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Implantology in Compromised Bone

Vandana Tiwari*, Rajshekhar Halli, Saurabh Khandelwal, Kaustubh Kulkarni, Umer Valiulla and Akanksha Singh

**Oral and Maxillofacial Surgery, Bharati Vidyapeeth Dental College & Hospital, Pune, MP, India.*

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ABSTRACT

Purpose: Dental implantology is one of the accepted and predictable treatment approaches for restoring lost tooth. However, deficiency of bone volume is the primary reason for avoiding implant treatment .This article describes various treatment modalities which includes implant placement following alveolar augmentation such as onlay bone graft, guided bone regeneration, direct sinus lift, alveolar distraction osteogenesis, and alveolar ridge split.

Methods: The method used to assemble all the information was a review of literature, along with multiple case reports.

Results: Following the completion of this article, it was concluded that. Implant placement without alveolar augmentation is possible with procedures such as lateralization of the inferior alveolar nerve with simultaneous implant placement, short implant, tilted implant, zygomatic implant and basal implant.

Conclusion: We conclude that further research and development and more concrete data on clinical cases is required to prove the efficacy of modified implants as a replacement to conventional implants.

Keywords: Zygomatic implant, Sinus lift, Basal implant, Bone graft, Nerve lateralization

INTRODUCTION

The loss of tooth can be psychologically traumatizing. Attempts to replace teeth have been seen even in ancient civilizations. When replacing missing teeth, available options include removable partial denture [RPD], conventional fixed bridge [FPD] or implant supported prosthesis. As known, RPD is a poor treatment option to restore esthetic and function. FPD has long been a treatment option with survival rate of 89.1% and 81.1% respectively at 5 &10 years. But for single tooth replacement by FPD requires crown preparation of adjacent teeth which increases incidence of caries, sensitivity, mobility and periodontal breakdown of abutment teeth [1]. Implant treatment eliminates necessity of abutment teeth. Thus, over the past few decades implant dentistry has grown in scope due to demonstrated success and predictability such that the clinician around the world consider it to be a form of standard care. What makes implant dentistry unique is the ability to achieve this goal, regardless of the atrophy, disease or injury of the stomatognathic system [2].

Dental implantology is one of the accepted and predictable treatment approaches for restoring lost tooth. Consequently, as the practice of implant rehabilitation has developed and matured, both patients and the reconstructive team have framed their treatment expectations [3].

According to Frost “bones which are subjected largely to compression load and experience no significant bending loads are composed largely of cancellous bone which is ideally constructed for the absorption and dissipation of energy”. Maxillary ridge is more cancellous than mandible and therefore may be a factor in the difference in the resorption of jaws. The deficiency of bone volume is the primary reason for avoiding implant treatment. For prosthetically determined implant placement, final prosthesis type and design dictates the number, size and ideal implant position. Such situations can be managed by bone augmentation to reestablish ridge volume. The morphology of bony defect is an important consideration in the selection of a method of ridge manipulation .The fewer the number of remaining bony walls, the greater is the need for osteopromotive techniques. These result in contour or

Corresponding author: Vandana Tiwari, Oral and Maxillofacial Surgery, Bharati Vidyapeeth Dental College & Hospital, Pune, MP, India, Tel: +918840345691; E-mail: vandanatiwari334@gmail.com

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dimensional changes, while preserving bone integrity and viability. The concept is to manipulate the residual bone to create an intrabony cavity with wider base or taller roof that heals like an extraction socket, with access of mesenchymal stem cells and normal wound healing mechanisms. The morphology of bony defect is an important consideration in the selection of a method of ridge manipulation.

Current bone manipulation techniques include inlay and onlay grafting, guided bone regeneration(GBR), bone expansion, bone splitting osteotomy, and different fixation devices such as bone screws, pins, titanium mesh, different augmentation materials, and different barrier membranes, have made it possible to install dental implant in regions that were previously considered unsuitable due to presence of insufficient bone [4].

DISCUSSION

Onlay bone graft: Onlay graft is a bone graft in which transplanted tissue is laid directly onto surface of recipient bone. Autologous cancellous bone grafts fulfill all the attributes of ideal bone grafts and are mostly utilized in the techniques of bone grafting. Hydroxyapatite and collagen provide an osteoconductive framework and induce both the regenerative and augmentation processes. For these reasons, the autogenous cancellous bone graft is considered the "gold standard" of bone transplantation [5].

Thus, during grafting, the graft should have the following attributes including

(i) Osteogenic activity or potentiality of the transplant material

(ii) The ability of the graft to survive and proliferate

(iii) The immune response of the host

(iv) The degree of induction that the newly transplanted material will experience and

(v) Affinity, which the host tissue exhibit towards the interstices of the implanted bone.

