Bone Ring Augmentation Around Immediate Implants: A Clinical and Radiographic Study

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Abstract

Purpose: The purpose of this study was to evaluate the efficacy of bone ring augmentation technique for three-dimensional augmentation of severely defective sockets along with placement of immediate dental implants. Materials and Methods: A clinical study was conducted on 14 patients with 15 defective sockets requiring extractions and immediate implant placement. Following extraction, bone ring with an implant osteotomy, harvested from chin, was sculptured and fitted into the extraction socket. The bone apical to the socket was prepared for implant through the central osteotomy of the ring. Implant was then placed through the ring into the apical bone. After 6 months, prosthesis was placed. Clinical and radiographic examination was done to evaluate the soft tissue and crestal bone level around implants immediate postoperatively and at 1st, 3rd, 6th, and 9th month postoperatively. Results: Out of 15 grafted sockets, 14 showed an evidence of bone healing with no significant crestal bone resorption. One ring showed soft tissue dehiscence which underwent severe resorption at 6th month postoperative visit. Conclusion: The bone ring augmentation technique is an effective method for three-dimensional augmentation of severely defective sockets. This technique helps in reducing the overall treatment time by allowing grafting and placement of implant simultaneously in a single visit. However, longer observation periods are needed to draw more definite conclusions on the success of bone ring augmentation technique.

Keywords: Bone ring augmentation, defective socket, immediate implant

Introduction

The replacement of a lost natural tooth by an osseointegrated implant represents one of the most significant advancements in dentistry. Implant supported restorations not only allows a patient to function with confidence but also helps enjoy a better quality of life.[1] Initial protocol for implant placement prescribes a healing period of 6–8 months after tooth extraction to allow for better primary stability at implant placement. However, with the continuing advances, immediate implant placement protocol was introduced in which implants can be placed immediately following tooth extraction.[2] Immediate implantation is advantageous as it helps in reduction of treatment time and surgical interventions as well as helps in preservation of bone and soft tissues.[3-5]

For immediate implant placement, extraction sockets should have little or no bone loss.[4] In case, extraction sockets are severely defective; immediate implant placement is usually not possible.[6] In such cases, therapeutic bone regeneration approaches in conjunction with principles of osteogenesis, osteoconduction, and osteoinduction should be used first before placing an implant.[4]

Various bone regeneration procedures and materials are utilized to provide adequate bone and soft tissue support for dental implants. It includes alveolar bone augmentation techniques such as guided bone regeneration, onlay grafting, particulate grafting, onlay block grafting, distraction osteogenesis, ridge splitting, application of various growth factors to stimulate bone formation, and in severe defects; a combination of above-mentioned techniques can be used in a staged manner.[7]

In cases of severely defective sockets, a new technique was introduced to augment the defective socket three-dimensionally with autologous “bone rings” and immediate implant placement.

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Materials and Methods

A clinical study was conducted on 14 patients with 15 defective sockets requiring extraction and immediate implant placement in the Department of Oral and Maxillofacial Surgery in our institute. The research protocol was reviewed by the Institutional Ethical Committee and Review Board. Patients ranging from 18 to 60 years having defective extraction sockets after extraction and willing to be treated with implant placement were included in the study. Patients having extraction sockets with no bony defects, medically compromised patients, presence of acute periapical pathology, alcoholics, and tobacco abusers were excluded from the study.

Seven systems from MIS Implants Technologies Ltd, Israel and surgical trephines from Helmut Zepf Medizintechnik Gmbh, Germany, were used in this study.

A complete case history was taken making use of a standard case history pro forma. Routine blood investigations were carried out.

The patients were informed about the potential risks and benefits and a consent was obtained for the procedure. Preoperative cone beam computed tomography was used for the evaluation of surgical site, amount of augmentation required and to decide the length and diameter of the implant to be used based on the regional anatomy.

