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Research Article

Modified Ridge Splitting and Bone Expansion Osteotomy for Dental Implant Placement in the Esthetic Zone with Guided Bone Regeneration Using Demineralized Freeze-Dried Bone Allograft and PRF Membrane

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Received: January 06, 2026; **Published:** February 04, 2026

Abstract

Introduction: Ideal implant placement is frequently impeded by an alveolar ridge that is too narrow. The lateral augmentation of the alveolar ridge is accomplished via alveolar ridge splitting, modified ridge splitting, bone expansion osteotomy, bone grafting, guided bone regeneration, and combinations of these methods.

Aims and Objectives: This research was conducted to assess the average labio-palatal width of the alveolar ridge before and after splitting with implant insertion, to compare the average labio-palatal width of the alveolar ridge between pre-prosthesis and post-prosthesis after six months; and to determine the mean labio-palatal width of the alveolar ridge prior to treatment and after treatment of implant placement.

Materials and Methods: Ten patients underwent treatment for single tooth replacement in the aesthetic zone through implant placement using modified ridge splitting and bone expansion osteotomy along with guided bone regeneration. Bone regeneration was accomplished using demineralized freeze-dried bone allograft (DFDBA) and a PRF membrane. In this research, we conducted modified ridge split bone expansion osteotomy with concurrent implant placement in the aesthetic area. The varied application of osteotomes and chisels alleviates the pressure at the crest by making chisel cuts slightly mesial and distal to the osteotomy. In contrast to segmental ridge splitting, there are no efforts to perform vertical osteotomy cuts. The osseous defect was packed with DFDBA and shielded by a PRF membrane after the appropriate-sized implant was inserted.

The patients were followed to see the response to rehabilitation clinically & radiographically for six months after loading of implant.

Results: The average pre-split labio-palatal width measured 3.70 ± 0.42 mm, whereas the average post-split labio-palatal width was 6.65 ± 0.47 mm. Consequently, the average increase in the crestal ridge following post-split was 2.95 mm. The average labio-palatal width before prosthesis was 6.15 ± 0.47 mm, whereas after prosthesis, it measured 5.95 ± 0.36 mm. Consequently, there was an average loss of 0.20 mm, likely resulting from the functional adaptation of the alveolar bone following implant loading. The labio-palatal width before treatment measured 3.70 ± 0.42 mm, while after treatment it increased to 5.95 ± 0.36 mm. Consequently,

following six months of functional loading of the implant, there was an average increase of 2.25 mm in the labio-palatal width of the alveolar bone compared to the pre-split labio-palatal width of the alveolar bone.

Conclusion: Altered ridge splitting and bone expansion osteotomy combined with guided bone regeneration utilizing demineralized freeze-dried bone allograft and PRF membrane for dental implant placement in the esthetic zone demonstrated reliable outcomes when appropriate case selection and meticulous surgical techniques were applied.

***Keywords**: Alveolar Ridge Augmentation; Dental Implants; Narrow Alveolar Ridge; Osteotomy; Ridge Expansion; Ridge Splitting*

Introduction

Inadequate width of the alveolar ridge frequently hinders optimal implant positioning. Guided bone regeneration, bone grafting, splitting of the alveolar ridge, and combinations of these methods are utilized for the lateral expansion of the alveolar ridge. Ridge splitting is a less invasive method suitable for alveolar ridges with sufficient height, allowing for immediate implant placement and reducing both morbidity and total treatment duration. The traditional method of the technique consists of dividing the alveolar ridge into two sections using osteotomes and chisels. Variations of this method involve the application of rotating instruments, screw spreaders, horizontal spreaders, and ultrasonic devices [1].

Aim of the Study

The goals of this study were to measure and compare the average labio-palatal width of the alveolar ridge before and after splitting with implant placement, to assess the differences between the pre-prosthesis and post-prosthesis mean labio-palatal width of the alveolar ridge after six months; and to determine the average labio-palatal width of the alveolar ridge prior to treatment and after implant placement treatment.