Direct sinus lift: Following extraction, pneumatisation of the maxillary sinus, poor quality of remaining alveolar bone and higher occlusal forces make implant placement in posterior maxilla a challenging task. Post-extraction expansion of maxillary sinus in inferior direction is 2.18 ± 2.89 mm for dentate v/s contralateral sites and 1.83 ± 2.46 mm for same site pre- and post- extraction.

Maxillary sinus pneumatises by 1.52 ± 2.15 mm after extraction of a molar [6]. Reduction in residual ridge height is about 2-3 mm for maxilla during first year after extraction [7]. This is due to the increased osteoclastic activity of periosteum, increase in positive intra-antral pressure and absence of stimulation for bone remodeling [8].

Vertical alveolar ridge augmentation is often required for implant placement in posterior maxilla. Maxillary sinus floor augmentation increases the amount of bone in the posterior maxilla by elevating sinus membrane from underlying bone and placement of bone graft beneath it. Implants can be placed at the same time as sinus floor augmentation surgery (simultaneous placement) or after a healing period (delayed placement).

After the loss maxillary molar and premolar, the maxillary sinus expands and lowers down, resulting in reduced subantral bone height, which is inadequate to insert adequately long implants. Further, long time edentulism leads to vertical ridge resorption, which further deteriorates the situation for the insertion of long implants and also increases the crown-implant height ratio. The first sinus lift was performed by Dr Oscar Hilt Tatum in February 1975 in Lee county hospital in Opelika, Alabama.

Sinus lift is indicated for patients having residual subantral bone is less than 10 mm in height, 5mm in width and maxillary sinus is free of any acute or chronic infection or pathology. However, it is contraindicated in heavy smoking, acute sinus infection, recurrent history of chronic sinusitis, uncontrolled diabetes, maxillary sinus hypoplasia cyst fibrosis and maxillary sinus malignant tumor.

Two main techniques of sinus floor elevation are as follows [9]

1. Lateral window (direct) sinus augmentation technique
2. Transcrestal (indirect) sinus augmentation technique

Lateral antrostomy is of two types

1. One stage antrostomy in which implant is placed simultaneous roomy with graft and is indicated for sufficient residual bone
2. Two stage antrostomy in which implant placement is done 6-12 months after graft placement and is indicated for cases when subantral bone height<4mm.

Graft material used for sinus grafting are, autogenous bone remains the gold standard. Iliac crest, chin, anterior ramus and tuberosity.

Advances and modifications in lateral approach of sinus lifting

- Lateral approach of sinus lifting using piezosurgery unit
- Lateral approach of sinus lifting using DASK**:** Dentium Advanced Sinus Kit

Disadvantage of lateral approach: Reduced blood to lateral wall of sinus, difficult access with reduced mouth opening, more chances of sinus rupture and postoperative complication, compared to the subcrestal approach, large amount of graft required and barrier membrane needed to cover window.

Advantage of crestal approach: Less invasive, improves maxillary bone density, less graft required, no barrier membrane needed, limited flap elevation required.

Disadvantage of crestal approach: Initial implant stability unproven, if the residual bone height is less than 6mm, limited height of sinus elevation compared to lateral approach. Higher chances of misaligning the long axis of osteotome during osteotomy.

Recent advancements and modifications in the crestal approach of the sinus lifting

Bicortical engagement without sinus grafting

If the subantral residual bone is more than 6-8mm in height and more than 10mm in width, a large diameter (6-7mm) and short length (7-9mm) implant can be inserted with bicortical engagement (in the crest bone as well as into the antral floor).

Hydraulic sinus lift technique

Given by Chen in 2005.

Osteotomy is initiated with a sinus drill, and water pressure is used to gently elevate the Schneiderian membrane from the sinus floor.

Intralift technique

A minimally invasive technique for lifting the sinus floor using piezoelectric surgery based on specific set of tips for the application of ultrasound. This technique opens a wide range of possibilities in terms of reducing the complexity and morbidity of open sinus lift.

Advantages of intralift technique

Minimally invasive technique, safe and fast technique, selective cut - cuts only bone without any injury to soft tissue including sinus membrane, hemostatic effect-minimum bleeding during surgery, fast healing and minimal failure risk.

Complications after sinus graft surgery

Membrane perforation, mucus retention cyst, bleeding, incisal line opening.

