

A Review on Bone Grafts in Implant Dentistry

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Abstract: Bone resorption is a natural phenomenon and can occur due to old age, loss of teeth, prolonged denture wear or as a result of systemic conditions. For the replacement of teeth by implant supported prosthesis, a minimum of bone density is required. Bone grafting is a method by which bone deficient areas are built up, with the use of different materials, such as autografts, allografts, alloplasts and xenografts. This article discusses the use of human bone material, synthetic material and blood components as successful grafting materials in implant dentistry. Their use has shown an effective amount of bone formation and proliferation in the defective sites and proves to be a beneficial choice in bringing back lost bone.

Keywords: Alveolar bone, Bone augmentation, Bone grafts, Implants, Only block graft, Guided bone regeneration

INTRODUCTION

With the advancement of reconstructive techniques, implants have become an increasingly available option for replacing missing dentition in patients. One of the challenges with implant placement is an unfavorable local condition of the alveolar ridge due to atrophy, which may cause insufficient bone volume in the horizontal and/or vertical dimensions. Many options for treatment of alveolar ridge defects are available, including varying surgical techniques as well as bone graft options. The technique and type of material used depend on the geometry and location of the defect [Fig-1].

On the loss of dentition, there is significant change in the alveolar bone due to the activity of osteoclasts during bone remodeling. The most significant change occurs during the 3 months after loss of dentition and can continue over time with an additional loss of 11% of volumetric bone. A study by Ashman showed that there is an average loss of 40% to 60% of the total bone height and width within the first 2 to 3 years. The greatest bone resorption occurs in the horizontal plane, which leads to a considerable loss of alveolar width [2].

Various factors like Close proximity of anatomic structures such as the inferior alveolar nerve or maxillary sinus, and size and shape of the defect may increase the complexity of the reconstruction.

For prosthetic driven dental implant therapy, sufficient bone must be present to allow placement of an implant of appropriate dimensions in a stable and correct orientation to allow construction of a successful prosthesis. Reconstruction of alveolar bone through a variety of regenerative surgical procedures has become predictable. Bone grafting is a surgical procedure that replaces missing bone with material from patients own body, an artificial, synthetic or natural substitute.

Deficiencies in bone may be restricted to small well defined defects involving one or more sites or may be much more generalized in their presentation affecting the entire jaw. Conventionally the aim is to have a border of 1mm of bone surrounding the implant at the time of placement [2].

Radiography using cone-beam computed tomography for complex defects is useful in determining the amount of bone available and type of bone augmentation technique will be needed [3]. Many options for treatment of alveolar ridge defects are available, including varying surgical techniques as well as bone graft options. Patient factors such as poor healing states or unsuccessful previous surgeries can transform a relatively straight forward defect to a more challenging one. This article reviews the different bone grafts, discusses the available materials, and presents applications in implant dentistry based upon topography and size of the bony defect.

OVERCOMING ALVEOLAR BONE DEFICIENCIES

- Autogenous bone grafts
- Guided bone regeneration
- Alloplastic graft materials

- Allografts
- Xenografts
- Bone promoting molecules

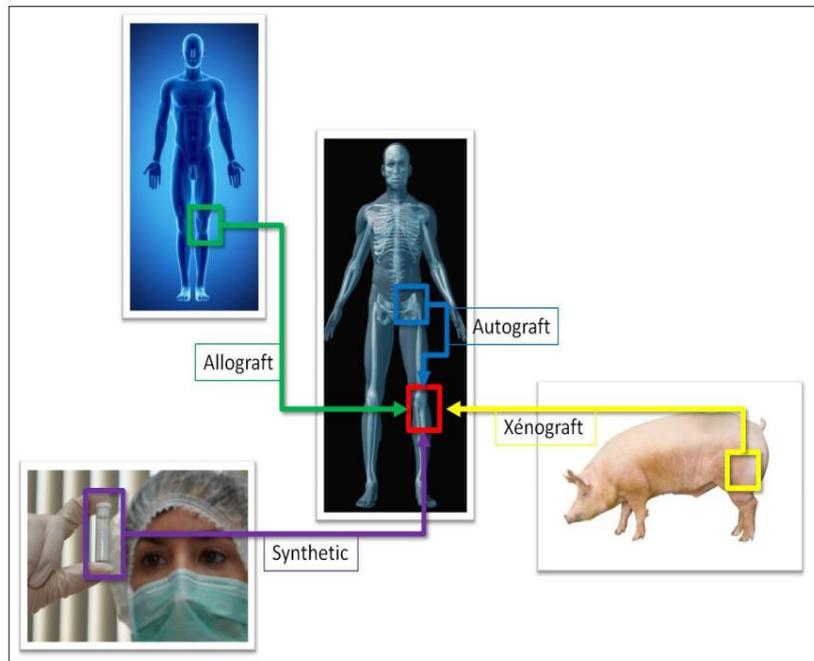


Fig-1: Different Bone Grafts

Autogenous bone grafts:

Autogenous bone remains the gold standard by which all other materials are judged. It involves utilizing bone obtained from same individual receiving the graft. It is harvested from intra and extra oral sites using trephenes or by taking bone blocks or chips [5].

