dependent on the tooth architecture. Dependency is so much so that the shape and volume of bone revolves around inclination, axis of eruption and the form of teeth. Therefore, atrophy of the alveolar bone is bound to occur on tooth removal.(1) Pietrokovski and Massler et al in 1967 studied the amount of bone tissue loss following unilateral tooth extraction and concluded that buccal bone resorbed more than the corresponding lingual or palatal side. Therefore, shifting the center of the ridge more palatally or lingually.(2) Studies have also proved that maximum bone resorption occurs in the initial three months following extraction.(3) Schropp et al in 2003 observed that 2/3rd of the bone width reduction occurred in the first three months.(4) Araujo and Lindhe et al in 2005 in an animal study observed alterations in bone width at different levels and stated that the buccal bone wall was thinner than the palatal or lingual bone wall and the width of bone decreased towards the base.(5) These studies proved that there is maximum reduction in bone width in the first three months making it difficult for the placement of implants in those regions.

Corresponding Author:
Dr. Abhaya Chandra Das,
Email: drabhaya2011@gmail.com

As per the classification provided by Les Tolstunov in 2014[6],

Ridge width	>10mm	8-10mm	6-8mm	4-6mm	2-4mm	<2mm	6-10/2-4mm	2-4/ 6-10mm
Ridge Deficiency	No deficiency	Minimal	Mild	Moderate	Severe	Extreme	"Hourglass"	"Bottleneck
Classification	0	I	II	III	IV	V	VI	VII
Indication for surgery	Hard tissue surgery not indicated.	Hard tissue surgery is rarely indicated	GBR or ridge split is often indicated	Ideal for ridge split. GBR or block bone graft can also be done.	Ridge split and block bone graft.	Large extra oral block bone graft	GBR can be done at mid ridge level	Ridge reshaping or GBR at the top of the ridge can be done.

Simion et al in 1992 was the first to introduce the ridge split technique in horizontally deficient ridges.[7] In the maxilla there is more cancellous or elastic bone, therefore the staged approach of expansion of ridge followed by loading after 2-4 months is preferred and for mandible that has dense cortical plates is preferred for crestal split or the greenstick fracture.[8]

CONCEPT OF BONE COLLAPSE AND BONE RESORPTION

Before going ahead with the ridge split procedure (RSP), it is important to understand the difference between bone resorption and bone collapse that defines bone deficiency in a particular region. On extraction of single or multiple teeth, the cancellous or spongy bone undergoes bone resorption. But the cortical bone undergoes collapse resulting in loss of function or stability as shown in **figure 1A**. This leads to buccal and lingual cortical plate lying proximal to each other with minimal amount of medullary bone within it. In case of extraction that includes trauma, both cortical and medullary bone loss occurs together resulting in a true corticomedullary bone loss. Thus , the ideal cases for a ridge split procedure includes a mild medullary bone resorption with mild to moderate loss of cortical bone and an alveolar width ranging from 3 to 5mm having a good alveolar height.

It is very difficult to separate two proximal cortical plates with very little interpositional medullary bone. The medullary bone is the area where the actual split occurs. Therefore, more the amount of interpositional medullary bone, easier it is to split the cortical plates and more predictable results can be expected. On flattening the coronal bone a good amount of cortical plate can be obtained.

SURGICAL PRINCIPLES OF RIDGE SPLIT PROCEDURE (RSP)

1. Development of a vascular bone flap.

2. Healing mostly occurs by the secondary intention.

3. Osteocondensation is one of the processes by which healing occurs.

4. Osteomobilization of cortical plates.

5. Healing occurs differently in maxilla and mandible.

MANDIBULAR TWO-STAGE ALVEOLAR RIDGE-SPLIT PROCEDURE[9]

STAGE 1: CORTICOTOMY

In the process of RSP, corticotomy is of prime importance because of the dense nature of the bone in the mandible. Three types of corticotomies are involved i.e. the crestal corticotomy, apical corticotomy and the vertical corticotomies (two in number) as shown in **figure 1B**. Corticotomy is usually done as a window in

the form of a rectangle as shown in **figure 1C**.