Materials and Methods

Ten patients were selected from the outpatient department of Periodontology and Implantology at Chandra Dental College and Hospital in Barabanki, Uttar Pradesh, India, with a primary complaint of a missing upper front tooth for one year, who sought a fixed prosthesis, ideally an implant-supported one, based on inclusion and exclusion criteria. The inclusion criteria for patients consisted of non-contributory medical/social and family histories, a partially edentulous upper front alveolar ridge; inadequate labio-palatal width of the alveolar ridge for implant insertion, with a minimum ridge width of 3 mm suitable for ridge splitting and lateral expansion. Exclusion criteria included inadequate alveolar ridge height that would compromise implant: crown ratio, immuno-compromised individuals, chronic tobacco users, infections or pathological issues at the surgical site, medically compromised individuals, and poor oral hygiene. Pre-operative and post-operative metrics were obtained through initial and final assessments of alveolar ridge width via CBCT. The investigations conducted included standard blood tests (BT, CT, Hb % and RBS), Denta Scan or suitable CT method, IOPA radiograph, and OPG. Follow-up occurred post-operatively six months after the placement of the implant and six months after the creation of the prosthesis.

Clinical examination of soft tissue and radiographic assessment of hard tissue were conducted for pre-operative evaluations of the implant site. The gingiva was assessed for its texture, consistency, and thickness. Transgingival probing was performed to assess bone topography. Occlusion and the inter-occlusal/incisal gap were likewise evaluated. Preoperative computed tomography (CT), IOPA, and OPG were conducted to evaluate the quality and quantity of bone at the implant placement location and served as a reference for deciding the implant size (Figure 1-3).

Prior to treatment, both verbal and written consent were acquired from the patient. This research received approval from the institutional ethics committee for human subjects and was also carried out in accordance with the Helsinki Declaration of 1975, revised in 2000.

The patient was instructed to do presurgical rinse by 0.2% chlorhexidine solution. The facial skin around the mouth was cleaned with spirit and scrubbed by 7.5% povidone-iodine solution. The intraoral surgical site was painted with 5% povidone-iodine solution [10].

Pre-operative antibiotics and analgesic were prescribed and the patient were prepared in a sterile environment. Local anesthesia, lignocaine 2% containing 1:80,000 adrenaline was injected in the area of surgery as an infiltration. A crestal incision was given and combined muco-periosteal and mucosal flap was reflected on labial aspect and only mucoperiosteal flap on palatal side. The combined flap provides advantage of proper flap closure after ridge expansion. The exact location of implant on the ridge was marked by an indentation created by surgical blade. Three types of ridge expanding instruments namely, oscillating saw, uni-beveled chisel, bibeveled osteotome and tapered osteotomes were used in the surgery. All these instruments were used by gentle tapping with mallet. Using Oscillator and uni-beveled chisel (2 mm), with bevel facing labial side, an indentation made on crestal cortex was perforated to reach cancellous bone. The bi-beveled osteotome 2.5 mm, 3.5 mm in length and tapered osteotome 2 mm, 3 mm diameter at the tip were used alternately to expand the osteotomy. All the instruments after tapping to desired depth were wiggled back and forth in a mesio-distal direction with slight buccal pressure. This allows expansion of ridge facially with advancing osteotomies as well as easy removal of instrument without any risk of fracturing the labial plate. Any crestal resistance if felt before reaching desired depth was relieved by advancing chisel cut mesial and distal to osteotomy. It was done using uni-beveled chisel. This chisel cut extension allowed better relieving of stress concentrated at the crest during ridge expansion with osteotome. Similarly, any apical resistance if felt was relieved by the smallest diameter pilot drill by untouching the crestal bone. The final instruments closely matched the shape of the implant. Self-tapping, threaded, implant of suitable length and diameter was carefully placed in expanded osteotomy at same surgical appointment. In all the cases osseous defect was filled up with DFDBA and covered with a PRF membrane after the implant of suitable dimension were placed and sutured (Figure 4-11). After six months of implant placement, radiographic evaluation of bone around implant was done (Figure 12). If it is good, then prosthesis was fabricated. After six months of fabrication of prosthesis, that is, one year from placement of implant, labio-palatal width of alveolar bone was measured (Figure 13 and 14). The final esthetic after 1 year shows esthetically satisfactory result (Figure 15).

