Effect of Alveolar Segmental Sandwich Osteotomy on Alveolar Height: A Preliminary Study

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Abstract

Purpose Bone loss following extraction is maximum in horizontal dimension. Height is also reduced which is pronounced on the buccal aspect. Various surgical procedures are available to correct the bone volume viz. GBR, onlay bone grafting, alveolar distraction and sandwich osteotomy. Sandwich osteotomy has been found to increase the vertical alveolar bone height successfully.

Objectives The objective of the study was to assess the effect of alveolar segmental sandwich osteotomy on alveolar height and crestal width.

Materials and Methodology A prospective study was undertaken from December 2012 to August 2014. Seven patients with 12 implant sites with a mean age of 36 years were recruited. All seven patients with 12 implant sites underwent alveolar segmental sandwich osteotomy and interpositional bone grafting. Alveolar bone height was assessed radiographically preoperatively, immediate post-op, and at 3 months post-op. Alveolar bone width was assessed radiographically preoperatively and at 3 months post-op. Statistical significance was inferred at $p < 0.05$.

Results The mean vertical augmentation at immediate post-op was 6.58 mm ($p = 0.001$). The vertical

augmentation that was achieved 3 months post-op was a mean of 3.75 mm which was statistically significant ($p = 0.004$). The change in alveolar height from immediate post-op to 3 month post-op was a mean 1.69 mm. The mean change in alveolar crestal width at 3 months was a mean of -0.29 mm ($p = 0.57$).

Conclusion Sandwich osteotomy can be used as an alternative technique to increase alveolar bone height prior to implant placement. Moderate alveolar deficiency can be predictably corrected by this technique.

Keywords Alveolar bone height · Sandwich osteotomy · Interpositional grafting · Buccal onlay · Sinus lift

Introduction

Tooth extraction is one of the most common dental procedures. Even with uneventful healing, the alveolar defect that results as a consequence of tooth removal will only become partially restored. The greatest amount of bone loss is in the horizontal dimension. There is also loss of vertical ridge height, which has been described to be most pronounced on the buccal aspect. The defect resulting from the loss of a tooth may be complicated by previous bone loss due to periodontal disease, endodontic lesions, or a traumatic episode. The situation becomes even more compromised when the alveolus has lost walls or height. The size of the residual ridge is reduced most rapidly in the first 6 months [1].

After tooth removal, the dental team faces the challenge of creating a prosthetic restoration that blends with the adjacent natural dentition. Sufficient alveolar bone volume and favorable architecture of the alveolar ridge are

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essential to obtain optimal functional and esthetic prosthetic reconstructions [1].

An alternative to block onlay graft or distraction osteogenesis is a local segmental osteotomy with interpositional bone grafting [2].

Interpositional grafting has the advantage of ensuring a good vascular supply to the graft, which should result in less resorption. One of the difficulties encountered is in the management of the soft tissues to preserve the blood supply of the cranial segment, which limits the amount of vertical elevation of the alveolar crest. The bone can be augmented as much as 4–10 mm [3].

Hence, a study was conducted to evaluate the change in vertical alveolar height by segmental alveolar sandwich osteotomy.

Materials and Methodology

A total of 12 implant sites with moderately resorbed alveolar ridges in 7 patients (4 males, 3 females, 25–58 years), who reported to the Department of Oral and Maxillofacial Surgery, M. S. Ramaiah Dental College, between December 2012 and August 2014, were included in the present prospective study. The study was approved by Institutional Ethics Committee, and informed consent was obtained from all patients.

Patients who met the following inclusion criteria were selected: vertical alveolar deficiency ranging from 3 to 7 mm, edentulous site spanning 2–3 teeth and minimum residual alveolar height of 5 mm. Patients with very thin alveolar ridge, known smokers, those undergoing radiotherapy, on long-term steroid therapy or on bisphosphonates and medically compromised patients were excluded from the study.

All patients were evaluated as per standard norms and selected according to the inclusion and exclusion criteria. Written informed consent was obtained from all the patients. Patients were numbered from I to VII chronologically as they underwent the procedure. Preoperatively, height and width of the alveolus were recorded clinically with UNC 15 probe and crestal width with boley's gauge and radiographically (OPG/CBCT). Segmental sandwich osteotomy was done under local anesthesia.