SURGICAL PROCEDURE

It starts with a crestal incision more towards the lingual side for the reflection of a full thickness mucoperiosteal flap. Two full thickness vertical incisions are given at 90 degrees from the crestal incisions in the adjacent teeth in the mesio or disto line angle to release the flap. The reflected flap should expose the bone atleast 1 to 2mm beyond the planned corticotomy site. After reflection of the flap, the corticotomy is performed with the help of thin fissure bur or piezoelectric tips. The crestal and the apical corticotomy are performed parallel to each other with a distance of 10-12mm between them. Corticotomies form a rectangular shape.

Of the four corticotomies, the most important corticotomy is the crestal one since it will be reopened to start the split. The depth of the cut should be the depth of the cortical bone i.e. 1.5 -2.5mm. The corticotomies are extended to the medullary layer of bone. This results in end of the first stage and the site is sutured with a resorbable 5-0 suture and the patient is recalled after 4-5 weeks for the commencement of the second stage.

STAGE 2: SPLITTING, EXPANSION, AND GRAFTING

In this stage, Osteomobilization is done by splitting the bone along the medullary bone leading to the movement of the bone buccally by forward movement. If in the stage 1, the buccal bone has been evenly weakened throughout then the Osteomobilization becomes easy. Therefore, they cause movement with the help of special osteotomes and spreaders.

SURGICAL PROCEDURE

The second stage of the surgery should be started only with a crestal incision as shown in **figure 1D**. Overzealous exposure of the bone is not required. Buccal periosteal vascularization is maintained by prevention of reflection of the flap.[10]

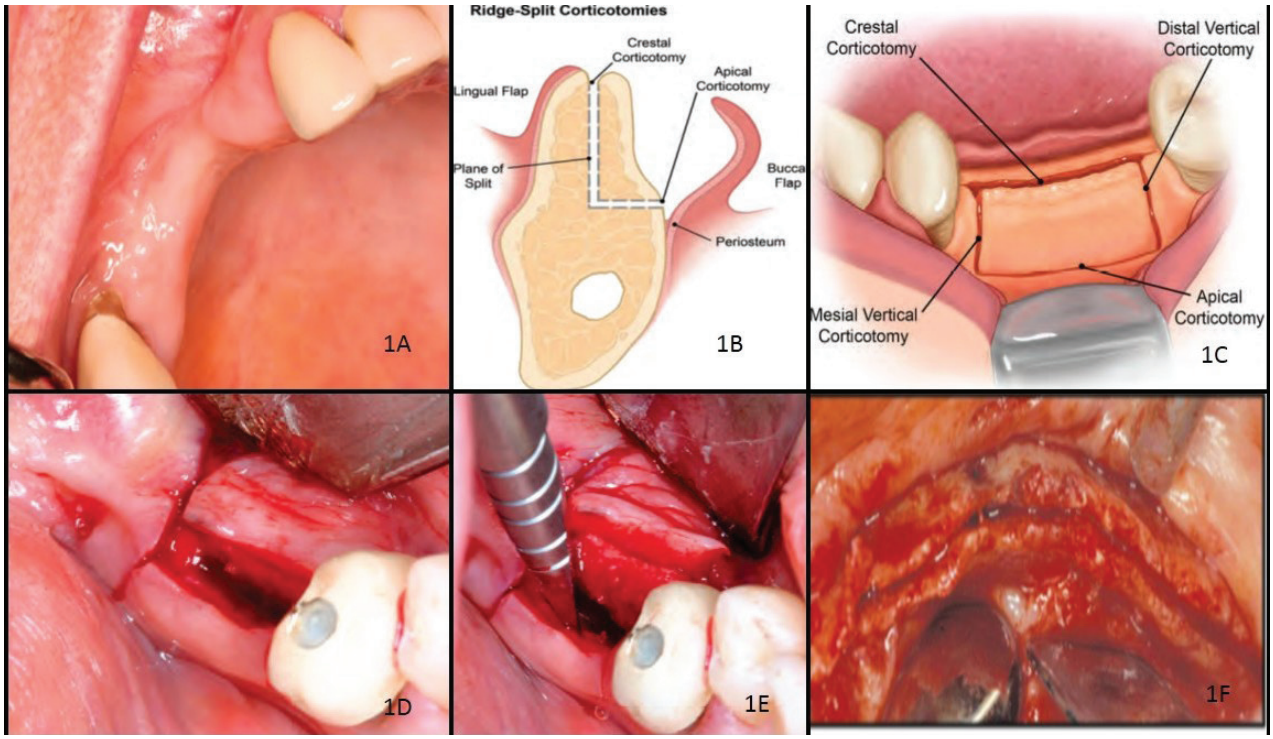

Figure: 1A (Volumetric bone loss), B (Buccal bone split), C (The four corticotomies for RSP), D (Exposure of crestal site), E (Buccal bone fractured using chisel), F (Combination of flap)