Figure 1: *Pre-operative clinical view.*

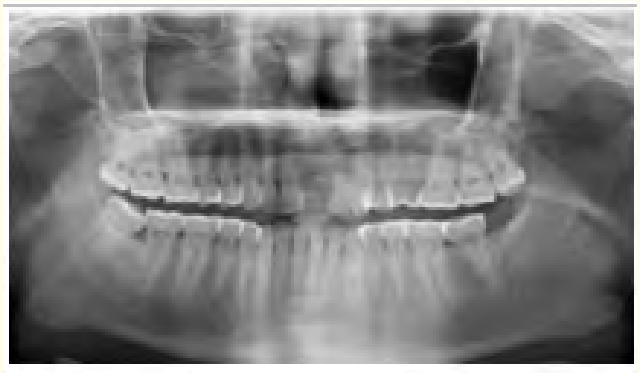


Figure 2: *Pre-operative radiographic view.*

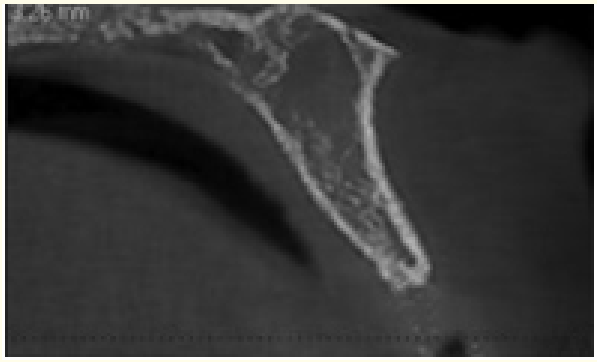


Figure 3: *Pre-operative cross sectional image showing 4.0 mm width at crest*

Figure 4: *Pre-operative width at the crest.*

Figure 5: *Use of oscillating saw to cut the cortex and crestal bone.*

Figure 6: *Use of Bi-beveled osteotome to initiate splitting and expansion laterally.*

Figure 7: *Tapered osteotome used to progress osteotomy.*

Figure 8: *Crest after ridge splitting.*

Figure 9: *Implant placement.*

Figure 10: *PRF and bone graft placed.*

Figure 11: *Suturing done.*

Figure 12: *Post-operative radiographic view after six months of implant placement.*

Figure 13: *Post-operative IOPA X-ray after one year.*

Figure 14: *Post-operative cross sectional image after one year.*

Figure 15: *Post-opratve clinical view after one year.*

Results

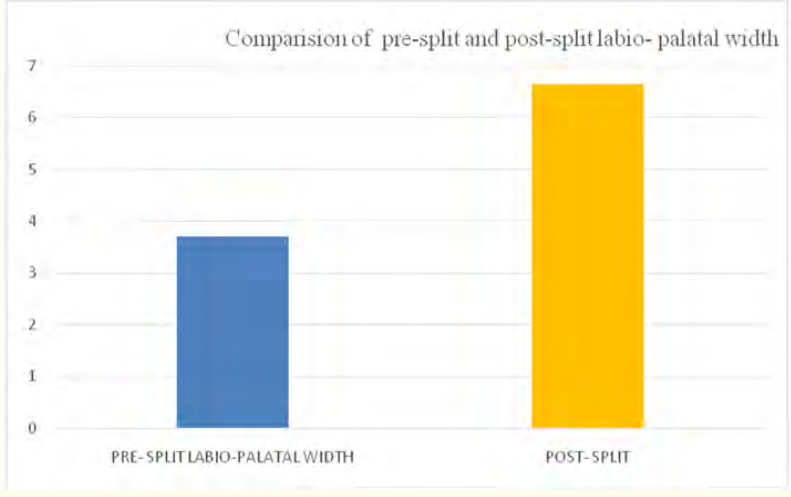
Mean value for pre-split labio-palatal width was 3.70 ± 0.42 mm while post-split mean labio-palatal width was 6.65 ± 0.47 mm (Table 1, 2 and graph 1). Thus, mean gain in crestal ridge after post-split was 2.95 mm. Pre-prosthesis mean labio-palatal width was 6.15 ±0.47 mm while post-prosthesis labio-palatal width was 5.95 ± 0.36 mm (Table 3, 4 and graph 2). Thus, there was mean loss of 0.20 mm which may be due to functional adaptation of alveolar bone after implant loading. Pre-treatment labio-palatal width was 3.70 ± 0.42 mm and post-treatment labio-palatal width become 5.95 ± 0.36 mm (Table 5, 6 and graph 3). Thus, after six months of functional loading of implant, there was mean gain of 2.25 mm of labio-palatal width of alveolar bone compared to pre-split labio-palatal width of alveolar bone.