The interpositional graft was harvested from anterior border of ramus or symphysis of mandible. Ten milliliter of blood was drawn from the patient to prepare PRF which was used at both recipient and donor sites. Postoperatively, alveolar height was measured radiographically (CBCT) immediately and after 3 months.

Two patients (patient II, III) underwent buccal onlay grafting, and one patient (patient V) underwent sinus lift in combination with sandwich osteotomy.

Surgical Procedure

Alveolar Sandwich Osteotomy

Under strict aseptic precautions, local anesthesia containing 2% lignocaine with 1:200,000 adrenaline was used and a regional block was given. A 2–3-cm-long incision was given in the buccal or labial vestibule in the edentulous region. The incision was kept 8–10 mm away from the crest. Full thickness mucoperiosteal flap was reflected. Reflection was also done slightly toward the crest of the ridge to expose the vertical osteotomy site. Two vertical and one horizontal osteotomy cuts were placed with a 701 tungsten carbide bur and a surgical handpiece. Osteotomy cuts were such that they make a groove on the lingual cortical plate. Two vertical osteotomy cuts directed toward the crest were placed at the anterior and posterior extent of the augmentation site. Horizontal cut was made to join the two vertical cuts. Horizontal cuts were made so as to take 3–5 mm of pedicle bone. Care was taken to be at least 1 mm away from the important anatomical structures (maxillary sinus or inferior alveolar nerve). Osteotomy was completed using hand osteotome and mallet taking care not to damage the lingual/palatal tissues by keeping a finger on the lingual/palatal side for palpation. Osteotome was used to elevate the osseous segment and create the gap. The amount of elevation was dependent on the elasticity of lingual/palatal tissues. Then, the bone to be grafted (size dependent on the extent of edentulous span) was harvested from either symphysis or the external oblique ridge. The harvested bone was recontoured to fit the gap, and the stability of the graft and osseous segment was confirmed (Figs. 1, 2). After achieving hemostasis, the site was closed

Fig. 1 Osteotomy and gap creation in mandibular posterior region (patient I)

Fig. 2 Harvested bone contoured and fit into the gap (patient II)

primarily with slight advancement of the buccal flap using 3–0 silk or vicryl sutures. All patients were prescribed Cap. Amoxicillin 500 mg, Tab. Metrogyl 400 mg and a combination of Diclofenac + Paracetamol + Serratiopeptidase thrice daily for 5 days. Patients were given instructions on importance of maintenance of oral hygiene and use chlorhexidine mouthwash. All patients were recalled after 7 days for suture removal.

Immediately after surgery and 3 months after the surgery, a CBCT was performed. The bone gain was measured and analyzed between the preoperative and immediate post-op and whether the bone gain was stable at 3 months. Complications if occurred during the healing period were also noted.

One-way analyses of variance (ANOVAs) and paired *t* test were used to test the difference between groups. The results were averaged (mean + standard deviation) for continuous data and number and percentage for dichotomous data and presented in tables and graphs. In all of the above tests, *p* value less than 0.05 was taken to be statistically significant. The data were analyzed using SPSS package (ver. 10.5).

Results

We noted that the mean age of the patients included in our study was 36.71 ± 14 years. Among the 7 patients, 3 (42%) were female and 4 (58%) were males. The patients selected in our study had primarily vertical alveolar deficiency with or without concomitant horizontal alveolar deficiency. Out of the 12 sites corrected for inadequate bone volume, 3 (25%) sites had both vertical and horizontal alveolar deficiency and 9 (75%) had only vertical alveolar deficiency. Of these 12 sites, 6 (50%) were in

Fig. 3 Pre-op CBCT of a patient showing periodontal bone loss in anterior mandibular region (patient VII)

anterior and 6 (50%) in posterior region. Six sites in anterior region included 5 in incisor and 1 in canine region. Six sites in the posterior region included 2 in premolar region and 4 in molar region. Distribution of sites according to arch, maxillary arch had 8 sites, and mandibular arch had 4 sites. Interpositional graft which was used was harvested from mandibular symphysis for 6 patients (10 sites) and external oblique ridge for 1 patient (2 sites).

Alveolar height at the 12 preplanned implant sites (center of implant) was recorded to assess the gain postoperatively and whether the gain was stable. Alveolar height was recorded preoperatively, immediate postoperatively and at 3 months postoperatively. The mean preoperative height was 10.44 ± 5.19 mm indicating a wide range and high variation in the alveolar height preoperatively. The mean immediate postoperative alveolar height was 16.6 ± 3.85 mm and at 3 months postoperative was 14.9 ± 4.68 mm (Figs. 3, 4). Within the 12 surgical sites, between the follow-up visits, analysis was carried out for alveolar height and it was seen to be significant ($p = 0.008$) (Table 1; Fig. 5).

