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Research Article

IMPLANT REHABILITATION IN COMPROMISED ALVEOLAR BONE: TO AUGMENT OR TO NOT AUGMENT

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ABSTRACT

Objective- The aim of this review is to evaluate the overall success, morbidity and patient acceptance of different surgical techniques used for implants placement by augmentation and non-augmentation of deficient edentulous alveolar ridges. **Method-** A series of cases managed in Department of Oral and Maxillofacial Surgery along with the recent available literature from year 2000 to 2016 were selected through an electronic and manual search of databases. The following procedures were considered and categorized into two groups: a) Implant placement following alveolar augmentation- onlay bone graft, guided bone regeneration, direct sinus lift, alveolar distraction osteogenesis, alveolar ridge split. b) Implant placement without alveolar augmentation- short implants, zygomatic implants, tilted implants, alveolar nerve repositioning. **Results and Conclusion-** Significantly greater bone height/width gain has been reported using direct sinus lift and distraction osteogenesis. Patient acceptance of the procedure was found better with short implants and tilted implants while poor with onlay block graft and distraction osteogenesis. Analyses of studies did not reveal differences between short (6-9 mm) and conventional (≥ 10 mm) rough-surfaced implants regarding their survival as well as primary stability. Preference must be given to those treatment modalities which are easier to execute, involves less surgical invasion, hasminimal risk of complications, and give satisfactory results within the shortest time frame. Separate dimension of patient medical condition and his ability to cope up with the procedure also needs to be judged before decision making.

INTRODUCTION

Successful dental implants osseointegration requires sufficient bone quantity as well as bone quality, these both may be compromised following tooth loss, atrophy, periodontal disease or trauma. These conditions can cause unfavorable horizontal, vertical and sagittal inter-arch relationship or lead to insufficient bone volume, which makes implant placement impossible from a functional and esthetic point of view. Alveolar bone augmentation can overcome the intrinsic limitations of reduced height/width of alveolar bone but inherent disadvantages include prolonged treatment times, high costs and increased surgical invasion associated with patient unacceptance towards the procedure, surgical site morbidity and other potential complications. On the other hand, non-augmentation options, such as reduced implant length and diameter or tilted implant, may on the other hand carry the risk of low predictability and reduced long-term success. Decision making in evidence-based implant dentistry includes all the diagnostic and treatment possibilities, surgeon's biases and expertise, patient's preferences and cost considerations (Flemmig & Beikler, 2009). Patient outcome assessment includes patient’s overall satisfaction with the treatment results, patient’s perception of the surgical intervention and its impact on oral health-related quality of life. Thus, decision making regarding the need to augment deficient alveolar bone is the dilemma faced by the clinicians in oral implant rehabilitation.

The aim of this review is to evaluate the overall success, morbidity and patient acceptance of different surgical techniques used for implants placement by augmentation and non-augmentation of deficient edentulous alveolar ridges.

MATERIALS AND METHOD

A series of cases managed in Department of Oral and Maxillofacial Surgery along with the recent available literature from year 2000 to 2016 were selected. Full text English

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language articles were found through electronic and manual search of journal databases. All observational studies (cross-sectional surveys, case-control studies and case series) on dental implant rehabilitation in patients presenting with deficient edentulous ridges following atrophy, periodontal disease, and trauma sequelae were included. Following implant rehabilitation techniques were considered and categorized into two groups:

1. Implant placement following alveolar augmentation- onlay bone graft, guided bone regeneration, direct sinus lift, alveolar distraction osteogenesis, alveolar ridge split.
2. Implant placement without alveolar augmentation- short implants, tilted implants, alveolar nerve repositioning, zygomatic implants.