Alveolar ridge split technique: Alveolar ridge split technique was introduced by Tatum Jr. in 1986 with the aim of increasing the amount of bone in the maxilla [10]. This was adapted by Summers [11]. Many variations of the ridge split technique have been described by various authors.

In 1992 Simion [12] used a longitudinal greenstick fracture in order to extend the socket, performed through osteotomies. In 1994, Scipioni [13] described another variation, whereby a partial thickness flap is created, followed by vertical intraosseous incisions and the simultaneous displacement of the buccal cortical plate, including a portion of cancellous bone, and the implant placement [3]. Success rate between 95% to 98% reported. In association with /without GBR or grafts.

Piezoelectric ridge expansion technique:

1. Narrow and rectilinear osteotomies performed
2. Peizo scalpel used to separate palatal flap from buccal osseous flap
3. Filled with bioactive glass and autogenous platelet rich plasma
4. Chin and Tooth [14] and Block [15] in 1996 based on secondary osseous healing [16].

Lateralization of inferior alveolar nerve with simultaneous implant placement

Progressive bone resorption often occurs following tooth loss or extraction ,resulting in moderately to severely atrophied mandible due to which the bone height posterior to mental foramen is inadequate to allow proper placement of endosteal implants and the use of optimal fixture lengths without potentially injuring the inferior alveolar nerve .One approach to avoiding nerve injury when placing implant in these situations is to reposition the inferior alveolar nerve laterally and then place the implant medial to the nerve [17]. Several repositioning techniques have been presented in the literature over the past 10 years, each with limitations [18-24].

Some of these techniques involve transpositioning the nerve by creating a window that includes mental foramen as well as area of implant placement, then releasing the nerve from the mental foramen and replacing the nerve distal to its original location but in this technique permanent nerve damage is a significant risk.

Other techniques involve lateralizing the nerve by repositioning it through a posterior cortical window rather than engaging the mental foramen. This approach however requires extensive stretching of the nerve. However a new technique used involving the use of 2 osteotomies, which minimizes these limitations-particularly the duration of sensory disruption and the risk of nerve paresthesia and inadvertent nerve transection or compression.

Short Implants: According to Nisand and Renofaurd [25] A short implant will be defined as an implant with a designed intrabony length of less than or equal to 8mm. An extra short implant as an implant with a designed intrabony length of less than or equal to 5mm. Short implants are indicated in area of reduced height such as maxillary posterior and mandibular posterior region, severely reduced edentulous mandible and to support single and multiple fixed restorations in posterior jaws.

The main advantage of using short implant is that it simplifies the implant surgery by avoiding the more invasive procedures like bone grafting, sinus lifting, new repositioning etc. and thus decreases the morbidity and reduces the healing period, it reduces the duration period of treatment and cost factor. It can also be used in the area where the bone is of poor quality such as posterior maxilla.

Though longer implant is always preferred as they have good stability and improved bone to implant contact but in case of short implant bone to implant contact may also be improved by the use of micro rough surfaces. Adequate implant primary stability can be achieved through adapted surgical preparation and new implant designs. Increasing the diameter of the implant is an effective method to increase the implant surface area .Wider diameter short implants will have increased FSA and improved primary stability. It allows engagement of a maximal amount of bone and better distribution of stress in the surrounding bone. An increase in the diameter reduces stress at the implant neck and is associated with good distribution of force compared with increase in implant length [26]. Implant strength and fracture resistance can be improved by increasing the diameter of implants.

Treatment of implants with ultraviolet light has been found to increase the bone implant contact from 55% to near maximum level of 98.2%. This result in 3 folds increase in osseointegration [27-29]. This increase is attributed to generation of superhydrophilicity, a significant decrease in surface hydrocarbons and improvement in electrostatic status of titanium surface after UV treatment. The biological effect along with UV enhanced surface properties is collectively defined as photo functionalization of titanium implants.

An animal study showed implants with 40% shorter length resulted in a 50% or more decrease in the strength of osseointegration, but after photofunctionalization, the osseointegration strength doubled and the disadvantage of short implants was eliminated [30].

Survival rate of short implants: Annibali in their systemic analysis and meta-analysis of short implants concluded that provision of short implant supported prosthesis in patients with atrophic alveolar ridges appear to be successful treatment option in the short term: however, more scientific evidence is needed for long term. Jockstad 2011 in his systematic review of short implants (less than 10mm) concluded that there is growing evidence that placement of short implants (<10mm) can be successful in partially edentulous patient.

Felice in their pilot study suggested that short implant may be suitable, cheaper and faster alternative to longer implants placed in augmented bone.