Further analysis was carried out to assess the gain in alveolar height from baseline preoperatively to immediate postoperatively and 3 months postoperatively. It was noted that mean difference in alveolar height between baseline preoperative to immediate postoperative was 6.16 mm

Fig. 4 Immediate post-op CBCT of patient VII showing the sandwich osteotomy and interpositional bone graft. Note the change in angulation of the osteotomized segment

Fig. 5 Three-month post-op CBCT of patient VII showing the uptake of the graft and maintenance of alveolar height during healing period

($p = 0.001$) and to 3 months postoperatively was 4.47 mm ($p = 0.004$). This difference from baseline to both 1 and 3 months postoperatively was statistically significant (Table 2). The difference between 1 and 3 month postoperative values was also statistically significant, indicating that there was significant loss of bone over the 3 month healing period. Loss of alveolar height during healing at all sites ranges from 0 to 6.5 mm with a mean of 1.69 mm (Table 3; Figs. 6 and 7).

Alveolar width at the crest was also recorded at the same 12 implant sites to assess the change in width due to surgery. Alveolar width was recorded preoperatively and at 3 months postoperatively. The mean alveolar width preoperatively was 4.9 ± 1.46 mm and at 3 months was 5.71 ± 1.5 mm. The difference is not being statistically significant ($p = 0.57$) (Table 4).

Postoperative sequelae such as wound dehiscence, graft exposure and graft resorption was also recorded. Any other complication if any was also noted. Out of the 12 sites, 1 site in patient I had wound dehiscence which was very small and healed in short period without any intervention and 2 sites in patient II, in the region of 22 and 23, developed wound dehiscence and graft exposure which

remained for a longer period leading to non-vitality of the crestal portion of the graft (approx. 2 mm). Another site showed an exuberant attempt at healing (hypertrophic tissue) at the closure/suture line.

Discussion

An alternative to block autografts and DO is sandwich osteotomy with interpositional graft. The interpositional bone graft, first described by Schettler in 1976, was initially performed for alveolar augmentation to improve denture retention. The maxillary interpositional Le Fort I bone graft has demonstrated stable healing. This work has generally taken a total jaw approach and was thought to be a more stable augmentation technique than onlay bone grafting. Interpositional graft procedure has been used segmentally for vertical alveolar augmentation prior to implant placement successfully by many surgeons. The vertical gain ranged from 3 to 7 mm [3–6].

In present study, alveolar sandwich osteotomy with interpositional bone grafting was done on 7 patients at 12 implant sites. Sites with only vertical defect underwent

Table 1 Mean alveolar height at different time intervals

Alveolar height	<i>N</i>	Mean	SD	Minimum	Maximum	' <i>f</i> ' value	' <i>p</i> ' value
Pre-op	12	10.44	5.19	2.8	17.5	5.538	0.008
Immediate post-op	12	16.6	3.85	12	22.5		
3 month post-op	12	14.91	4.68	13	22.5		

Table 2 Comparison of alveolar height at each time interval

	Visit	Visit	Mean difference	'p' value
Alveolar height	Pre-op	Immediate post-op	6.16	0.001
		3 month post-op	4.47	0.004
	Immediate post-op	3 month post-op	1.69	0.012

Table 3 Loss of alveolar height during healing

Sites	Immediate post-op	3 month post-op	Loss over 3 months
1	13.5	13	0.5
2	12.5	11.5	1
3	14.5	13.8	0.7
4	17	14.7	2.3
5	19.3	18	1.3
6	13.5	13	0.5
7	13.5	13	0.5
8	18.5	14.5	4
9	20	17	3
10	12	5.5	6.5
11	22.5	22.5	0
12	22.5	22.5	0

Fig. 6 Graph showing mean alveolar height at different time intervals**Table 4** Comparison of crestal width at different time intervals

Alveolar width	N	Mean	SD	Mean difference	p value
Pre-op	12	4.97	1.46	-0.29	0.57
3 month post-op	12	5.71	1.5		

sandwich osteotomy and interpositional bone grafting. Autogenous cortico-cancellous block graft was harvested from mandibular symphysis or external oblique ridge and

LOSS OF ALVEOLAR BONE HEIGHT DURING HEALING **Fig. 7** Graph showing loss of alveolar height during healing

used interpositionally. The osteotomized segment and the graft were stable without the use of osteosynthesis. Of these, patient V with two sites underwent a combined procedure for increase in height; sinus lift was done along with sandwich osteotomy. Additional materials used for this patient included hydroxyapatite and platelet rich fibrin. Patient II and III underwent buccal onlay combined with sandwich osteotomy.

