Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.elsevier.com/locate/mjafi

Original Article

Evolving surgical prosthetic rehabilitation protocol for success of dental implant placed in distracted alveolar ridge

Col S.K. Rath^{a,*}, Brig Ramen Sinha (Retd)^b, Col Derek D'Souza^c^a Senior Advisor (Periodontology and Oral Implantology), Army Hospital (Research & Referral), New Delhi 110010, India^b Professor & HOD, Dept of Oral & Maxillofacial Surgery, Vydehi Institute of Dental Sciences, Whitefield, Bangalore, India^c Commanding Officer, 200 MDC, C/O 56 APO, India

ARTICLE INFO

Article history:

Received 17 July 2011

Accepted 19 December 2011

Available online 14 September 2012

Keywords:

Distraction

Implants

Ridge augmentation

ABSTRACT

Background: Remodelling of bone in the form of resorption generally follows the extraction of a tooth. During all stages of atrophy of the alveolar ridge, characteristic shapes result from the resorptive process, as influenced by anatomic alterations in the alveolar bone. Various ridge augmentation procedures have been documented as predictable means of establishing new vital bone for implant placement, out of which distraction osteogenesis is one such modality. Hence the following study has been conducted to evolve a surgico-prosthetic rehabilitation protocol in grossly atrophic alveolar ridge by distraction osteogenesis and subsequent implant placement and to provide an effective alternative to lost dental tissue to serving soldiers, their families and ex-servicemen of the Indian Army in a cost effective manner.

Methods: A total of 30 patients with ridge defects in age group between 18 to 70 years were selected for the study. The net success rate of distraction procedure was 93.33% (100% in maxilla and 80% in mandible) with 2 cases deemed as failures out of a total of 30 cases. The average amount of defect compensated was 76.1% (85.1% and 59.5% in maxilla and mandible respectively).

Results: For the implant surgical procedure the success rate was 100% and subsequently prosthetic rehabilitation on implants was proved to be successful.

Conclusion: Distraction osteogenesis of an atrophied ridge for further implant placement certainly proves to be successful procedure by this study. Further studies in the same procedure using a larger sample size will definitely be more beneficial.

© 2012, Armed Forces Medical Services (AFMS). All rights reserved.

* Corresponding author. Tel.: +91 9765894052 (mobile), +91 20 26446463 (office).

E-mail address: drathfamily@yahoo.com (S.K. Rath).

0377-1237/\$ – see front matter © 2012, Armed Forces Medical Services (AFMS). All rights reserved.

<http://dx.doi.org/10.1016/j.mjafi.2011.12.002>

Introduction

Remodelling of bone in the form of resorption generally follows the extraction of a tooth. During all stages of atrophy of the alveolar ridge, characteristic shapes result from the resorptive process, as influenced by anatomic alterations in the alveolar bone. Placement of endosseous implants has become an option in comprehensive periodontal treatment plan for both fully and partially edentulous patients, and in cases of compromised ridges, placement of such implants can hamper the overall prognosis of the final prosthesis.¹

Various ridge augmentation procedures have been documented as predictable means of establishing new vital bone for implant placement. A variety of procedures, including guided bone regeneration (GBR), autogenous and allograft blocks, have been used to increase bone volume prior to implant placement. The latest addition to the various ridge augmentation techniques is distraction osteogenesis (DO).²

DO is defined as a surgical process that involves the gradual, controlled displacement of a surgical fracture that results in simultaneous enlargement of the volume of bone and soft tissue. It is definitely advantageous over other ridge augmentation procedures which have disadvantages like graft sloughing, need for a secondary bone donor site, and the unpredictable amount of vertical bone height obtainable. Distraction osteogenesis is a predictable way to grow unlimited vertical bone height without these complications.^{3,4}

Hence the following study has been conducted to evolve a surgico-prosthetic rehabilitation protocol in grossly atrophic alveolar ridge by distraction osteogenesis and subsequent implant placement and to provide an effective alternative to lost dental tissue to serving soldiers, their families and ex-servicemen of the Indian Army in a cost effective manner.