One hour before the surgery, 2 g amoxicillin or 600 mg clindamycin (if allergic to penicillin) was given. Before the surgical procedure, patients were instructed to rinse the mouth with 0.2% chlorhexidine gluconate. Surgical site was prepared [Figures 1a and 4a] and extraction was done.

Following extraction and elevation of full thickness flap, defect was visualized [Figure 1b]. The diameter of the graft required was defined by a trephine cutter. The bone in the donor region was exposed by giving vestibular degloving incision [Figure 1c]. A slight touch with a rotating trephine cutter was made to define the donor site of the bone transplant [Figure 1d]. The cutter used on the donor site was one size larger than the one defined at the augmentation or recipient site. With the bone graft to be harvested still anchored in the bone, the implant bed was prepared on it following the usual manufacturer’s protocol [Figure 1e]. The bone transplant was then prepared to its definitive depth using the trephine cutter and the annular bone graft was removed using a bone rasp or a chisel [Figures 1f and 2a].

The recipient site was prepared using the trephine cutter to receive the graft such that ring graft was fitted snugly inside the socket. The annular bone graft was then put in place with its spongious aspect facing the depth of the donor site, while its cortical aspect encompasses the neck of the implant. The implant bed on the recipient site was prepared through the bone graft following the usual manufacturer’s protocol. The implant was then inserted through the bone graft subcrestally, obtaining primary stability from the local bone and using its crestal portion to keep the bone graft in place and cover screw was placed [Figure 2b].

Spongious bone obtained from the donor region was used for additional augmentation. The bone graft area was then covered with PRF membrane [Figure 2c]. Totally, tension-free wound closure was done. Pressure bandage was applied on chin for 24 h. All patients were prescribed amoxicillin 500 mg TID, metronidazole 400 mg TID, and diclofenac 50 mg BID, along with chlorhexidine 0.20% mouth rinse twice daily for 1 week. At 1 week of surgery, sutures were removed.

After 6 months, second-stage surgery was performed. Flap was raised to access marginal portion of implant and cover screw was replaced with gingival former. Gingival former was subsequently replaced with permanent abutment and implant was loaded with final restoration [Figures 2d and 4b].

All patients were followed up for 9 months after implant placement during which patients were evaluated clinically for infection (pus discharge), pain, soft tissue dehiscence (cover screw exposure, bone ring exposure), loss of sensation, periodontal parameters (modified plaque index, modified sulcus bleeding index, and implant mobility), and radiographically for changes in crestal bone level [Figures 3a-d and 5a-d].

To measure the changes in crestal bone level, we have adopted the method described by Yoo et al.[12] The length (mm) of the implant was measured on the radiograph. Next, the distance between the observed crestal bone and the recipient site was measured on the radiograph.
implant–abutment interface was measured at the mesial and distal implant surfaces. The actual implant length was known based on manufacturing standards. To adjust the measurements for magnification error, the following equation was used to determine the corrected crestal bone levels:

\[
\text{Corrected crestal bone level} = \frac{\text{measured crestal bone level} \times \text{actual implant length}}{\text{measured implant length}}.
\]

A horizontal line tangential to the coronal border of the implant was used as reference. The baseline value was considered 0 at the reference plane. Measurements from this line to the most coronal height of the crestal bone on the proximal surfaces around the implants were done to evaluate the mesial and distal vertical crestal height of the bone. Values coronal to reference plane were considered negative and apical were considered positive.

**Statistical analysis**

All data were subjected to statistical analysis. Data were entered in Microsoft Excel and analyzed using Statistical Package for Social Science, version 21 package (IBM Corp. Armonk, NY). The results were averaged (mean ± standard deviation) for continuous data and number and percentage for dichotomous data. Normality of data was tested using Shapiro–Wilk test. Student’s t-test was used for normally distributed data. \( P < 0.05 \) was accepted as indicating statistical significance.