Pre-split labio-palatal width		Post-split labio-palatal width	
Mean	3.7	Mean	6.65
Standard Deviation	0.421637021	Standard Deviation	0.474342
Sample Variance	0.177777778	Sample Variance	0.225
Range	1.5	Range	1.5
Minimum	3	Minimum	6
Maximum	4.5	Maximum	7.5

Table 1: *Mean pre-split and post-split labio-palatal width of alveolar ridge.*

t-Test: Paired Two Sample for Means		
	Pre-split labio-palatal width	Post-split labio-palatal width
Mean	3.7	6.65
Variance	0.177777778	0.225
t stat	-59	

Table 2: *Comparison between changes in mean pre-split and post-split labio-palatal width of alveolar ridge.*



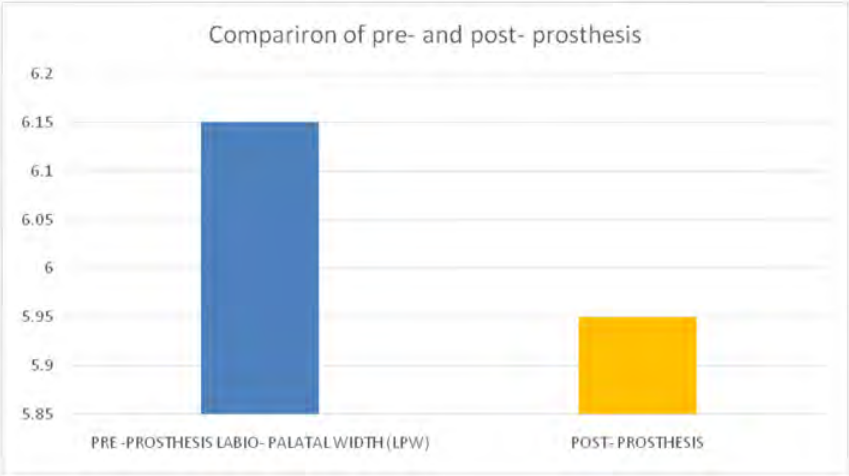
Graph 1: *Showing pre-split and post-split labio-palatal width of alveolar ridge.*

Pre-prosthesis labio-palatal width		Post-prosthesis labio-palatal width	
Mean	6.15	Mean	5.95
Standard deviation	0.474341649	Standard deviation	0.368932
Sample variance	0.225	Sample variance	0.136111
Range	1.5	Range	1
Minimum	5.5	Minimum	5.5
Maximum	7	Maximum	6.5

Table 3: *Mean pre-prosthesis and post-prosthesis labio-palatal width of alveolar ridge.*

t-Test: Paired two sample for means		
	Pre-prosthesis labio-palatal width	**Post-prosthesis labio-palatal width**
Mean	6.15	5.95
Variance	0.225	0.136111111
t stat	2.449489743	

Table 4: *Comparison between changes in mean pre-prosthesis and post-prosthesis labio-palatal width of alveolar ridge.*



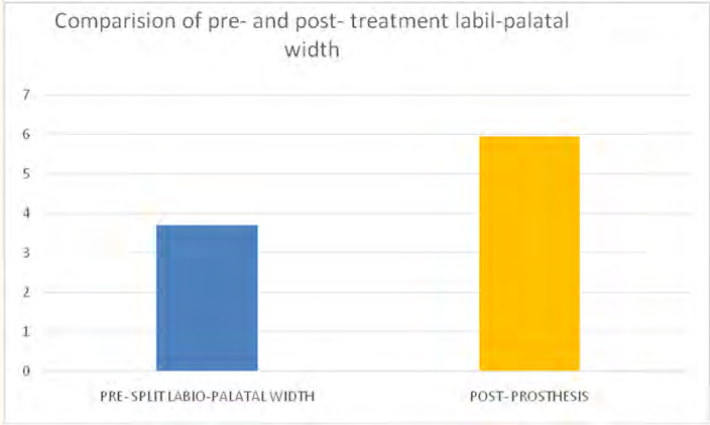
Graph 2: *Showing pre-prosthesis and post-prosthesis labio-palatal width of alveolar ridge.*

Pre-split labio-palatal width		**Post-prosthesis labio-palatal width**	
Mean	3.7	Mean	5.95
Standard Deviation	0.421637021	Standard Deviation	0.368932
Sample Variance	0.177777778	Sample Variance	0.136111
Range	1.5	Range	1
Minimum	3	Minimum	5.5
Maximum	4.5	Maximum	6.5