Intra oral sites

Intra-oral harvesting has many merits in that the surgeon is working in an environment which is familiar, and the graft is of the same developmental origin.

Favoured intra-oral sites include the mandibular symphysis, retro molar areas, maxillary tuberosity, exostoses and other edentulous areas local or remote to the surgical site. (Fig 2 and 3).

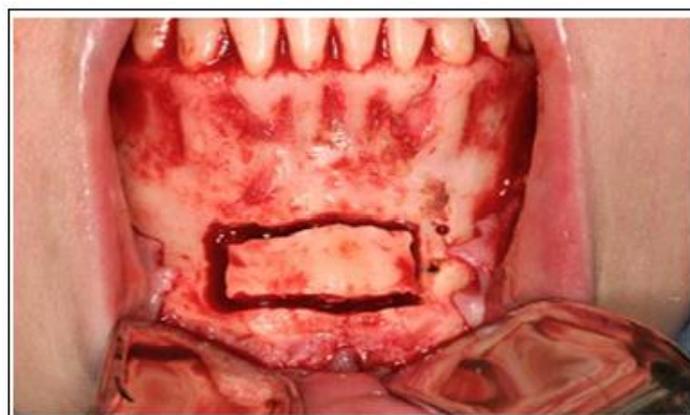


Fig-2: Autogenous bone grafts from harvested from chin

Further bone collection is possible by using surgical bone traps attached to the suction apparatus

when taking grafts or preparing implant osteotomy sites.

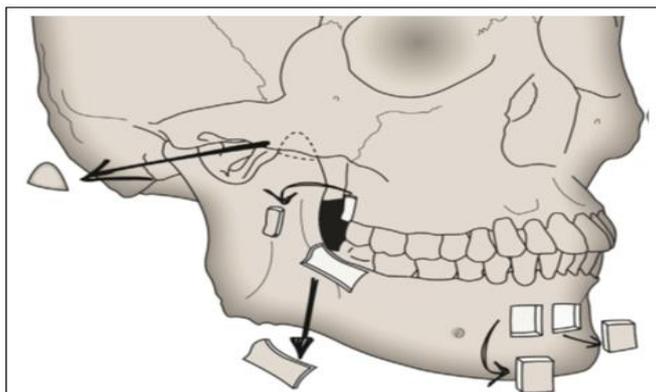


Fig-3: Possible bone harvesting sites from the Mandibular region.

Arrows are pointing to bone harvested from various possible harvesting sites.

Extra oral sites

Larger defects require bone from extra oral sites; the most common of which is iliac crest. It is a source of abundant cancellous bone and corticocancellous bone particularly when anterior and posterior crests are utilised. It can be shaped to the contour of the mandible.

Advantages of Autogenous bone grafts

- Autogenous bone is the most preferred because there is less risk of graft rejection as the grafts is originated from patient's body. Readily available from adjacent or remote sites
- It would be osteoinductive and osteogenic as well as osteoconductive.

Disadvantages Autogenous bone grafts:

- Additional surgical site is required.
- Potential location for postoperative pain and complications
- Although autograft procedures fulfill many of the characteristics of an ideal bone graft material, autografts are more invasive due to the additional

surgical manipulations required to obtain donor tissue, and are limited by the relatively small quantity of bone that can be obtained from such techniques.

Guided bone Regeneration

- This procedure is indicated when there is no sufficient bone for implantation or in the case of optimal implant installation for esthetic or functional needs.
- Guided bone regeneration is a reconstructive procedure of alveolar ridge using membranes. Most popular technique used for treatment of localised ridge deficiency. In its simplest form GBR can be used to promote bone fill of a defect before implant treatment. GBR techniques use a particulate graft with an overlying membrane that promotes stabilization of the graft material and protects the healing graft from competing, nonosteogenic cells. This membrane may be resorbable or nonresorbable.
- One of the most used is **Goretex**, an expanded poly tetrafluroethylene.(Fig 4)