Onlay block grafts

Onlay bone grafts are used for augmentation of horizontal or verticalalveolar ridge deficiencies. In on lay graft, along with the use of autogenous bone which is generally harvested from intra or extraoral donor sites, allogeneic and synthetic bone graft materials have also been documented (Waasdorp & Reynolds, 2010). After obtaining the block graft, it is prepared to the required size and adapted to the recipient site. The block can be fixed over the alveolar crest or on the labial surface of the ridge depending upon the required augmentation, with fixation screws (Fig 1). Onlay block graft with simultaneous implant placement although shortens the healing phase butare undesirable due to inherent drawbacks like rapid graft resorption, high probability of wound dehiscence failed osseointegration and lesser bone-implant contact, thus making the one-step procedure undesirable. (Stellingsma *et al*., 2004).

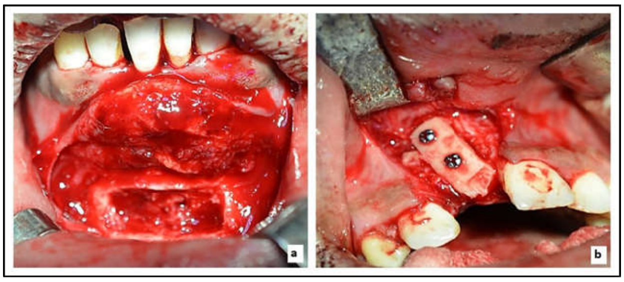

Figure 1 Onlay block graft- (a) cortical chin block of 3cm×2cm is obtained, (b) chin block is prepared and stabilized using compression screws at the labial aspect of 11 tooth region.

Outcome- The postoperative morbidity due to secondary surgery for bone harvesting from intraoral sites are mostly represented by transient neural disturbances involving branches of the inferior alveolar nerve. As reported in the literature, the incidence of neural disturbances related to bone harvesting from the chin ranges from 10% to 50%, while those from the mandibular ramus range from 0% to 5%. Extraoral bone harvesting from the iliac crest showed temporary pain/gait disturbances. Overall complications of this procedure commonly involve wound dehiscence at 3.3% mean rate and total graft loss at 1.4% rate. (Chiapasco *et al*., 2009).

Guided bone regeneration

Guided bone regeneration is a surgical technique which involves the use of barrier membranes with particulate bone grafts or/and bone substitutes. The rationale of alveolar augmentation by guided bone regeneration is primarily based on the migration of pluripotent and osteogenic cells (e.g. osteoblasts) to the vertical or horizontal bone defect site and preventing migration of undesired cells from the overlying soft tissue as well as cells impeding bone formation (e.g. epithelial cells and fibroblasts). Within the first 24 hours, the graft material inside is filled with the blood clot which releases growth factors (e.g. platelet derived growth factor) and cytokines (e.g. IL-8) to attract neutrophils and macrophages. The clot is then replaced with granulation tissue. The osteogenic potential of the mesenchymal stem cells present in the granulation tissue form the osteoid which is further mineralized to form the woven bone. This forms the template for apposition of lamellar bone leading to gain in bone height/width (Fig 2). The barrier membranes with osteoconductive potential (e.g. platelet rich fibrin membrane) further accentuates the bone forming process (Javed A *et al*. 2010).

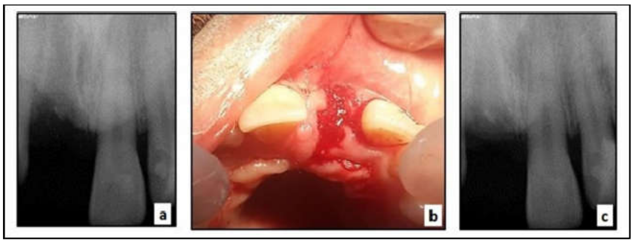

Figure 2 Guided bone regeneration- (a) immediate post extraction radiograph shows alveolar ridge defect following extraction of decayed 21 tooth, (b) extraction socket was overpacked with demineralized particulate bone graft and covered with platelet rich fibrin membrane, (c) six month post-extraction radiograph revealed adequate gain in alveolar ridge height.