Partial thickness flap could be used to allow visibility as well as to maintain the vascularization of the bone that is to be splitted in **figure 1E**.[11]

Elian et al in 2008 gave a technique where he used a full thickness flap for the crestal area and a partial thickness flap for the rest of the elevated flap as shown in **figure 1F**.[12]

According to Tolstunov, the best way to identify the crestal groove is to vertically drop a number 15 blade and create a mark or indentation on the spongy bone where the next set of instruments (osteotomes) can be used. Variety of instruments along with osteotomes is shown in **figure 2A**.

SPLITTING

For this process to take place osteotomes and chisels are a prerequisite. The force required is a gentle tap with light to medium force to produce a greenstick fracture of the buccal segment of the bone. There are two types of buccal segment of bone i.e. "Island flap" and the "Book flap". Jensen et al in 2010 stated that once the I flap is obtained a movement of around 3mm is possible.[13] Maximum thickness or the most available thickness that provides a good result through an I flap is 2mm. **Jensen et al in 2009** conducted a study to check the marginal bone stability using 3 different flap approaches and concluded that alveolar widening by crest splitting by all three approaches resulted in alveolar width increase after 1 year but the full thickness flap resulted in some amount of gingival recession and facial bone loss.[14]

GRAFTING

The most ideal grafting material would be the one that maintains the split during the time of healing and provide osteoconduction. Xenografts like Puros, Allo-Oss, Bio-Oss and Nu-Oss can be used. The packing needs to be done by applying light pressure as shown in **figure 2B**. Once the graft has been assimilated, the graft needs to be isolated from the oral environment by the usage of barrier membranes. Non resorbable membrane would require a surgical reentry for its removal while resorbable doesn't. However, a resorbable membrane interferes with the tissue healing and predictable outcome. After desired placement of membrane, suture is given as shown in **figure 2C.**

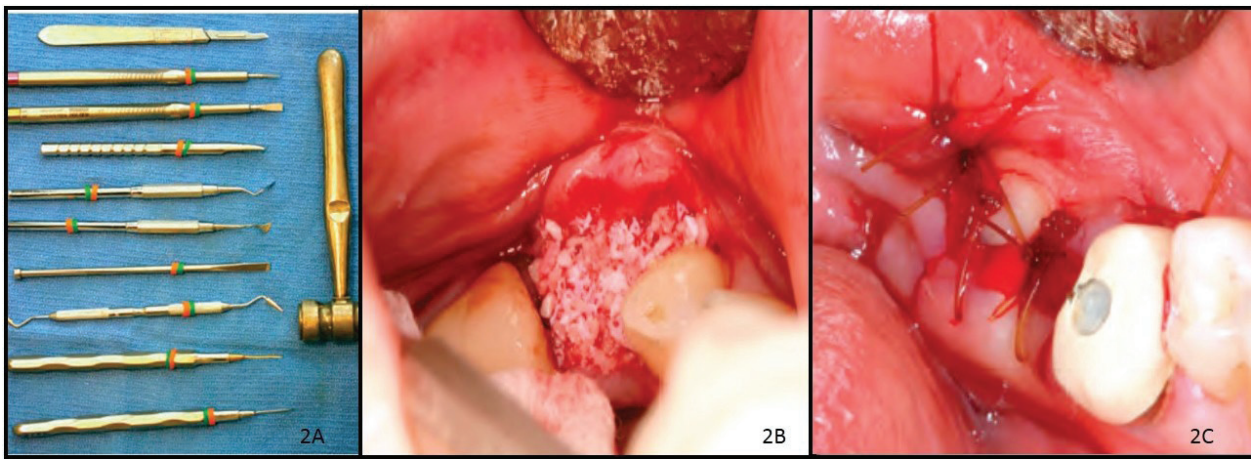

Figure: 2 A (Instruments required for RSP), B (Placement of bone graft of choice), C (Suture placed)

THREE STAGE SPLIT CREST TECHNIQUE (HU ET AL,2008)[15]

Hu et al in 2008 came up with a three stage procedure for the split crest technique. In the **first stage**, only corticotomy is done following mid crestal incision and reflection. It ends with primary flap closure and the patient is recalled after **2-3 months**.

