Alveolar ridge augmentation using distraction osteogenesis: a clinical trial

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ABSTRACT

Background: Severely resorbed ridges present a great challenge to prosthodontic rehabilitation. Available reconstructive options include autologous/alloplastic augmentation with questionable results, or regeneration of new bone under gradual and controlled tension using distraction osteogenesis. This study focused on use of distraction osteogenesis for the treatment of vertically deficient alveolar ridges to assess its feasibility and outcome.

Materials and Methods: Alveolar distraction osteogenesis (ADO) was studied at 10 different intra-oral, partial or complete edentulous sites. After a latency period of 5 days, distraction was carried out for 6–7 days at the rate of 0.5 mm every 12 hours (1 mm/day). Distractor was removed after a consolidation period of 12 weeks.

Results: The mean height gained at the 10 intra-oral sites was 4.8 mm with standard deviation of ± 0.056 . The mean follow-up period was 2 years. Complications of therapy included hardware failure, wound gape and extra-oral scar. The overall complication rate was 10%.

Conclusion: Distraction osteogenesis is a promising option to aid uneventful prosthodontic rehabilitation of severe vertically resorbed alveolar ridges.

Keywords: Distraction osteogenesis, resorbed residual ridge, vertical bone gain.

INTRODUCTION

Dental rehabilitation using various forms of prosthesis has been a long-standing practice. However, good quality and quantity of bone, which is a prerequisite for favorable prognosis, is often not available, especially in the vertical dimension. Two methods to improve this vertical discrepancy include graft augmentation^{1,2} and distraction osteogenesis.³

Research into osteogenic distraction originated in the fields of orthopedics and traumatology, but has now become popular in the craniofacial region. Distraction may offer a number of advantages over other tissue augmentation treatments, including simultaneous connective and muscle tissue growth. Alveolar distraction has been reported to obtain a significant increase in the surrounding soft tissues with predictable outcome, low morbidity, low infection rates, and a significantly shorter waiting period for rehabilitation (12 weeks) in comparison with the traditionally used augmentation methods.^{4,5}

Clinical indications for which the alveolar distraction may be recommended include severe atrophy or segmental deficiencies of the alveolar ridge that may compromise

implant placement esthetically or functionally (unfavorable crown-implant index), narrow alveolar ridges where horizontal distraction is needed, gradual vertical movement of ankylosed teeth, conditions where orthodontic displacement is impossible or has not been successful, and gradual vertical shift of an osseointegrated implant together with the surrounding alveolar bone is required.

Despite promising results, only a few studies have examined the efficacy of alveolar distraction osteogenesis (ADO) in improving vertically compromised ridges.^{6–9} This study was therefore performed in a North Indian Dental Hospital, with an aim to evaluate the alveolar ridge augmentation using distraction osteogenesis at 10 different sites, with associated complications,^{10,11} if any.

MATERIALS AND METHODS

Subjects with vertically deficient alveolar ridge in the mandible, falling within the age group of 25–55 years, visiting the

Figure 1 (A) Proposed alveolar distraction osteogenesis site. (B) Distractor in situ. (C) Preliminary orthopantomogram showing distractor in place. (D) Note the vertical height gained following distraction.

outpatient clinic of the Department of Oral and Maxillofacial Surgery were eligible to be a part of the study. The subjects should have had no history of systemic disease and should have consented for the procedure, to be included in this study. Ten distraction sites in five subjects with deficient alveolar ridges were selected for alveolar regeneration by distraction osteogenesis using an extra alveolar device (TRIMOX, India). Subjects with knife-edged ridges, insufficient bone between the alveolar crest and inferior alveolar canal (<5 mm), history of smoking, radiation, chronic systemic disease, or evidence of non-compliance were excluded from the study. The study was approved by the institutional research committee and informed written consent was obtained from the participants.

Models were essential for the prediction of the amount of bone augmentation needed at a gross level. Pre-operative measurements were done on clinical models and orthopantomogram. The vestibule–crestal height was measured on the models as recorded height (RH), while that obtained by elevating the ridge to desirable results as R_w . Required height gain (RHG) was obtained as the difference between R_w and R .¹²

Surgery was performed under general anesthesia, after a thorough history, examination, and pre-operative assessment. A horizontal incision in the vestibule of the concerned region

was made and the mucoperiosteal flap was reflected, exposing the buccal cortex without disturbing the crestal mucosa. Bending and adaptation of the distraction device was performed before osteotomy and screw holes were marked. The transport segment was osteotomized into an inverted trapezoidal shape with oscillating/reciprocating saws, and/or chisels as applicable. The distractor was positioned and fixed in place with monocortical screws. The transport segment was mobilized, although it remained attached to the mucoperiosteum. The device was activated to test for the mobility of the transport disc without any hindrance. The system was returned to its initial position and the flap was sutured. The sutures were removed on the fifth postoperative day.