**Results**

A total of 14 patients were selected in which 15 implants were placed immediately after extraction in defective sockets with bone ring augmentation technique. Seven patients were male (50%) and 7 were female (50%). Mean age of the patients

Figure 2: (a) Donor site after graft harvesting. (b) Placement of implant through ring graft. (c) Placement of platelet-rich fibrin membrane. (d) Patient 1: Final prosthesis

Figure 3: (a) Preoperative intraoral periapical. (b) Immediate postoperative intraoral periapical. (c) 6-month postoperative intraoral periapical. (d) 9 months postoperative intraoral periapical

Figure 4: (a) Patient 2: Preoperative view. (b) Final prosthesis

Figure 5: (a) Preoperative intraoral periapical. (b) Immediate postoperative intraoral periapical. (c) 6-month postoperative intraoral periapical. (d) 9-month postoperative intraoral periapical

Figure 6: Soft tissue dehiscence
was 30.35 ± 7.13 years with a range of 20–42 years. Around 50% of the patients were between the age of 20 and 30 years.

Out of 15 implants placed, 7 were placed in the maxilla (6 anterior and 1 in posterior) and 8 in the mandible (1 anterior and 7 in posterior). In maxillary anterior region, the chief cause of extraction of teeth was trauma while in mandibular posterior region, chief cause of extraction was caries.

Distribution of implant length in study population is given in Table 1. Diameter of implants used was 3.75 mm (80%) and 4.2 mm (20%).

In all 15 cases, grafts were harvested from interforaminal (chin) region using a unilateral vestibular degloving incision. All ring grafts were monocorticocancellous in nature and were detached from chin region using a sharp chisel or bone rasp. No signs of bone ring fracture was present in any of the ring at the time of detachment.

Twelve rings were harvested using a 7.5 mm diameter trephine and 3 rings using a 10 mm diameter trephine. In rings with 7.5 mm diameter, internal osteotomy diameter was 3.75 mm while in rings with 10 mm diameter, internal osteotomy was 4.2 mm. The mean dimension of harvested bone ring graft was 4.57 ± 1.13 mm.

All patients had slight postoperative edema next day after surgery which subsided completely after 3–4 days. There was no sign of infection, pain, or loss of sensation both at implant site as well as donor site 1 week after surgery. One patient (6.67%) had soft tissue dehiscence of bone ring graft at implant site at 1-week follow-up [Figure 6]. However, all implants, including the one which had soft tissue dehiscence, remained firm and stable throughout the follow-up visit. At the end of 6 months, all 14 patients (accounting for 15 implants) received single-unit fixed partial restoration. At last evaluation, all prostheses were functioning.

Radiographic evaluation of 14 implants showed minimal resorption of bone ring graft during healing period. The graft which had soft tissue dehiscence underwent severe bone resorption and was considered a failure. This ring graft was excluded from further statistical analysis. Crestal bone loss at the end of 6 months for all grafted sites is given in Table 2. At 6th month postoperative visit, mean crestal bone loss was 0.76 ± 0.38 mm mesially while 0.78 ± 0.23 mm distally. Mean percent bone loss at the end of 9th month postoperative visit was 17.58 ± 8.19% mesially and 18.30 ± 6.62% distally. Net mean bone gain at the end of 9th month postoperative visit was 3.70 ± 1.10 mm mesially and 3.69 ± 1.10 mm distally.