Outcome-A study by Zitzmann *et al*. (2001) showed significant differences in marginal bone resorption (1.4mm following guided bone regeneration and 1.2mm in normal alveolar bone) which is not much of clinical relevance. Authors also reported that no differences in implant survival rates following guided bone regeneration could be found when compared to implants in normal alveolar bone. Up to 40% of initial bone gain undergoing resorption was reported (Chiapasco *et al*., 2009). Mean increase in horizontal bone of 2.6mm and vertical bone of 3.6mm have been reported (Jensen &Terheyden, 2009). Failures of this procedure are mostly due to premature membrane exposure which causes infection, wound dehiscence and ultimately loss of regenerated bone.

Direct sinus lift

The rationale of sinus floor elevation is based on the principle of guided bone regeneration using the Schneiderian membrane as a natural barrier to compensate sinus pneumatisation. Direct sinus lifting is a ridge augmentation procedure which helps in increasing the amount of bone in posterior maxilla in the area of premolar and molar by lateral window approach and lifting the Schneiderian membrane followed by placement of a graft material (Fig 3). Grafting material used can be autogenous bone, allograft, bovine bone mineral, calcium sulfate, hydroxyapatite. This procedure is recommended when residual bone is less than 5-6mm. Only membrane elevation accomplished via the lateral sinus wall as described by Boyne is taken into consideration here as it leads to augmentation of larger edentulous region with direct accessibility. In order to reduce the treatment time, this technique has also been modified by simultaneously placing dental implants following the sinus floor elevation. The implants are driven into their positions in the arch such that the implant bases are visible through the created window. Then the elevated Schneiderian membrane is allowed to rest over the implant base along with the bone graft material inside the cavity. This avoids the consolidation phase of 3-4 months which was there between sinus lift and implant placement.

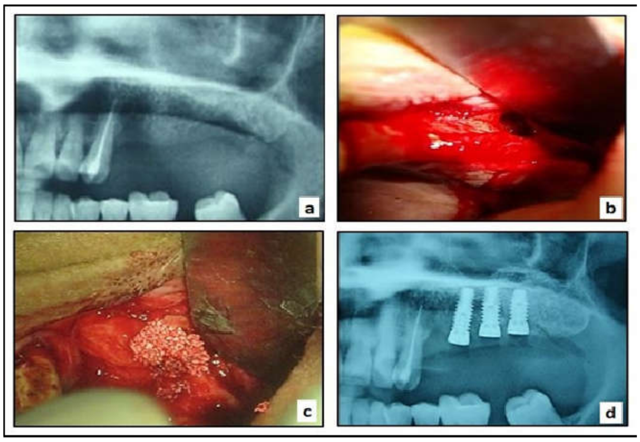

Figure 3 Direct sinus lift- (a) preoperative radiograph revealed residual alveolar bone between the maxillary sinus floor and alveolar crest of 26,27 tooth region to be less than 6mm, (b) a oval window was created in the lateral maxilla following which the schneiderian membrane was dissected using elevators, (c) particulate bone graft mixed with patient's whole blood was placed in the cavity and was packed after achieving adequate elevation of the membrane, (d) six months post-operative radiograph taken after placement of three dental implants showed proper placement of implants in sufficiently gained bone.

***Outcome*-**The most frequent complication reported is the iatrogenic perforation of the schneiderian membrane with a frequency of 10-20% (Chiapasco *et al*., 2009; Pjetursson *et al*., 2008). Significantly greater bone heights have been gained using the direct sinus lift technique (Zitzmann & Schärer, 1998). It has been reported that postoperative sinusitis occurs at a mean rate of 3% and 1% following direct sinus lift procedure (Pjetursson *et al*., 2008; Tan *et al*., 2008). Complications such as sinusitis tend to occur in previously unhealthy sinuses. Preoperative screening of maxillary sinus is mandatory to rule out infected sinus in order to reduce the chances of postoperative sinusitis.

Distraction osteogenesis

Alveolar distraction osteogenesis was first documented by Chin and Toth in 1996. Its rationale is based on the biologic phenomenon that new bone fills in the gap created when two bone segments are slowly separated under tension.