ZYGOMATIC IMPLANT

The placement of implants in the zygomatic bone as an alternative to maxillary reconstruction with autogenous bone grafts has been considered a viable option in the rehabilitation of atrophic maxilla.

The zygomatic implants are self-tapping screws in with a well-defined machined surface. They are available in eight different lengths ranging from 30 to 52.5 mm. They present a unique 45° angulated head to compensate for the angulation between the zygoma and the maxilla. The portion that engages the zygoma has a diameter of 4.0 mm and the portion that engages the residual maxillary alveolar process a diameter of 4.5 mm [31,32].

In an article in 1993, Aparico mentioned the possibility of inserting dental implant in zygomatic bone [33]. In 1997, Weischer cited the use of zygoma as a support structure in the rehabilitation of patients subjected to maxillectomies following Branemarks's description. Uchida in 2001 measured the maxilla and zygoma in 12 cadavers, observing that the apex of 3.75mm diameter implant requires a zygoma at least 5.75mm in thickness. With respect to implant placement, they advised that an angulation of 43.8° or less increases the risk of perforating the infratemporal fossa or the lateral area of the maxilla; if the angulation is more vertical, 50.6° or more, this increases the risk of perforating the orbital floor.

Zygomatic implants can be used in patients with totally and partially edentulous maxilla that have insufficient bone volume for placement of regular implants posterior to canines. It can also be used in patients presenting with severe resorption of posterior maxilla (i.e. <4mm bone height distal to canine) but with sufficient amount of bone in anterior region, so at least three implant per quadrant can be placed. In patients with small bone volumes also in the anterior part of maxilla, the zygomatic implant can be used in conjunction with a bone-augmentation procedure of the anterior segment. Zygomatic implants are also indicated when contraindications exist for harvesting on the iliac bone graft.

Zygomatic implants are contraindicated in acute sinus infection, maxillary or zygoma pathology, mandibular hypomobility. However relative contraindications include chronic infectious sinusitis, Bisphosphonate therapy and smoking.

Complications:

- Intrasurgical complications include invasion into infratemporal fossa or orbit and excessive bleeding
- Late complications include sinusitis, non osteointegrated implant, local infection, fistula at implant level, paresthesia and bruising
- Prosthetic complications include problem with speech, oral hygiene, fracture of prosthetic and abutment screw.

Recent developments in the zygomatic implants:

1) **Placement of implant under local anesthesia:** This procedure is recommended if the surgeon is experienced and the procedure takes less than 1.5h. The local anesthetic procedure includes the use of four different local anesthetic approaches simultaneously normal infiltration anesthesia in the buccal sulcus from the central incisor tooth to the third molar tooth, infraorbital nerve block, block of the sphenopalatine ganglion and infiltration anesthesia around the zygoma.
2) **Immediate loading**: Ostman et al treated 20 patients with 123 oxidized implants for loading with a provisional fixed bridge in the totally edentulous maxilla within 12 h. They reported the loss of one (.8%) of the 123 implants in the study group after 1 year of loading.
3) **Use of multiple zygomatic implants**: The use of multiple zygomatic implants (i.e. two to three in each side) was suggested by Bothur and Duar used four zygomatic implants and no premaxillary conventional implants in the prosthetic rehabilitation of 12 patients with edentulous and severely resorbed maxilla. They found that the overall survival rate was 95.8% after 30 months of follow up.
4) **Extrasinus approach**: First introduced by Miglioranca in 2006. With the extrasinus approach, no opening of the sinus wall is made. Because the implant path is along or laterals to the sinus wall, the engagement of zygomatic bone is visualized.
5) **Sinus slot approach**: Stella and Warner introduced the "sinus slot approach" in 2000. This slot is made directly through the buttress wall without concern of compromise to the sinus membrane. The slot results in a smaller antrostomy that will serve to orient the twist drills for implant placement.
6) **Zygoma anatomy guided approach**: In 2013 Aparicio proposed a surgical technique based on the relationship between the zygomatic/alveolar crest complex and the various anatomies guided zygomatic implants pathways (ZAGA) [34]. Based on zygoma anatomy guided approach protocol implant placement can be classified as:-Type 0 (intrasinus path), type I (combined intra-extra path), type II (combined extra-intra), type III (extrasinus path).

BASAL IMPLANT

Basal implants are dental implants that employ the basal cortical portion of the jaws for implant retention. These implants are uniquely and specifically designed for the sole purpose of gaining anchorage from the basal cortical bone and have gone through several changes and modifications in the past several decades.

First single-piece implant was developed and used by Dr. Jean-Marc Julliet in 1972.