Material and methods

The subjects for the study were selected randomly, with no discrimination on the basis of sex, caste, religion or

socioeconomic status from those attending the OPD at Department of Dental Surgery of Armed Forces Medical College, Pune. A total of 30 patients in age group between 18 and 70 years were selected. The patients selected had presence of partially edentulous arch with grossly atrophic alveolar ridge, and with a clinical and radiographic evidence of bone loss of at least 3 mm from the alveolar crest of the adjacent teeth [Fig. 1]. They also had adequate space for placement, activation and retention of intraoral distraction device. These patients did not have any systematic contraindication to routine periodontal surgery. Patients who were pregnant or lactating, those who had taken antibiotics during last 6 months of initial examination, those on long term steroid therapy and smokers were excluded from the study.

At first appointment patient education as well as oral hygiene instructions were given. A verbal and written informed consent was taken from patients. A thorough scaling and root planning were done till adequate plaque control was achieved. The laboratory investigations required for surgeries were carried out. Prior to surgery, models were prepared and acrylic stents were fabricated. Intraoral peri-apical radiographs were taken for all the selected sites having intra osseous defects following a standardized technique.

After securing adequate anaesthesia at the surgical site, a trapezoidal paracrestal incision was made without involving marginal gingival of adjacent teeth, and the flap was reflected apically and coronally [Fig. 2A]. Horizontal and vertical osteotomies were made through the buccal and palatal plates, leaving the palatal mucosa and periosteum intact. The transport segment was mobilized with hand chisels. Then, a vertical osteotomy was made through the mobile alveolar transport segment to allow placement of the transport rod. The Leibinger Endosseous Alveolar Distraction (LEAD) system was used to fixate the transport segment. The LEAD system uses an apical base plate and a more coronal transport plate fixed to bone using mini screws [Fig. 2B]. The transport rod was threaded through the transport plate and rests most apically on the base plate [Fig. 3]. Interocclusal clearance was checked, and the area was closed with primary intention.

Fig. 1 – Presence of partially edentulous arch with grossly atrophic alveolar ridge.

Fig. 2 – A: A trapezoidal paracrestal incision made and the flap reflected apically and coronally. B: Base plate and transport plate fixed to bone using mini screws.

Postoperatively, the patient was placed on Amoxicillin 500 mg, three times a day for 5 days, Combiflam three times a day for 5 days and Chlorhexidine 0.2% mouth rinse 10 ml twice daily for 7 days.

A latency period of 1 week was observed before the distraction began. After 1 week of healing, the rate of distraction was two turns of the threaded rod to equal 1 mm per day. The distraction was performed by the patient daily and continued for 10 days. The distracted bony segment healed for 1 month, and then the transport rod was removed. After 3 months, once the radiographic fill of alveolar bone was

confirmed the patient was taken up for surgical placement of a two stage implant system. After implant placement and successful achievement of osseointegration [Fig. 4], gingival former was placed, which was subsequently replaced by abutment upon which the indicated prosthesis was fabricated following routine protocols [Fig. 5].

The clinical parameters were recorded at baseline, 30, 90, 180 and 365 days postoperatively which included:

1. Vertical ridge deficiency at baseline and subsequent gain postoperatively was measured as the distance from the

Fig. 3 – The transport rod threaded through the transport plate and resting most apically on the base plate as seen in intraoral periapical radiograph.

Fig. 4 – Endosseous implant placed and successful osseointegration achieved as seen in the intraoral periapical radiograph.

cemento-enamel junction to the crest of the alveolar ridge.

2. Primary, postoperative and post-restorative implant stability using Periotest.
3. Primary, postoperative and post-restorative mobility of adjacent teeth using Periotest.

Results

The age range of the selected patients were between 18 and 70 years with the average age being 37.73 years. The average age for the maxillary defects was 34.55 years, while that for mandibular defects was 37.6 years. Mean vertical ridge defect

was 4.6 mm. Thickness of available bone was between 4 and 8 mm with an average of 5.8 mm.

The number of missing teeth were between 1 and 4 with the mean being 2.33. Range of mobility of teeth adjacent to the edentulous span was within the accepted range. Average latency period following distractor placement was 6.16 days. The average duration of distraction was 4.57 days. The mean period of retention of distraction rod was 19.4 days. Mean consolidation period of 88.75 days was observed for both subgroups. The average gain in ridge height was 3.5 mm (4 mm in maxilla and 2.5 mm in mandible) which was found to be statistically significant when compared to baseline parameters [Table 1]. However 2 cases showed resorption of bone and collapse of the distracted segment with failure of

Fig. 5 – Placement of abutment upon which the indicated prosthesis was fabricated following routine protocols.