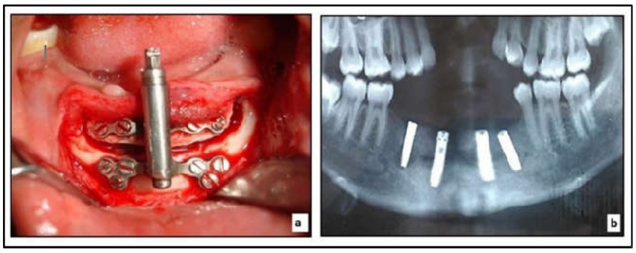

Figure 4 Alveolar distraction osteogenesis- (a) due to compromised anterior mandibular ridge height an intraoral distraction device was placed following creation of the transport segment by horizontal and vertical osteotomy cuts, (b) the radiograph shows the proper placement of four implants in the newly gained bone height after completion of the distraction and consolidation phase.

This science is applied for augmentation of the alveolar bone using miniature distraction devices (Rachmiel A *et al*. 2001). Alveolar distraction can be divided into two categories, in which bone is gained vertically called vertical distraction (Fig 4) and in which bone is gained horizontally called horizontal distraction. When compared with other augmentation techniques distraction osteogenesis avoids bone grafting and harvesting procedure from other body parts and associated complications as well as it also repositions the soft tissue along the hard tissues (Rachmiel A *et al*. 2001).

***Outcome*-**This procedure involves the need for daily activation, temporary compromised speech, eating and appearance disabilities which affects the patient acceptance towards the procedure. As reported by Chiapasco *et al*. (2009), complications include partial relapse of initial bone height (8%), change of distraction vector (8%), basal bone or segment fracture (3%), fracture of distraction device (2%), incomplete distraction (2%) and transient paresthesia (2%). Overcorrection of the ridge by distraction may give rise to local tissue tears or ischemia (Bernstein *et al*., 2006). Authors have also reported with lingual/palatal shifting of the distracted segment with mean frequency of 13% - 35.4% may be due to improper device positioning or local muscle pull.

Alveolar ridge split

Ridge split technique also known as split-crest technique for implant placement was originally described by Simion *et al*. 1992. This technique by creating a 4-wall defect, provides an adequate width for implant support, protects the interpositional graft from exposure and displacement and promotes vascularization from both the cortices and basal bone during healing phase (Fig 5). Minimum ridge width required for ridge split is 3-4 mm and an adequate ridge height of >10 mm is required to achieve primary stability during immediate implant placement (Shivashankar VY *et al*. 2013). Bone splitting of knife-edge ridge is possible only by the presence of spongy bone between buccal and lingual cortical plates.

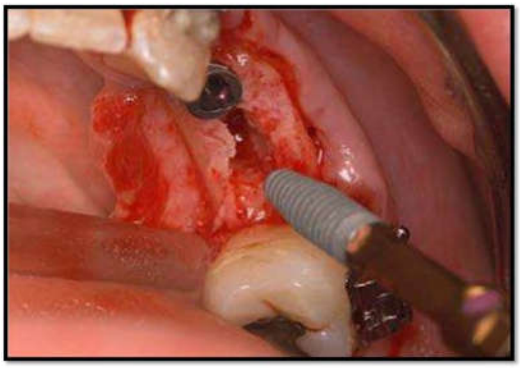

Figure 5 Alveolar ridge split- following a crestal osteotomy and expansion of the buccal and palatal cortical plates in 23, 24 region two dental implants were placed and the residual gap was filled with demineralized particulate bone graft.

***Outcome*-**Most frequent complication encountered in this technique is malfracture of the buccal plate. Due to the low bone density and thin cortical plates rate of complications are lesser in the maxilla. Mandibular alveolar splitting is more difficult due to the denser buccal plate thus posing a risk of a more invasive and more traumatic surgical procedure. In the available literature, there is a paucity of data with regard to the stability of initial bone volume and marginal bone resorption in reaction to the surgical trauma of expansion.