Rationale for using basal implants: Basal bone is less prone to bone resorption and infections. It is highly dense, corticalized and offers excellent support to implants. The conventional implants are placed in the crestal alveolar bone which comprises of bone of less quality and is more prone to resorption. The basal bone is less prone to bone resorption because of its highly dense structure. The implants which take support from the basal bone offer excellent and long lasting solution for tooth loss. Load bearing capacity of cortical bone is many times greater than spongy bone [35,36].

Types of basal implant: The two types BOI (Basal Osseo Integrated) and BCS (Basal Cortical Screw) basal implants are specifically designed to utilize strong cortical bone of the jaw. Screwable basal implants (BCS brand) have been developed with up to 12 mm thread diameter can be inserted into immediate extraction socket.

Lateral basal implants or basal osteointegrated implants are placed from the lateral aspect of the jaw bone [35]. Masticatory load transmission is confined to the horizontal implant segments and, essentially, to the cortical bone structures .The screwable basal implants are flapless implants and are inserted through gum, without giving a single cut, inserted like a conventional implant. Bicortical screws (BCS) are also considered basal implants, because they transmit masticatory loads deep into the bone, usually into the opposite cortical bone, while full osseointegration along the axis of the implant is not a prerequisite. BCS provide at least initially some elasticity and they are not prone to peri-implantitis due to their polished surface and their thin mucosal penetration diameter.

Parts of basal implants: The basal implants are single piece implants in which the implant and the abutment are fused into one single piece. It has 3 parts-abutment portion, connection and implant portion [37].

Indication: All kinds of situations when several teeth are missing or have to be extracted, when the procedure of 2-stage implant placement or bone augmentation has failed. All kinds of bone atrophy i.e. in case of very thin ridges and insufficient bone height [38].

Contraindications: Basal implants are contraindicated in special cases where bilateral equal mastication cannot be arranged, e.g. when chewing muscles or their innervations are partly missing, medical conditions like recent myocardial or cerebrovascular accident (stroke) and immunosuppression. Medicines that are used in treatment of cancer, drugs that inhibit blood clotting and bisphosphonate.

Advantages of basal implants: Can be immediately loaded, one piece implantology, basal cortical bone support, minimally invasive and minimal surgical complications, works well in compromised bone, better distribution of masticatory forces, reduced peri-imlantities incidence and in medically compromised situation like diabetes.

Disadvantages: For basal osteointegrated implants open flap surgery is needed. Gum incision and suturing are necessary, unlike implants, as BCS implants may be inserted without a flap procedure. Only a properly trained prosthodontist can accomplish the surgical procedure without any complication. If placed by inexperienced or untrained hands problems will surely come.

Complication: Complication of basal implant includes functional overload osteolysi in which masticatory forces transmitted through the basal implants may create local microcracks in the cortical bone. These microcracks are repaired by a process called remodeling. This will temporarily increase the porosity of the affected bone region as well as reduce the degree of mineralization. Basal implants in this status have a good chance of getting reintegrated at a high degree of mineralization, if loads are reduced to an adequate amount [39].

MELATONIN AS A PROSTEOGENIC AGENT IN IMPLANTOLOGY

Melatonin (N-acetyl-5-methoxytryptamine) is an indolamine synthesized mainly by the pineal gland and also by a variety of other tissues, such as the retina, bone marrow and intestine [39].

A number of *in vitro* studies have reported that melatonin is an important mediator in bone formation, promoting osteoblast differentiation. Links between melatonin and bone metabolism have been documented in many studies. In addition, melatonin has been reported to modulate calcium metabolism and prevent osteoporosis and hypocalcaemia, probably because of its interaction with other bone-regulatory factors, such as parathyroid hormone, calcitonin and prostaglandins. Several studies have shown that melatonin stimulates proliferation and differentiation of human osteoblasts *in vitro*, as well as the synthesis of type I collagen and other proteins of the bone matrix. Based on these *in vitro* data, the effects of melatonin on the process of osseointegration of titanium implants have been evaluated in various animal models and, more recently, in a pilot human trial, with generally positive results reported.

CONCLUSION

Recent findings about surface modifications, immediate loading, short implants and sinus lifting have improved the success rate of implants. However, there are limitations due to the lack of long-term or clinical studies. A long-term clinical trial and a more predictive study are needed. Despite of the data available on their success in treating a variety of cases these implants have gained little trust among conventional implantologists, it seems further research and development and more concrete data on clinical cases is required to prove their efficacy as a replacement to conventional implants.

CONFLICT OF INTEREST

There is no conflict of interest.

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All authors have viewed and agreed to the submission.

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