In the **second stage**, a split crest knife is used to give an incision at the crest to only view the ridge crest or a limited full thickness flap. Then particulate bone graft is placed in the interpositional gap and then suture is placed with primary closure. Then patient is recalled

after 4-6 months for the implant placement.

In the **third stage**, patient is recalled after 4-6 months for implant placement.

ALVEOLAR RIDGE SPLIT TECHNIQUE USING PIEZOSURGERY(Moro et al 2017)[16]

Vercelotti et al 2000 introduced the use of piezoelectric surgery in the treatment of atrophic jaw. The advantage of using piezosurgery is that it is safer, easier and decreased the complications that are encountered when done with osteotomes.

In this study the bone regeneration was evaluated and found both vertical and lateral augmentation occuring with values of 3.2±0.4 mm and 5.2±0.7 mm. Use of piezosurgery reported no cases of infection and post operative complication. This study has used various kinds of piezo tips for the comfortable cutting of the bone.

The first set of tips that were used in this study was the square shaped tips which had the advantage of performing the osteotomies faster and efficiently as shown in **figure 3A, 3B**. The second set that were used in this study were with blunt edges that had the advantage of being less aggressive to avoid damage to vital structures. After splitting of alveolar bone, desired bone graft is placed along with suitable membrane as shown in **figure 3C**.

MAXILLARY SINGLE-STAGE ALVEOLAR RIDGE-SPLIT PROCEDURE[18]

Maxilla is composed mostly of spongy or the cancellous bone which is soft in nature. Here in maxilla, a crestal corticotomy along with limited vertical corticotomies are required with a split thickness flap which comprise the single stage approach.