Table 5: *Mean pre-split and post-prosthesis labio-palatal width of alveolar ridge.*

t-Test: Paired two sample for means		
	Pre-split labio-palatal width	**Post-prosthesis labio-palatal width**
Mean	3.7	5.95
Variance	0.177777778	0.136111111
t Stat	-59	

Table 6: *Comparison between pre-split and post-prosthesis labio-palatal width of alveolar ridge.*



Graph 3: *Showing pre-split and post-prosthesis labio-palatal width of alveolar ridge.*

Discussion

It is well-established that alveolar ridge < 5 mm requires augmentation procedure in order to receive endosseous implant with healthy peri-implant bone of 1.5 to 2 mm. If implants are placed in areas of inadequate ridge width then following problem can occur: Dehiscence of labial bone predisposing chances of peri-implantitis, leading to unesthetic metal display through gingiva, leaving a thin bone < 1 - 1.5 mm may predispose to resorption of thinner labial plate in near future, meeting gingival recession and implant exposure; and undercuts present on alveolar bone gives rise to off-axis loading [2]. All these problems can be overcome by augmenting bone either through grafting or by other means. Various treatment options to managed horizontally deficient ridge include increasing width by osteoplasty, using narrow diameter implant, ridge augmentation by autogenous block graft, corticocancellous particulate bone graft and allograft using GBR membrane, distraction osteogenesis and ridge splitting with bone expansion techniques, etc.

Increasing width with osteoplasty results in FP2 and FP3 prosthesis. Narrow diameter implant presents greater mesial and distal cantilever, thus higher tendency of fatigue fracture with abutment and its screw loosening [3]. Ridge augmentation with bone block and GBR technique carries additional donor site, long term waiting period 6 - 12 months, risk of membrane exposure infection and increase cost to patient without 100% success rate [4,5]. Distraction osteogenesis leaves patient uncomfortable and is cumbersome [6].

Although ridge splitting and bone expansion appears to be technique sensitive but has many advantages over different technique [7,8]. It takes advantage of inherent quality of flexibility of cancellous bone. Maxillary bone is pliable and can be slowly manipulated to improve quality (compaction and corticalization) and expanded to desired width. When clinicians allow times for manipulation of bone, it can eventually mold to desired location. It never allows loss of patient bone which is usually unavoidable by mere drilling procedure [9]. The success of this technique also depends on maintaining integrity of labial bone, which occurs as long as periosteum is intact. Periosteum due to its elastic nature allows bone expansion and manipulation and acts as a barrier membrane and makes micro-fracture heals very well because of intact blood supply. Hence it is advisable to leave intact periosteum encasing the bone which can achieved by raising conservative muco-periosteal flap in area of implant placement and then further mucosal flap to coronally advance flap closure [10].

The ideal indications of ridge splitting and bone expansion procedure are those sites that do not require vertical ridge augmentation and having cancellous bone present between labial and palatal cortical plate. It can be best done in a narrow ridge of minimum 3 mm with greater preference in maxillary bone over mandibular bone [10].

The technique of ridge expansion osteotomy developed by Summers uses sequence of progressively increasing osteotome to create an osteotomy closely receptacle to implant dimension [11,12]. Though this technique provides atraumatic approach for bucco-lingually deficient ridge but Padmanabhan and Gupta demonstrated greater crestal bone loss associated with osteotome technique compared to conventional technique [13]. However they made no attempt to relieve stresses at crest associated with the use of osteotome. The extension of chisel cut mesial and distal to osteotomy prevents stress concentration at the crest and thus crestal bone loss.

Several authors advocated different ridge split technique [14] in which crestal cut osteotomy is joined to adjacent vertical osteotomy cut on either or on both side followed by creation of greenstick fracture of buccal plate. After the expansion of osteotomy to appropriate size, it is either grafted with bone graft (two step) [15] or implant is placed at same appointment (single step) [16]. This technique jeopardizes the blood supply to the fractured buccal plate and hence rate of sequestration is high if not done carefully.

Sethi and Kaus have reported more than 97% of success rate in two staged implant placed by osteotome through maxillary expansion in a 5 years study [17].

Conclusion

Modified ridge splitting and bone expansion osteotomy with guided bone regeneration by demineralized-freeze-dried bone allograft and PRF membrane for placement of dental implant in esthetic zone showed the predictable results when proper case selection and careful surgery was performed. This technique if done skillfully and carefully can be helpful to expand and remove labial undercuts, which are major causes of fenestration during implant placement. This will also prevent off-axis loading.

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Volume 25 Issue 2 February 2026