Table 1 – Average distraction parameters.

S. no.	Parameters	Maxilla			Mandible			Total		
		Mean	SD	n	Mean	SD	n	Mean	SD	n
01.	Latency period (days)	6.15	0.98	20	6.2	1.135	10	6.16	1.02	30
02.	Time of distraction (days)	4.75	0.85	20	4.2	0.42	10	4.57	0.77	30
03.	Removal of distractor (days)	21.35	9.18	20	15.5	7.38	10	19.4	8.94	30
04.	Consolidation period (days)	88.75	1.44	20	88.75	1.38	10	88.75	1.40	30
05.	Gain in height (mm)	4 ($p < 0.01$) ^b	0.79	20	2.5 ($p < 0.05$) ^a	1.43	10	3.5 ($p < 0.01$) ^b	1.25	30

^a Correlation is significant at level of 0.01 ($p < 0.01$).
^b Correlation is significant at the level of 0.05 ($p < 0.05$).

distraction due to which no implants were placed in these two failed distractions.

However a total of 50 implants were placed in 28 patients with 2 implants placed in 22 subjects and a single implant each in 6 subjects. A total of 35 (70%) implants were placed in maxillary arch while 15 (30%) were placed in the mandible. Implants were placed of two available dimensions 3.3×11.5 mm (58%) and 2.8×10 mm (42%). Maximum no. of implants (74%) were loaded after 6 months of implant placement. Primary implant stability was observed to be within the prescribed range with an average value of -0.571 (-1.05 in maxilla and 1.875 in mandible) [Table 2]. Results which were obtained post-osseointegration were in the same range.

A total of 40 prostheses were placed in the subjects with 28 (70%) single crowns and 12 (30%) fixed implant retained partial dentures. Of these 70% were placed in maxilla and 30% in mandible. Prostheses stability was measured at the time of insertion and was found to be within prescribed limits i.e. -1.61 periotest value (-2.19 and 0.142 for maxillary and

mandibular prostheses respectively). The readings were repeated at 1 year interval and 3 prosthesis i.e. 2 Fixed partial dentures (FPDs) and 1 single crown were found to have increased mobility and were deemed as failures. The final mean periotest values for prostheses were found to be 0.428 (-0.476 for maxillary prostheses and 3.428 for mandibular prostheses).

The net success rate of distraction procedure was 93.33% (100% in maxilla and 80% in mandible) with 2 cases deemed as failures out of a total of 30 [Table 3]. The average amount of defect compensated was 76.1% (85.1% and 59.5% in maxilla and mandible respectively). For the implant surgical procedure the success rate was 100%. Prostheses insertion showed a complete success rate, however, at 1 year recall it showed a success rate of 92.5% (96.4% for maxillary prostheses and 83.33% for mandibular prostheses) with a failure of 3 prostheses out of 40. The net success rate of the protocol was determined to be 83.33% (95% in maxillary arch and 60% in mandibular) with 5 cases deemed as failures out of a total of 30 [Chart 1].

Table 2 – Implant parameters.

S. no.	Parameter	Site of defect		Total
		Maxilla	Mandible	
01.	Subjects with No. of implants placed			30
	0	0	2(20%)	2(6.67%)
	1	5(25%)	1(10%)	6(20%)
	2	15(75%)	7(70%)	22(73.33%)
02.	Size of implant placed			
	Total no	35(70%)	15(30%)	50
	3.3×11.5 mm	29	0	29(58%)
	2.8×10 mm	6	15	21(42%)
03.	Primary implant stability (avg.)	-1.05	1.875	-0.571
04.	Time for osseointegration			50
	Imm. loading	0	0	0
	4 mon	0	13	13(26%)
	6 mon	35	2	37(74%)
05.	Type of prosthesis			
	Total	28(70%)	12(30%)	40
	Single crown	19	9	28(70%)
	FPD	9	3	12(30%)
06.	Prosthesis stability (avg)			
	At insertion	-2.19	0.142	-1.61
	At 1 year	-0.476	3.428	0.428

Table 3 – Success rate of procedure.