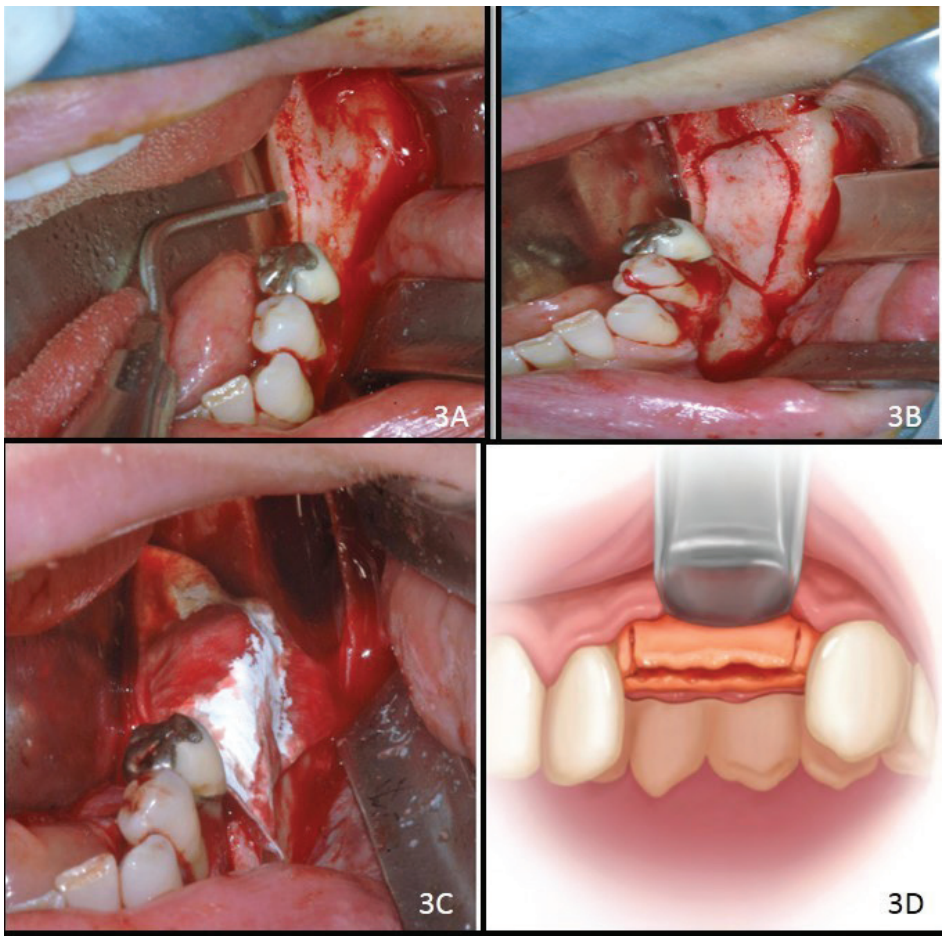

Figure: 3 A (grooving of the center using low power of Piezo), B (Prepared osteotomy site), C (Resorbable membrane covering the grafted materials), D (Maxillary single stage ridge split procedure)

The buccal flap is reflected only to the extent where proper visualization of the buccal bone (2-3 mm) can be done. Crestal incision must be given slightly to the palatal side to visualize the crestal aspect of the bone. A combination flap is the most preferred type used. The next step is to go ahead with the crestal corticotomy. The corticotomy involves a crestal corticotomy with the two small vertical corticotomies to assist in limiting the fracture of vertical component and propagating a horizontal one.

The crestal corticotomy can be initiated using a 15c blade, piezo tips or 701 bur. But the best way to initiate is the use of 15C blade to make a small initial indentation to gain access to the medullary bone. Further chisel osteotomes are used to widen the split and go apically till the vestibular depth and then the pressure is transferred laterally for the green stick fracture to take place. The best way to go about is to stay parallel and towards the palatal plate which transfers the pressure superiorly and prevents buccal thinning or fracture. The small vertical osteotomies guide the fracture in a vertical direction as shown in **figure 3D**. This controls the amount of greenstick fracture and also preserves the integrity of the close by teeth or roots.

APICAL U-SHAPE SPLITTING TECHNIQUE(WU ET AL IN 2019)[19]

In the anterior maxilla, ridge splitting technique with immediate loading is preferable.[20,21] There are many advantages to this technique that includes less use of bone substitute, immediate loading and usage of the cancellous bone for fracture less bone spreading. More the cancellous bone, better outcome can be predicted. During RST, splitting of the bone segment might result in greenstick fracture of the segment due to the concavity owing to its pattern of resorption. The principle for U shape splitting concentrates on expanding the thinnest area or the most concave area leaving alveolar crest alone.

SURGICAL PROCEDURE

Mucoperiosteal flap is reflected for the bone able to be seen. In this procedure, bone is scored in a U shape till the cancellous bone. The osteotomy is done just above the lower portion of the concavity to the depth of the cancellous bone. The vertical osteotomy was done 1 mm of the adjacent roots and the cuts are extended beyond the undercuts. Then, the released bone end was gently leveled out using a periosteotome through a greenstick fracture so as to create enough space for implant placement. Following which an immediate implant placement can be done as shown in **figure 4**.