Short implants

Dental implants of length lesser than 10 mm are considered as short implants. Due to the evidence of positive clinical results with the use of short implants, it has become an accepted technique to avoid invasive bone graft surgery (Fig 6). In order to increase the osseointegration, the use of rough surface and wider diameter is incorporated along with shorter length. However, literature says that increased implant diameter cannot compensate for length reduction (Malo *et al*., 2007; Pommer *et al*., 2011). Short implants may be splinted to each other or with longer implants in fixed partial dentures to enhance force distribution.

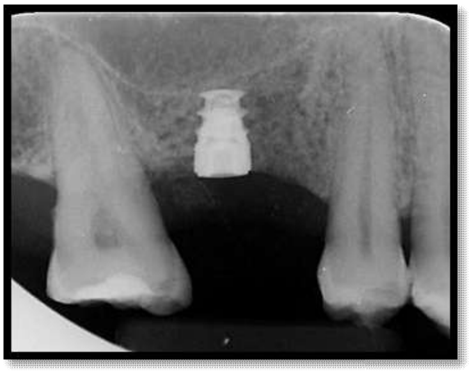

Figure 6 Short implant- the radiograph shows the placement of a 6mm implant in the 27-tooth region due to the proximity of the maxillary sinus floor with the alveolar crest of the respective region.

Outcome- Failures with short implants within the first year of prosthetic loading has been reported (Neves *et al*., 2006). Meta-analyses by Esposito *et al*. (2010) on comparison of vertical augmentation procedures with short implants revealed that vertical augmentation procedures resulted in more statistically significant complications.

Tilted implants

Implants with an inclination greater than 15° (up to 35°) towards the occlusal plane are considered as tilted implants (Friberg, 2008). The biomechanical rationale for using inclination of distal implants is based on the reduction of cantilever length and as a consequence give rise to better load distribution of the prosthesis support (Fig 7).

Figure 7 Tilted implant- the radiograph shows the placement of four dental implants among which the posterior two implants where placed with an angulation toward the occlusal plane to compensate the reduced mandibular bone height.

Clinical evidence supports that tilting of implants allow for increased cortical anchorage, primary stability and also enables to use longer implant in reduced bone height scenarios.

Outcome-Tilted implants gave adequate primary stability when compared with axial implants. Tilting of implants used in anterior maxilla and maxillary tuberosity region showed success in avoiding perforation into sinus cavity without reducing the length of the implant. It has also been reported that parasinusal tilting of dental implants reduces the length of cantilever segments which improves the biomechanical load distribution over the implant (Block & Haggerty, 2009).

Zygomatic implants

Zygomatic implant technique involves the positioning of two bilateral implants of length between 35-55 mm anchored to the zygomatic bone following an intrasinusal trajectory. Zygomatic implants are placed from the alveolar crest, passes through the maxillary sinusclose to the zygomatic bone (Fig 8). Zygomatic implants are an alternative to bone augmentation and thus are used in the rehabilitation of resorbed or partially resected maxilla (Friberg, 2008).

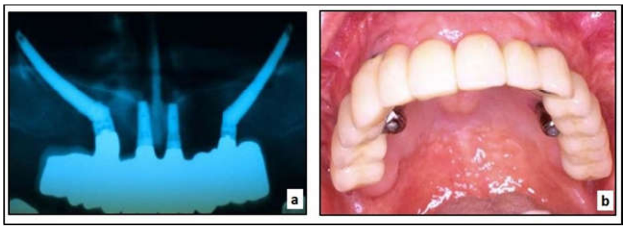

Figure 8 Zygomatic implant- complete maxillary arch rehabilitation was done by placing two bilateral zygomatic implants and two conventional implants in 13 and 23 tooth region. (a) radiograph showing the proper placement of implants, (b) implant supported denture

Outcome-Most frequent complication involved with zygomatic implants is the palatal emergence which leads to prosthetic difficulties (Att *et al*., 2009). Other complications reported are postoperative sinusitis, temporary paresthesia, epistaxis, facial and periorbital hematoma and orbital penetration (Block & Haggerty, 2009), peri-implant bleeding, soft tissue hyperplasia and increased pocket depths (Aparicio *et al*., 2008). Zygomatic implants due to their posterior position can cause problems with oral hygiene maintenance. Cases causing oro-antral fistula formation and maxillary sinusitis have also been reported.