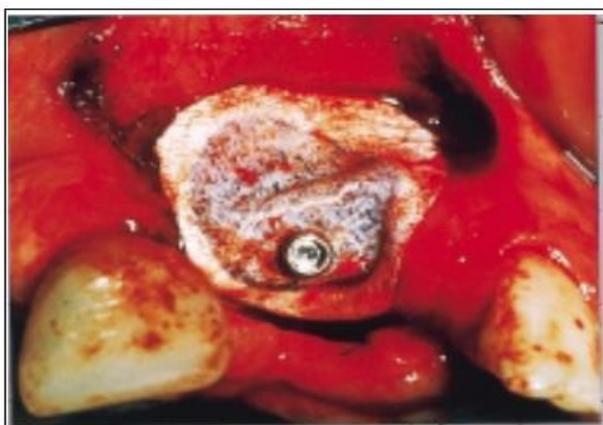


Fig-4: The membrane (Gore-Tex) in position.

It is secured to the post by a small retaining screw.

The edge of the membrane can also be secured with small screws or tacks

The ideal properties of GBR membranes are:

- Biocompatible to minimize any inflammatory response.
- Occlusive to prevent passage of cells during the healing period. Some membranes are semipermeable and allow passage of fluid where as others have been tried which are totally impermeable.
- Physical properties which allow the space under the membrane to be maintained.
- Enhance wound stability and protection of the initial clot and delicate granulation tissue. Stabilization of the membrane may be improved by securing it with small screws/pins or the implant cover screw.

It can also be used to regenerate bone in dehiscence's and fenestrations around implants at the time of placement but it must be remembered that any bone thus created does not contribute to initial implant stability and its long-term significance is currently not known. Wound closure and stability are very important when using GBR and great efforts to maintain the vitality of the overlying soft tissues need to be made. Flaps with wound edges remote from the surgical site are recommended and wound closure without producing any tension in the soft tissues is required. Soft tissue break down over sites where membranes are involved can allow bacterial infection, compromised healing and possibly failure of Osseo integration. For larger, more complex alveolar defects, only grafting is more predictable. GBR with titanium mesh can also be used for localized ridge augmentation [10].

Alloplastic graft materials

Alloplastic materials for bone growth are synthetic or deorganified biocompatible materials

developed to cover a broad range of clinical applications for bone growth and soft tissue support.

- Developed as an alternative to Autografts.
- They are primarily made from ceramics and include bioactive materials like Hydroxyapatite, Tricalcium phosphate, bioactive glasses.
- They provide an osteoconductive frame work for bone, but are not osteoinductive and are unable contribute to Osseo integration.

Hydroxyapatite

Hydroxyapatite is an alloplastic material. A biocompatible ceramic produced through a high-temperature reaction and is highly crystalline form of calcium phosphate. Hence, its composition is similar to that of cortical bone [12]. The nominal composition of this mixture is $Ca_{10}(PO_4)_6(OH)_2$ with a calcium-to-phosphate ratio of 10:6. The most unique property of this material is its chemical similarity with the mineralized phase of bone. It is an osteoconductive material and shows high biocompatibility [13]. Variety of forms from porous resorbable particles to dense non resorbable and block forms are available. The larger the particle size, the longer the material will remain at the augmentation site [15].

Tricalcium phosphate

TCP has calcium to phosphorous ratio of 3:2. It is intended to provide a scaffold for initial bony proliferation. TCP is prepared by sintering processes. It is very sensitive to heat and sterilization, which may change its properties, including resorption rate (Fig 5). It can be used in combination with osteogenic and/or osteoinductive materials because it provides improved handling characteristics to the graft during placement [15].



Fig-5: Tricalcium phosphate

Bioactive glasses:

- They are osteoconductive synthetic alloplastic bone grafting material.
- They have bone-bone bonding properties through corrosion of glass when exposed to bodily fluids to produce silica gel and a calcium phosphate surface layer.

- The calcium phosphate layer then recrystallises into hydroxycarbonate apatite which is able to bond to bone. This surface layer bears more similarity to the mineral component of bone than hydroxyapatite [5].

Allografts

- Human bone material in the form of freeze dried bone or demineralized freeze dried bone [10].
- The donor bone is harvested from cadavers, processed and sterilized.
- Available as thin sheets of cortical plate or much larger bone blocks. (Fig 6)



Fig-6: Allografts

- They are predominantly used as a scaffold for bone repair and are resorb able, but often remain as inert fragments long after placement.
- Despite the measures taken to ensure sterility and non-infectivity of these grafts some doubt must remain as to their absolute safety.
- Allografts form bone by osteoinductive effect on surrounding undifferentiated mesenchymal cells in the soft tissue over the graft as the blood vessels grow into the graft. It may also form bone by the osteoconduction phenomenon when the host bone resorbs the material and grows into its scaffold [15].