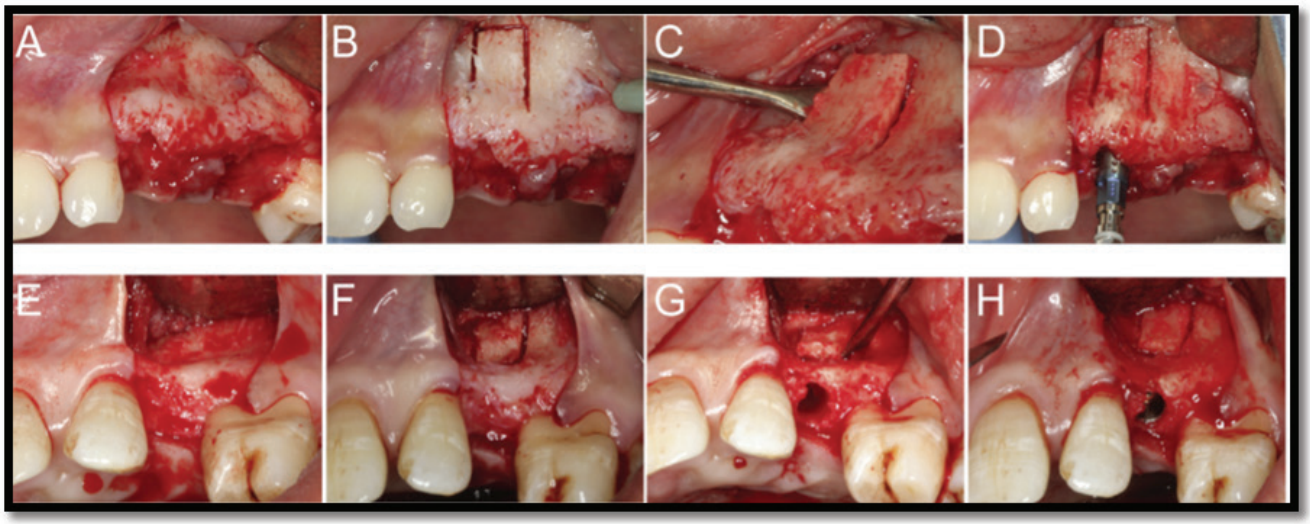

Figure 4 –Apical u shape split procedure

Wu et al in 2018 reported that the use apical u shape split procedure resulted in greater ridge width gain in comparison to GBR technique.[19] The advantages of this technique over GBR include its ability to maintain the space. This technique is however not free of limitations. Deeper defects resulted in jeopardizing the bone flap and the elevation is not possible in that case. Deeper defect resulted in thinner bone flap which resorbs faster due to lack of blood supply. Therefore, this technique holds well for the less deep defects.

CONCEPT OF BONE EXPANSION

One of the most important complications of implant dentistry is the atrophic ridge in the maxilla. Narrow crests make it difficult for the implantologists for the placement of implants which led to discovery of ridge expansion procedures. Summers in 1994 first introduced the expansion osteotomes which were cylindrical and conical in shape. The shape of the instrument explains a lot about the mechanism by which bone expansion in maxilla occurs. The first thing that needs to be understood is that the maxilla is composed of less dense bone and more of spongy bone and trabecular bone. Summers expansion osteotomes are cylindrical-conical in shape with steady escalation of the instrument diameter wherein the base of each instrument corresponds to the active part of the next one which can be clearly seen in the **figure 5A**.[22]

BONE SPREADING TECHNIQUE (BST) (Nishioka et al 2010)(23)

This technique is basically an alternative Summers osteotomy technique which involves less trauma to the bone while expanding it followed by implant placement. Screw spreaders are used with increasing diameters to expand the bone laterally as shown in **figure 5 B, C.**

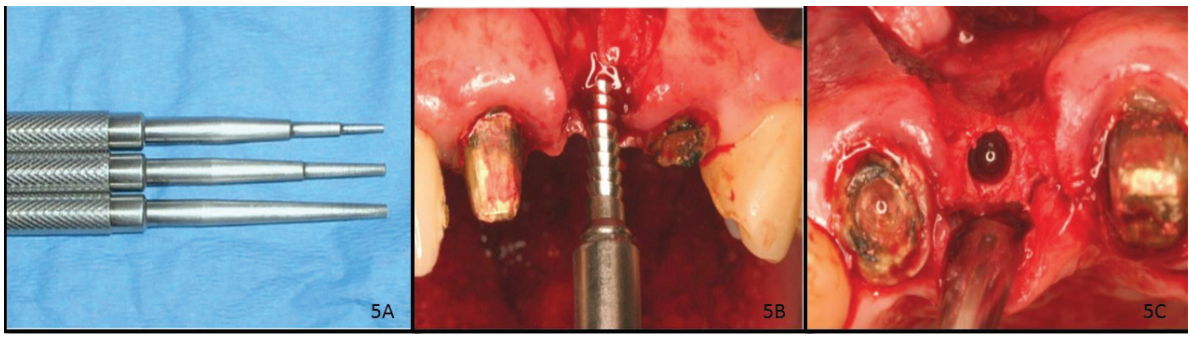

Figure: 5 A (Summers expansion osteotomes), B (Placement of thread former), C (Broadening of the cavity)

Nishioka et al suggested that this technique was feasible for the patients with a spongy bone width of 2.5mm between the cortical walls.[24] This technique allows the clinicians for implant placement in areas where the bone thickness is very less. It has a control system that controls the horizontal dimension to a certain width and also prevents excessive expansion of the medullary bone.