Alveolar nerve transposition

The rationale of inferior alveolar nerve transposition is to create space for the implants beyond the mandibular canal as far as the inferior border of the mandible, by exposing the neurovascular bundle from a lateral approach and repositioning it laterally (Block & Haggerty, 2009) (Fig 9).

Figure 9 Alveolar nerve transposition- (a) osteotomy was done in the lateral body of the mandible extending 45-47 region, (b) following removal of the buccal cortical plate the inferior alveolar nerve was carefully retracted out, (c) two dental implants were placed following which the nerve was placed back lateral to the implants and covered with demineralized particulate bone graft.

Major complication of this procedure is high incidence of neurosensory disturbances, risk of mandibular fracture and increased crown lengths associated with compromised implant esthetics (Chrcanovic & Custodio, 2009).

DISCUSSION

After thorough review of the literature, various limitations of the augmentation and non-augmentation techniques were compiled. In general, onlay block graft and guided bone regeneration showed no inherent limitations. Alveolar ridge split was limited to a minimum residual bone width of 4 mm. Short implants and tilted implants required minimum of 5-7 mm bone height. Vertical distraction osteogenesis was limited to a minimum residual bone height of 6 mm. In case of anterior maxilla, short implants were not being considered as good option here, as increased crown lengths cause compromised implants esthetics. In case of posterior maxilla, sinus lift procedure residual bone height of 4-6 mm has been suggested. Zygomatic implants were required to be placed in conjunction with premaxillary implants. Distraction osteogenesis in this region is limited by the proximity of the maxillary sinus. In case of posterior mandible, alveolar nerve transposition has been reported with limitations due to risk of nerve damage.

Based on the literature search and follow-ups of our cases in the department, it was found that significantly greater bone height/width gain has been reported using direct sinus lift and distraction osteogenesis. Augmentation of vertical bone height using distraction osteogenesis has been demonstrated to yield significantly lower bone resorption versus onlay grafts as well lower marginal bone resorption versus guided bone regeneration. But patient morbidity was recorded higher in procedures like onlay block graft, sinus lift due to additional secondary surgeries for graft harvest and prolonged treatment phase. There were also certain degrees of complication regarding secondary graft harvest and invasiveness of these procedure, comparatively more in onlay block graft procedure. In case of non-augmentation techniques, alveolar nerve transpositioning showed considerably higher morbidity and complication rates (e.g. paresthesia, dysesthesia). Patient acceptance was found better with short implants and tilted implants with almost no reported complications, mostly due to simplicity and less time-consuming nature of the procedure. Studies showed that short implants can become osseointegrated and bear functional load after placement and their survival as well as crestal bone level maintenance is comparable with conventional length implants. Analysis of observational studies did not reveal differences between short (6-9 mm) and conventional (≥ 10 mm) rough-surfaced implants regarding their survival and primary stability. Use of tilted implants was found comparably advantageous in posterior ridges.

CONCLUSION

Every surgical procedure presents advantages and disadvantages. Preference must be given to those treatment modalities which are easier to execute, involves less surgical invasion, has minimal risk of complications, and give satisfactory results within the shortest time frame. Selection of the appropriate surgical technique should not only be based on the location in the mouth but also on complete vs. partial edentulous patient situations. Separate dimension of patient medical condition and his ability to cope up with the procedure also needs to be judged before decision making.

Also, there is a need for much precise comparative studies with these parameters because, although there is abundant literature regarding various treatment techniques in compromised alveolar bone, but there is significant lack of clinical studies about the success rate and comparative effectiveness of these techniques to guide decision making regarding the most appropriate techniques in various clinical conditions.

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