In the present study, the vertical alveolar height preoperative ranged from 2.8 to 17.5 mm with a mean of 10.44 mm, immediately post-op ranged from 12 to 22.5 mm with a mean of 17.06 mm and 3 months post-op ranged from 11.5 to 22.5 mm with a mean of 14.9 mm. The mean vertical augmentation at immediate post-op was 6.58 mm. The vertical augmentation was achieved 3 months post-op ranged from -0.3 to 14 mm with a mean of 3.75 mm ($p = 0.004$) which is significant.

In a study done by Jensen et al., 10 partially edentulous patients underwent SO in anterior maxilla. The vertical gain achieved was from 3 to 6 mm. Implant esthetics were judged to be satisfactory [2]. In another study by same author, SO was done in mandibular posterior region in 8 patients with 10 sites. The vertical gain achieved was from 4 to 8 mm [4]. Thus, the vertical augmentation gained in present study is similar to that reported in the literature.

The mean crestal width of alveolar bone preoperative was 4.97 mm. Change in width at 3 months in our study ranged from loss of 3.9 mm to gain of 2 mm. If the 3 sites

Fig. 8 Final OPG of patient I

Fig. 9 Incision placement in mandibular posterior region

which had undergone additional width correction, is not considered, the change in width ranged from -3.9 to 0.6 mm with a mean of -0.85 mm and SD of 1.63 mm. This could be due to change in the angulation (buccal/palatal tilt) of the osteotomized segment or due to remodeling/resorption.

In a study by Hashemi and Javidi in 2010, the mean difference in width 3 months after sandwich osteotomy was 1.00 mm with SD of 2.06 mm [7]. Choi et al. [3] reported the change in width during healing, from immediate post-op to 3 months post-op, of 1 mm. Thus, the change in width recorded in the present study is similar to that reported in the literature.

At the time of completion, study implants have been placed in 5 of 12 sites. Implants were placed in patient I in 2 sites after 6 months following SO, of dimension 4×10 mm and 4.5×8.5 mm (Figs. 8 and 9). In patient II, implants were placed in 2 sites after 7 months, of dimension 3.5×10 mm and 3.5×11 mm. In patient III, implant was placed in 1 site after 7 months, of dimension 3.5×10 mm. Other sites have completed 3-month follow-up and are awaiting implant placement. In patient IV, the height was corrected successfully, but implant has not been placed as it requires secondary surgery for width correction.

The mean reduction in alveolar height from immediate post-op to 3 month post-op was 1.69 mm. This loss in height could be due to remodeling or resorption. Choi et al. [3] reported the change in height during healing, from immediate post-op to 3 months post-op, of 2.1 mm, which is comparable to our study.

Three patients had a greater decrease in height during the healing period. The decrease in height (2.3 mm, 76%) which occurred during the healing period was more in patient II at one site which underwent combination procedure of sandwich osteotomy and buccal onlay. Both the sites in this patient suffered long-term partial exposure of the buccal onlay graft and its subsequent non-vitality which required it to be trimmed for healing. This patient had lost teeth along with alveolar bone and covering soft tissue due to trauma (RTA), and there was scar tissue at the surgical site preoperatively. It is known that scar tissue is always difficult to manipulate surgically and has reduced blood supply. The patient III also had undergone sandwich osteotomy plus buccal onlay and saw a change in height of 1.3 mm during healing. This decrease in height during healing can be attributed to increased tension on buccal flap during primary closure and less blood supply to the osteotomized segment from the flap causing remodeling or resorption. In patient V, the osteotomized crestally displaced segment underwent complete resorption. Even after encountering surgical difficulty and resorption, it was possible to place the implant at all 3 sites in patient II and III.