S. no.	Parameter	Site of defect		Total
		Maxilla	Mandible	
01.	Distraction procedure			
	1. Total no	20	10	30
	2. Failures	0	02	02
	3. Success rate	100%	80%	93.33%
	4. Average amount of defect compensated	85.1%	59.5%	76.1%
02.	Implant procedure			
	1. Total no	35	15	50
	2. Failures at 6 mon	0	0	0
	3. Success rate	100%	100%	100%
03.	Prosthetic procedure			
	1. Total no	28	12	40
	2. Failures at 1 year	01	02	03
	3. Success rate	96.4%	83.33%	92.5%
04.	Proposed protocol			
	1. Total no	20	10	30
	2. Failures	01	04	05
	3. Success rate	95%	60%	83.33%

Discussion

In the past two decades, dental rehabilitation of edentulous patients by means of implant-supported prostheses has presented a significant treatment alternative to conventional restorations, with great improvement in masticatory function for both partially and completely edentulous patients. A deficit in edentulous ridge height may cause insufficient bone support for implants and an increased maxillo-mandibular distance with unfavourable crown-to-implant ratios, as well as unfavourable aesthetic results. Reconstruction of the alveolus is challenging because the deformity involves deficiencies in both bone and mucosa.^{5,6}

Distraction osteogenesis may be considered a possible alternative to many surgical techniques, such as alloplastic graft augmentation, autogenous onlay bone grafting, and guided bone regeneration. It can be applied to the dentoalveolar area to create new bone and mucosa. It is less invasive, less time intensive and associated with less morbidity than harvesting

bone grafts. Another significant advantage is that both hard and soft tissues are reconstructed with this technique.^{1,7}

There have not been any long term studies combining the protocols of distraction osteogenesis, implant reevaluation and prosthesis reevaluation, hence this is the first research of its kind and there being no established criteria for examination and evaluation, the workers had to develop a protocol and suitable recall periods to estimate adequate success criteria comprising the principles of distraction osteogenesis, implant surgery success protocols and finally prosthetic rehabilitation and establishing success or failure.

Careful patient selection is important for success of this procedure. As recommended by reviewers on this topic all sites selected were in the anterior region for ease of placement and removing bias for technique sensitivity and patient factors. Distraction osteogenesis is ideally suited for reconstructing defects in the anterior aesthetic zone and has advantages over bone grafting especially in this region. Distraction osteogenesis allows alveolar bone gain and soft tissue elongation, resulting in a significant improvement in the quantity and quality of keratinized gingiva without requiring the use of foreign materials. No donor site is needed, and clinically controlled alveolar ridge augmentation can be achieved.^{8–10}

An understanding of the potential complications of a given surgical technique, and of appropriate treatments, is fundamental for correct implementation of that technique. In the present study, we therefore evaluated complications arising in alveolar distractions, all performed with LEAD System distractors. Fracture of the transport segment during osteotomy is a complication that can be avoided only by preventative measures. Care should be taken in manipulation, and no attempt should be made to move the segment until the osteotomy is complete.^{11,12}

As per the studies by Stellingsma et al¹³ and Degidi,¹⁴ when the distractor is assembled and positioned, it is thus important to bear in mind the forces exerted by the lingual mucoperiosteum attached to the segment and to angle the threaded rod slightly outward to compensate for this force during distraction. Elimination of the sharp edges allows rapid growth of the mucosa over the bone, in contrast to the situation expected with a free bone graft. This complication does not require interruption of the distraction procedure.

Bone formation defects were observed in 3 cases as seen during second surgery for implant placement. In first case, the defect was a dehiscence defect due to the loss of a fragment of bone from the transport segment during the osteotomy. In the other two cases, there was no evident explanation for the defect observed. All of these defects were successfully treated. Even though the timing of removal of a distraction device typically is between 1 and 6 months after the completion of distraction osteogenesis, we have removed the distraction devices at the end of 1 month in all our cases. Earlier removal of a device may result in inadequate ossification during the consolidation phase with significant relapse.