Comparative panoramic radiographs were recorded in the postoperative period prior to distraction and at 12 postoperative weeks, at the end of consolidation phase. Radiographic analysis was carried out to calculate the amount of RHG and achieved vertical bone gain (VBG) on each radiograph.¹² The magnification factor (MF) of each panoramic radiograph was first obtained, by dividing the real size (RS) of the activation rod of the alveolar distractor by its image size (IS). Length of the distractor prior to activation (LD1), i.e. distance between the superior portion of the basal plate and the superior portion of the transport plate, was measured

Table 1 Age, edentulous span, and location of distraction osteogenesis of included subjects

S. no.	Age	Site 1	Edentulous span	Site 2	Edentulous span
1	35	Anterior maxilla	1	Anterior mandible	1
2	35	Anterior mandible	1	Posterior mandible	3
3	42	Anterior maxilla	3	Anterior mandible	4
4	52	Anterior maxilla	3	Posterior mandible	4
5	53	Anterior mandible	3	Posterior mandible	5
Minimum	35		1		1
Maximum	53		3		5
Mean	43.40		2.2		3.4
Standard deviation	8.792		0.553		0.856

and coupled with MF. Length of the distractor post activation (LD2) was recorded using the same method, 12 weeks postoperatively. The VBG was measured as the difference between LD2 and LD1.¹²

The distraction procedure consisted of a postsurgical latency period of 5 days, followed by distraction for 6–7 days at the rate of 0.5 mm every 12 hours (1 mm/day).¹³ After a consolidation phase of 12 weeks, when there was radiographic evidence of good bone formation, the distractor was removed (Figure 1). Statistical software was used to evaluate the results of distraction osteogenesis by calculating VBG and the complications of the procedure. Tests used included mean values, SD, Wilcoxon test, and *P* values for significance ($\alpha=0.05$).

RESULTS AND DISCUSSION

Correction of facial deformities especially when coupled with soft tissue deficiency is an uphill task. In the past, researchers have primarily resorted to osteotomies^{1,14} and graft placement^{2,15} for achieving the objective. This study was primarily aimed at investigating the potential of the techniques of distraction osteogenesis in the treatment of vertically deficient alveolar ridges. In this study, five subjects with vertically deficient alveolar ridges were treated using distraction osteogenesis technique, at 10 different sites. Only subject sites belonging to the American College of Prosthodontics (ACP 2004) classifications III and IV, i.e. sites that required osteotomies or graft procedures to implement prosthetic rehabilitation,¹⁶ were made part of the study. Other inclusion and exclusion criteria as previously mentioned served to avoid confounding or ambiguity in the results.

Magnification factor for each site was calculated with mean values of 0.85 and SD of ± 0.05 , which correlated well with the findings of Mazzonetto et al (0.80 ± 0.06),¹² who radiographically evaluated the effectiveness of ADO for vertical reconstruction of atrophied alveolar ridges in

partially edentulous patients. A total of 60 vertical distraction osteogenesis procedures were performed in 55 patients and VBG was assessed. The mean alveolar distraction achieved in 60 cases was 6.27 mm (range 0–10.83 mm); 51.6% of the distractions were performed in the posterior mandible (mean VBG 4.60 mm), 36.7% in the anterior maxilla (mean VBG 7.46 mm), 8.3% in the anterior mandible (mean VBG 6.73 mm), and 3.3% in the posterior maxilla (mean VBG 6.32 mm). Our study correlated well with the above study with 50% of the 10 sites in the maxilla and 50% in the mandible. Of the 10 intra-oral sites, 70% were anterior and 30% were posterior (Table 1).