SPLIT-CREST TECHNIQUE

This technique uses the piezo surgery device and the ultrasonic bone surgery device to make precise cuts and osteotomies for splitting the alveolar crest giving more predictable outcome. Piezoelectric transducers have more energy in terms of bone cutting. Piezo-electric materials when subjected to intense electric field, typically in the 500–750 V/mm range.[25]The rationale of the treatment is the trauma that is caused to the bone due to the use of chisels. In the mandible, the stresses are more due to the presence of dense bone. Therefore the use of oscillating instruments is effectual and less strenuous on the patient.

EXTENSION CREST TECHNIQUE

Chiapasco et al suggested the use of a new device in 2006 called as the extension crest device as shown in **figure 6 A, B**. It was anticipated to be used for the sagittal osteotomy in case of atrophied ridge. The extension crest device provides a slow and steady expansion of the sagittal osteotomy and also reduces the risk of the buccal plate fracture.[26]

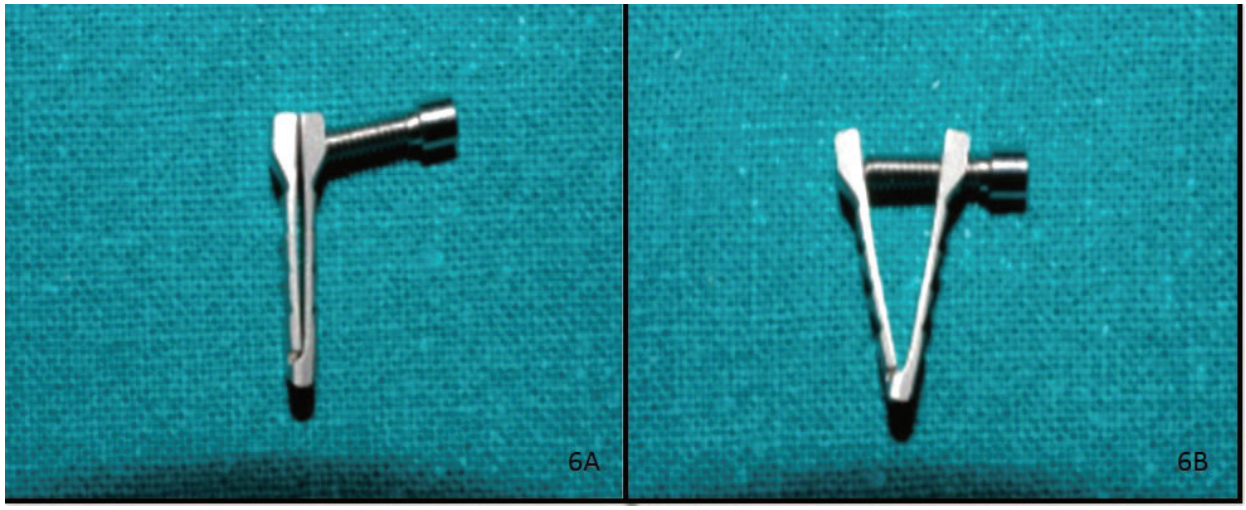

Figure: 6 A (Non activated extension crest device), B (Activated Extension crest device)

COMPLICATION

- Fracture of the buccal plate
- Infection and uncontrolled bleeding
- Neurosensory complication in case of nerve damage(Rare)

Conclusion

The literature has demonstrated different techniques of the ridge split procedure which can be used in case of resorbed ridges. The staged approach is always preferred over single stage ridge split procedure as they have higher implant success rate. Although it is an invasive procedure, it has successfully helped in rehabilitating highly resorbed ridges and should be used as and when necessary. The disadvantages however are the technique sensitivity that comes with the practitioner's experience and confidence.

Conflict of Interests: The authors declare they have no conflicts of interests.

Ethical Issues: Approved

Funding: None

References

1. Tallgren A. The continuing reduction of the residual alveolar ridges in complete denture wearers: A mixed-longitudinal study covering 25 years. J Prosthet Dent. 1972 Feb;27(2):120–32.
2. Pietrokovski J, Massler M. Alveolar ridge resorption following tooth extraction. J Prosthet Dent. 1967 Jan;17(1):21–7.
3. Johnson K. A study of the dimensional changes occurring in the maxilla following tooth extraction. Aust Dent J. 1969 Aug;14(4):241–4.
4. 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 Aug;23(4):313–23.
5. Araujo MG, Lindhe J. Dimensional ridge alterations following tooth extraction. An experimental study in the dog. J Clin Periodontol. 2005 Feb;32(2):212–8.
6. Tolstunov L. Classification of the Alveolar Ridge Width: Implant-Driven Treatment Considerations for the Horizontally Deficient Alveolar Ridges. J Oral Implantol. 2014 Jul;40(S1):365–70.
7. 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.
8. Scipioni A, Calesini G, Micarelli C, Coppè S, Scipioni L. Morphogenic bone splitting: Description of an original technique and its application in esthetically significant areas. Int J Prosthodont. 2008 Sep 1;21:389–97.
9. Tolstunov L, Hicke B. Horizontal Augmentation