**DISCUSSION**

Initially, Brånemark prescribed a protocol for implant placement in which a healing period of 6–8 months was necessary between tooth extraction and implant placement to allow for better primary stability at implant placement.[2] However, following extraction, subsequent bone resorption of alveolar ridge may result in a loss of height as well as up to 50% of width[13] that might negate the placement of dental implants. With the continuing research, to overcome this drawback, immediate placement protocol was introduced where the implant is installed in conjunction with tooth extraction.[2]

The ideal extraction site for immediate implant placement is one with little or no periodontal bone loss on the tooth that is to be extracted.[4] However, defective sockets resulting from either periodontal disease or surgical trauma during extraction may have an insufficient quantity of bone for successful implant placement. Several classification systems have been proposed for classifying such defects.[6,14-16]

Salama and Salama classified the defective sockets into three types. According to them, type I defects can be managed using the principles of guided tissue regeneration (GTR). Type II defects can either be converted to type I defects using orthodontic extrusive augmentation or by GTR alone when orthodontic extrusive augmentation is not possible. Both type I and II defects are suitable for immediate implantation. However, type III defects are severely compromised and immediate implant placement is usually not possible. In such cases, a two-step approach is used. The first step is the augmentation procedure while the second step is the actual implant placement.[6]

Several approaches reported in the literature for augmentation procedure includes bone augmentation with barrier membrane technique, particulate bone grafting technique, block grafting

| Table 1: Distribution of implant length |
|----------------------------------------|-----------------|
| Implant length (mm)   | Frequency (%)   |
|-----------------------|-----------------|
| 10                    | 1 (7.0)         |
| 11.5                  | 1 (7.0)         |
| 13                    | 6 (40.0)        |
| 16                    | 7 (47.0)        |
| **Total**             | **15 (100.0)**  |

| Table 2: Crestal bone level at different visits |
|-----------------------------------------------|-----------------|
| Serial number | Mesial bone loss at 6 months | Distal bone loss at 6 months |
|----------------|-----------------------------|-----------------------------|
| 1              | 0.4                         | 0.49                        |
| 2              | 0.23                        | 0.88                        |
| 3              | 1.5                         | 1.11                        |
| 4              | 0.54                        | 0.59                        |
| 5              | 0.65                        | 0.85                        |
| 6              | 0.61                        | 0.67                        |
| 7              | 0.3                         | 0.35                        |
| 8              | 0.32                        | 0.39                        |
| 9              | 5.2                         | 5.31                        |
| 10             | 1.24                        | 0.75                        |
| 11             | 0.59                        | 0.49                        |
| 12             | 0.62                        | 0.65                        |
| 13             | 0.46                        | 0.59                        |
| 14             | 0.57                        | 0.72                        |
| 15             | 0.47                        | 0.4                         |
approaches, membranes used in combination with block grafts and/or particulate graft materials, ridge split technique, and distraction osteogenesis.\textsuperscript{[7]}

However, to reduce the overall treatment time and difficulties in the management of severely defective sockets, a new technique was introduced by Stevens \textit{et al.} to augment the defective socket three-dimensionally with autologous “bone rings” and immediate implant placement in a one-stage procedure.\textsuperscript{[8]}

A prospective study was conducted with the purpose of evaluating the effectiveness of autologous bone ring augmentation technique for the immediate implant placement in defective sockets. A total of 15 implants were placed in 14 patients. Out of 14 patients, 7 were male and 7 were female. Mean age of the study population was 30.35 ± 7.130 years and around 93% of the patients were in the age group of 21–40 years. With regard to age, it was observed that younger and middle age patients were more interested in conserving adjacent teeth structure, therefore opting for implant therapy over fixed partial dentures.

All autologous bone ring grafts were harvested from interforaminal region/symphysis region using vestibular degloving incision. Synphysis region was chosen as the donor site because it can be easily accessed, avoids cutaneous scars, has low morbidity, provides membranous bone so shows less resorption and early revascularization as compared to endochondral bone, has ample supply of corticocancellous bone as compared to other intraoral sites, and there is no need for hospital stay.\textsuperscript{[17-26]} In this study, sulcular incision was not preferred as it leads to marginal bone loss and can present esthetic problems with associated gingival recession.\textsuperscript{[20,23]}