The mean required bone height gain (RHG) and actual bone gained (VBG) correlated with a coefficient of 0.080 in our study (Wilcoxon signed rank test), with a *Z* score of 2.814 and *P* value of 0.048, suggesting thereby that a statistically significant correlation existed with respect to the expected bone height and that obtained by distraction (Table 2 and Figure 2). Since the data were not normally distributed and the sample size was small ($n=10$), the above analysis was applicable as an alternative to paired *t*-test for small samples ($n < 20$). The average bone gain was 4.8 ± 0.05 mm which was significant when compared with the predistraction height of the residual alveolar ridge (correlation coefficient=0.6) (Tables 3 and 4). The mean bone gained in this study correlated well with that of previous studies.^{17,18}

We found that alveolar ridges may be successfully lengthened vertically by callus osteogenesis and the overlying soft tissue responded favorably. All cases showed a favorable increase in height. This technique may be advantageous over grafting procedures and osteotomies which are fraught with difficult sustainability and complications such as infection, rejection, and relapse.¹⁹ Alveolar distraction osteogenesis can provide a proper basis for the insertion and osseointegration of endosseous load-bearing implants with good implant survival, few surgical complications, and good patient satisfaction.¹⁵

The complications associated with ADO included extra-oral scar,²⁰ which occurred in all cases. However, none of the patients considered the scar unacceptable owing to single tab

Figure 2 Bar graph to depict the required versus the actual bone gain. $Z=2.814$; $P=0.048$.

Table 2 Comparison of actual bone gained (VBG) and expected bone gain at 10 sites

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Recorded height (mm)	6	5	5.5	6	6	5.8	5.5	4	4.6	5
Expected gain (mm)	4	5	4.5	4	4	5	4.5	6	5.4	5
Vertical bone gain (mm)	5	4	5	4	4.2	4.9	5.2	5.5	5.0	5.5

$Z=2.814$, $P=0.048$. The Wilcoxon signed rank test was performed to correlate R with VBG as a nonparametric test, since data were not normally distributed ($n=10$). VBG=vertical bone gain.

Table 3 Initial and final distances between distractor arms with vertical bone gain

VBG (cm)	Frequency	Percent	Valid percent	Cumulative percent
0.40	2	20	20	20
0.42	1	10	10	30
0.49	1	10	10	40
0.50	3	30	30	70
0.52	1	10	10	80
0.55	2	20	20	100
Total	10	100	100	

VBG=vertical bone gain.

scar per mandibular site. Mazzonetto and Maurette¹² observed 8.44% complications which compromised success. Alveolar distraction osteogenesis technique was demonstrated to be an effective tool to treat vertical defects of alveolar ridges with a success rate of 91.66%. Alveolar distraction osteogenesis in reconstructed jaws can produce consistent evidence of bone regeneration, with stable augmentation results clinically, histologically, and radiographically, thus making it a predictable surgical procedure prior to oral implant rehabilitation.¹⁹ However, when planning alveolar bone distraction,

Table 4 Vertical bone gain frequency

Site	D1 (cm)	D2 (cm)	LD1 (cm)	LD2 (cm)	VBG (cm)
1	1.10	1.70	0.89	1.39	0.50
2	1	1.50	0.79	1.20	0.40
3	1.20	1.80	1	1.50	0.50
4	1.10	1.54	0.99	1.39	0.40
5	1.10	1.57	0.99	1.41	0.42
6	1	1.60	0.81	1.30	0.49
7	1.10	1.70	0.92	1.44	0.52
8	1.20	1.88	0.97	1.52	0.55
9	1.00	1.55	0.90	1.40	0.50
10	1.10	1.71	1	1.55	0.55

VBG=vertical bone gain.

greater distraction should be performed to compensate for the inclination of the distractor rod and possible bone loss. This adjustment should increase the efficacy of distraction osteogenesis.²⁰ Lee indicated that osteotomies and corticotomies induce different alveolar bone reactions, which can be exploited for tooth movement.²¹

Hardware failure and wound gap were observed in 10% of the sites in our study; however, these did not affect the final results and could be managed conservatively. Four of

the five subjects enrolled were successfully rehabilitated prosthetically by the 90th postoperative day. The fifth subject, who had oral submucous fibrosis, was operated for the condition with split thickness skin graft placement and was rehabilitated on the 120th day postoperatively. Therefore, the overall complication rate in this study was 10%, making the success rate 90%.

Drawbacks of the technique such as extra-oral scar and restricted control over the fragments emerged. These may be overcome in time by the development of newer intrabony devices such as implant distractors. The limited sample size and short duration were also limitations of the study.

CONCLUSION

The study envisaged the use of the distraction technique for the treatment of vertically deficient alveolar ridges. Our experience in the use of the technique in restricted time frame and small sample size brought to the fore its versatility and also exposed its pit falls. Knowledge on the use of distraction osteogenesis as an instrument for maxillofacial regeneration is still in its inception. Further study and long-term follow-up is essential to allow its development into a full-fledged science. Future study areas could include studying the load-bearing capacity of distracted bone compared with normal residual alveolar bone and examining the horizontal distraction of deficient alveolar bone.

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