Through the Ridge-Split Procedure: A Predictable Surgical Modality in Implant Reconstruction. J Oral Implantol. 2013 Feb 1;39(1):59–68.

10. Duncan JM, Westwood RM. Ridge widening for the thin maxilla: a clinical report. Int J Oral Maxillofac Implants. 1997 Apr;12(2):224–7.
11. Pikos MA. Buccolingual expansion of the maxillary ridge. Dent Implantol Update. 1992 Nov;3(11):85–7.
12. Elian N, Jalbout Z, Ehrlich B, Classi A, Cho S-C, Al-Kahtani F, et al. A Two-Stage Full-Arch Ridge Expansion Technique: Review of the Literature and Clinical Guidelines: Implant Dent. 2008;17(1):16–23.
13. Jensen OT, Bell W, Cottam J. Osteoperiosteal Flaps and Local Osteotomies for Alveolar Reconstruction. Oral Maxillofac Surg Clin N Am. 2010 Aug;22(3):331–46.
14. Jensen OT, Cullum DR, Baer D. Marginal Bone Stability Using 3 Different Flap Approaches for Alveolar Split Expansion for Dental Implants—A 1-Year Clinical Study. J Oral Maxillofac Surg. 2009 Sep;67(9):1921–30.
15. Hu G-H, Froum S, Alodadi A, Nose F, Yu Y-C, Suzuki T, et al. A Three-Stage Split-Crest Technique: Case Series of Horizontal Ridge Augmentation in the Atrophic Posterior Mandible. Int J Periodontics Restorative Dent. 2018 Jul;38(4):565–73.
16. Moro A, Gasparini G, Foresta E, Saponaro G, Falchi M, Cardarelli L, et al. Alveolar Ridge Split Technique Using Piezosurgery with Specially Designed Tips. BioMed Res Int. 2017;2017:1–8.
17. Vercellotti T. Piezoelectric Surgery in Implantology: A Case Report - A New Piezoelectric Ridge Expansion Technique. Int J Periodontics Restorative Dent. 2000 Sep 1;20:358–65.
18. Anitha K, Kumar SS, Babu MRR, Candamourty R, Thirumurugan null. Immediate implants in anterior maxillary arch. J Nat Sci Biol Med. 2014 Jan;5(1):82–9.
19. Wu Q, Yang B, Gao S, Gong P, Xiang L, Man Y, et al. Apical U-shape splitting technique for undercut areas of the anterior alveolar ridge: a prospective non-randomized controlled study. Int J Oral Maxillofac Surg. 2019 Mar;48(3):388–94.
20. González-García R, Monje F, Moreno C. Alveolar split osteotomy for the treatment of the severe narrow ridge maxillary atrophy: a modified technique. Int J Oral Maxillofac Surg. 2011 Jan;40(1):57–64.
21. Bassetti MA, Bassetti RG, Bosshardt DD. The alveolar ridge splitting/expansion technique: a systematic review. Clin Oral Implants Res. 2016 Mar;27(3):310–24.
22. Summers RB. A new concept in maxillary implant surgery: the osteotome technique. Compend Newtown Pa. 1994 Feb;15(2):152, 154–6, 158 passim; quiz 162.
23. Nishioka R. Bone spreading technique. Dent Today. 2010 Dec 1;29:72–3.
24. Nishioka RS, Souza FA. Bone Spreader Technique: A Preliminary 3-Year Study. J Oral Implantol. 2009 Dec;35(6):289–94.
25. 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.
26. Chiapasco M, Ferrini F, Casentini P, Accardi S, Zaniboni M. Dental implants placed in expanded narrow edentulous ridges with the Extension CrestR device. A 1-3-year multicenter follow-up study. Clin Oral Implants Res. 2006 Jun;17(3):265–72.