Various complications are reported in the literature with the use of vestibular degloving incision such as temporary mental nerve paresthesia, lip ptosis, wound dehiscence, and nonvitality of lower incisors. However, in this study, no such complications were encountered. This was because incision was given unilaterally at least 1 cm away from the mucogingival junction. Furthermore, incision was not extended beyond canine region and a pressure dressing was applied postoperatively. Pommer \textit{et al.} have recommended to leave at least 8 mm of bone from the apices of lower anterior teeth.\textsuperscript{[27]} However, in this study, no damage to neurovascular bundle was found after keeping only 5 mm safety margin from teeth apices.\textsuperscript{[25,28-32]}

Dimension of the graft ring was determined using the exact dimension of the socket and the implant to be placed. Outer diameter of the ring should match the dimension of the socket and inner diameter should match the diameter of the implant. Further, recipient site was prepared using a trephine bur to accommodate the graft with a snug fit. This provided for the absolute stability of the implant bone ring complex which was essential for the early healing and decreased resorption of the graft.\textsuperscript{[33]} Furthermore, this preparation provides access for trabecular bone blood vessels to the graft and accelerates revascularization. Surgical trauma created also allows for the regional acceleratory phenomenon to occur, which results in tissue healing two to ten times faster than normal physiologic healing.\textsuperscript{[20]}

At the time of insertion, all implants bone ring complex showed adequate primary stability as measured clinically. Thus, the basic criteria for success of immediate implants\textsuperscript{[34]} and successful grafting were being fulfilled.\textsuperscript{[33]}

After placing the implant, recipient site was covered with platelet-rich fibrin membrane which provides growth factors and accelerate wound healing by stimulating angiogenesis and mitogenesis.\textsuperscript{[35]}

In all cases, donor site healed well without any sign of infection, paresthesia, or soft tissue dehiscence. In 14 cases, recipient site healed well without any sign of soft tissue dehiscence or infection. However, in one case, soft tissue dehiscence was seen at recipient site with exposure of implant-bone ring complex. The reason for this can be attributed to sharp edges of the bone ring graft and suturing done under tension. Smoothening of bone ring graft was done and graft was left to heal by secondary intention. However, there was severe resorption of the ring graft seen at the end of 6th month postoperative visit.

In this study, the radiographic evaluation demonstrated mean mesial bone resorption of 0.76 ± 0.38 mm and mean distal bone resorption of 0.78 ± 0.23 mm at the end of 9th month postoperative period. The present data are in agreement with a study conducted by Crespi \textit{et al.} who demonstrated that after a 24-month follow-up, mean mesial and distal bone loss were 1.16 ± 0.32 mm and 1.17 ± 0.41 mm, respectively.

The present study showed a mean bone gain of 3.70 ± 1.10 mm on mesial aspect and a mean bone gain of 3.69 ± 1.10 mm on distal aspect of implants at the end of 9th month postoperative period with a mean percent bone loss of 17.58 ± 8.19% mesially and 18.30 ± 6.62% distally around implants. The results are comparable with a study conducted by Ozaki and Buchman\textsuperscript{[26]} which states 73.1 ± 14.7% of the cortical membranous grafts were retained at the end of 16 weeks.

The success rate of bone ring graft was 93.33% as one bone ring graft in which soft tissue dehiscence was present underwent severe resorption. Minimal crestal bone resorption in other patients during the follow-up of 9 months reflected good incorporation of bone ring graft into the adjacent alveolar bone with good osseointegration of implants into the grafted socket.

**Conclusion**

Bone ring augmentation technique is an effective alternative option in reducing the treatment duration for implants placed in extremely defective sockets. It must, however, be noted that patient selection and primary stability of implant bone ring complex play a crucial role in the success of bone ring implants. Furthermore, a total tension-free closure and rounded
Margins of ring graft are important to prevent any soft tissue dehiscence at recipient site. However, further trials involving a larger sample size and longer follow-up periods are necessary before declaring bone ring augmentation technique as reliable procedure.

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Conflicts of interest
There are no conflicts of interest.

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