Sandwich osteotomy without any combination procedure was done in 7 sites out of 12. The loss of alveolar bone height in these sites is mean 1.2 mm over 3-month period (from immediate post-op to 3 month post-op). In a study by Felice et al., SO was done, and autogenous bone and synthetic bone grafts (Bio-Oss) were compared for interpositional bone grafting. Over a 4-month period, the autogenous bone group lost 1.1 mm of bone and the Bio-Oss group 0.6 mm [8]. Thus, the loss in alveolar bone during the healing period is reported in the literature and is similar to the present study. Present study shows that sandwich osteotomy successfully maintains the alveolar

height achieved immediately post-op even up to 3 months post-op with minimal loss.

Patient V with 2 sites underwent a sinus lift combined with sandwich osteotomy in left maxillary posterior region, similar to the procedure described by Jensen et al. [9]. This procedure can greatly help in increasing the bone in the atrophic maxillary posterior region. Augmentation of almost 20 mm was found immediately post-op in this patient. It did lead to palatal inclination of the osteotomized segment immediate postoperatively. At 3 months, the alveolar augmentation of 12 mm at 1st molar, 14 mm at 2nd molar and the decrease in width from 12.1 to 8.2 mm was seen.

Patient VI with one site (2nd molar) in the maxillary posterior region site underwent SO alone. Residual bone height of 5.8 mm and width of 13.6 mm was present. This procedure was very technique sensitive. The horizontal cut had to be such that sinus was not perforated. Even after deciding the angulation of the cut previously, it was noted that the cut ended on the crest rather than on palatal side. Nevertheless, vertical augmentation obtained was significant. The augmentation of 5 mm was seen only on the buccal half of ridge tilting the crest buccally. The width of the crest also changed from 13.6 to 5.5 mm immediate post-op. While placing the horizontal cut, a thick buccopalatal ridge and sinus approximation can cause a change in its angulation thus causing a rotation of the osteotomized segment. This along with bur diameter has an effect on the final vertical gain.

Complication observed were wound dehiscence and graft exposure which are common and relatively less (25% of sites) as compared to onlay bone grafting and similar to that reported in literature. In patient VI, at 10 days post-operatively excessive hypertrophic tissue along with inflammation was observed at both surgical site and harvesting site. Patient was advised to apply an antibiotic gel and gently massage the area. It reduced after another 10–15 days at both sites but recurred at the augmentation site after another 15 days. Hypertrophic tissue at the graft harvest site was excised at that appointment and sent for histopathology examination. Histopathology report came as granulation tissue. Hypertrophic tissue at the augmentation site was also excised thereafter. Patient was advised to continue with the gel and mouthwash. Following this, it healed completely and uneventfully. Upon taking a thorough history, patient had undergone surgery twice for removal of nasal polyps. At 3-month follow-up, the CBCT showed the complete resorption of the osteotomized segment. This could be attributed to either chronic inflammation or small thickness (3 mm) of the osteotomized segment or both.

Earlier sandwich osteotomy was advised only for the anterior or inter-canine region. Later, it has been developed

and proved to be successful for mandibular posterior region. Recently, Jensen et al. [9] have shown it to work even in maxillary posterior region combined with sinus lift. In our study also, alveolar bone has been successfully augmented by sandwich osteotomy in both anterior and posterior regions in maxilla and mandible.

Thus, 12 sites in 7 patients successfully achieved mean alveolar bone augmentation of 3.75 mm through alveolar segmental osteotomy surgery, and 5 sites have been restored with implants. The other sites are on follow-up and awaiting implant placement. The bone augmented appears to be stable through the period of healing and osseointegration. The technique appears to be a viable alternative to block onlay grafting or guided bone regeneration to permit dental rehabilitation in terms of increasing the bone above the nerve, reshaping the alveolar crest, and normalizing the interocclusal distance [10]. Since the findings relate to a small number of patients, further studies with a larger number as well as the morphofunctional analyses of biopsies may be necessary to determine the ultimate treatment of choice for vertical augmentation of the alveolar ridge [3].

Conclusion

Thus, we conclude that alveolar segmental sandwich osteotomy can be successfully used in patients with moderate alveolar deficiency for bone augmentation prior to implant placement. It can also be combined with other bone augmentation procedures like buccal onlay and sinus lift to address the complex defects. This study had the limitation of a small sample size and a short duration of follow-up. A study with a larger sample size with a longer period of follow-up is warranted to obtain a more statistically significant result.

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Compliance with Ethical Standards

Conflict of interest All authors have no conflict of interest in the study.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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