The net success rate of 83.33% is exceptional considering the unsuitability of these sites for prosthetic rehabilitation and is similar to those obtained by other means in long term studies. The distraction protocol per se also showed a very high success rate of 93.33% which is in fact higher than those obtained with other large sample studies. The amount of defect fill of 76.1% is

Chart 1 – Success rate of protocol.

corresponding to available literature of larger samples like those studies done by Stellingsma et al¹³ and Degidi.¹⁴

Conclusion

Alveolar ridge distraction osteogenesis may be indicated for atrophic alveolar processes resulting from periodontal disease, trauma, congenital deformity, marginal bone resection of a tumour or fenestration of a cyst, orthodontic local open bite caused by vertical malposition of tooth segments, ankylosed teeth, extraction and traumatic avulsion of teeth. Alveolar ridge osteo distraction is not recommended for severely atrophic mandibles, in patients with severe osteoporosis or of extremely advanced age and in patients with space limitations for device placement. The present study confirms that distraction osteogenesis provides an opportunity to obtain a natural formation of bone between the distracted segment and basal bone in a relatively short time span, thus avoiding the necessity of autogenous bone harvesting. This leads to a reduction of morbidity and a shortening of operating time. The successful result of ridge augmentation by distraction is responsible for the formation of adequate quality and quantity of bone tissue, which can provide primary stability of implants and favourably withstand the biomechanical demands of loaded implants.

Therefore it is recommended that with appropriate patient selection and operator training, this devised protocol is a predictable and safe method for rehabilitation of atrophic alveolar ridges within a short time period. Further studies combining this protocol with biomimetics and biological enhancers shown to improve osteogenic potential are recommended for improvement of the outcomes.

Conflicts of interest

All authors have none to declare.

Acknowledgement

This paper is based on Armed Forces Medical Research Committee granted by the office of the Directorate General

Armed Forces Medical Services and Defences Research Development Organization, Government of India.

REFERENCES

1. Position paper dental implants in periodontal therapy. *J Periodontol.* 2000;71:1934–1942.
2. Bertolami CN. Principles of tissue engineering. *J Oral Maxillofac Surg.* 1998;56:24–31.
3. Lieberman JR, Friedlander GE. *Bone Regeneration and Repair.* 1st ed. Humana Press; 2005:195–196
4. Pikos MA. Chin graft as donor sites for maxillary bone augmentation—part II. *Dent Implantol Update.* 1996;7:1–4.
5. Misch Carl E. *Contemporary Implant Dentistry.* 2nd ed. vol. 1. Mosby; 1999:3–11
6. Spikermann, Donath, Hassell. *Implantology.* 1st ed. Thieme Medical Publishers.1995:94–104.
7. Seibert J, Nyman S. Localized ridge augmentation in dogs. A pilot study using membranes and hydroxyapatite. *J Periodontol.* 1990;61:157–165.
8. Emtiaz S, Noroozi S, Carames J, Fonseca L. Alveolar vertical distraction osteogenesis: historical and biologic review and case presentation. *Int J Periodontics Restorative Dent.* 2006;26:529–541.
9. Chiapasco M, Zaniboni M, Rimondini L. Autogenous onlay bone grafts vs. alveolar distraction osteogenesis for the correction of vertically deficient edentulous ridges: a 2–4-year prospective study on humans. *Clin Oral Implants Res.* 2007;18:432–440.
10. Rocchietta I, Fontana F, Simion M. Clinical outcomes of vertical bone augmentation to enable dental implant placement: a systematic review. *J Clin Periodontol.* 2008;35:203–215.
11. Esposito M, Grusovin MG, Felice P, Karatzopoulos G, Worthington HV, Coulthard P. The efficacy of horizontal and vertical bone augmentation procedures for dental implants – a Cochrane systematic review. *Eur J Oral Implantol.* 2009 Autumn;2(3):167–184.
12. Enisliadis G, Fock N, Millesi-Schobel G, et al. Analysis of complications following alveolar distraction osteogenesis and implant placement in the partially edentulous mandible. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2005;100:25–30.
13. Stellingsma C, Vissink A, Meijer HJ, Kuiper C, Raghoobar GM. Implantology and the severely resorbed edentulous mandible. *Crit Rev Oral Biol Med.* 2004;15:240–248.
14. Degidi M, Pieri F, Marchetti C, Piattelli A. Immediate loading of dental implants placed in distracted bone: a case report. *Int J Oral Maxillofac Implants.* 2004;19:448–454.