Xenografts

- Graft materials derived from other animal species. One of the most used is Bio oss
- Used to provide an inert frame work for bone regeneration either alone or in combination with autogenous bone graft [15].

Eg: Bio loss

- It is bovine bone in which the organic component is completely removed to leave the mineralized bone architecture. (Fig 7)



Fig-7: Bio loss

- This renders it non immunogenic and presumably safe from the possibility of Trans species infection.
- Other naturally occurring mineralised substances such as Coral have been advocated as it has a pore size which allows bone in growth.
- Recent research has produced some promising results describing the induction

of osteoblasts and mineralised bone following implantation of Nacre (the calcium carbonate shell of molluscs) [5].

Bone promoting molecules (Fig 8)

- The identification and production of bone morphogenetic proteins is a recent advance in regenerative therapy.

- These are natural and recombinant growth factors used alone or in blend with other material such as transforming growth factor-

Beta (TGF-Beta), platelet derived growth factor (PDGF), fibroblast growth factor and bone morphogen protein [17].

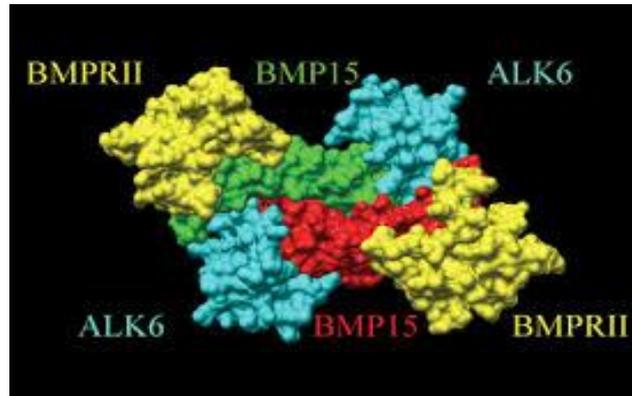
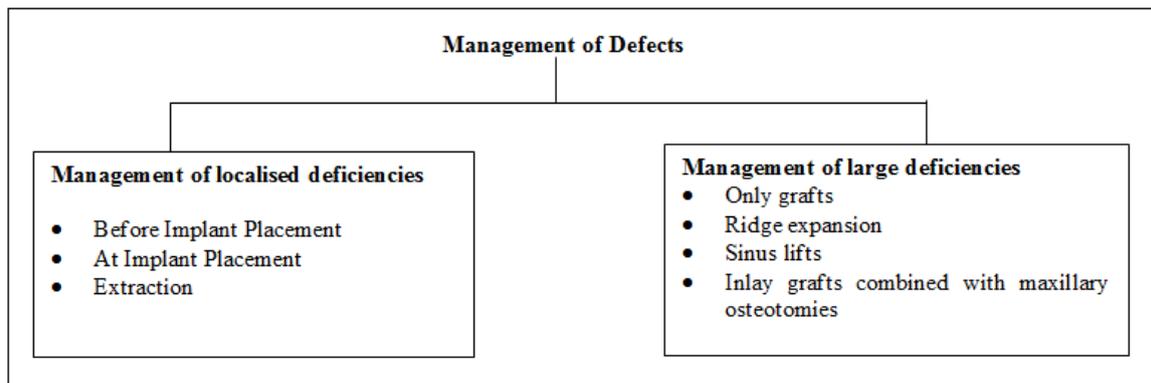


Fig-8: Bone promoting molecules



MANAGEMENT OF LOCALISED DEFICIENCIES

- Small deficiencies in the alveolar ridge may be treated using simple techniques before implant placement or at implant placement or extraction [15].

Before Implant Placement

- Bone augmentation before implant placement is generally the preferred option. (Fig 9)



Fig-9: Bone augmentation Before Implant Placement

- This is particularly the case for non-submerged or single stage implants.
- Alveolar defects should be augmented at least 3 months before implant placement, if delay greater than 6 months may result in resorption of the graft.

At Implant Placement:

- Implant placement in thin ridges may result in incomplete bone coverage of the implant surface.
- The resultant defects are dehiscence's involving marginal bone or more apically located fenestration.

- The clinician has to decide whether or not these require bone augmentation using grafts or GBR. This will mainly depend upon the size, location and morphology of the defect.
- Attempts should be made to repair large dehiscences with grafts to produce a more favorable situation.
- Fenestrations are probably of little clinical significance and usually require no treatment. (Fig :10)

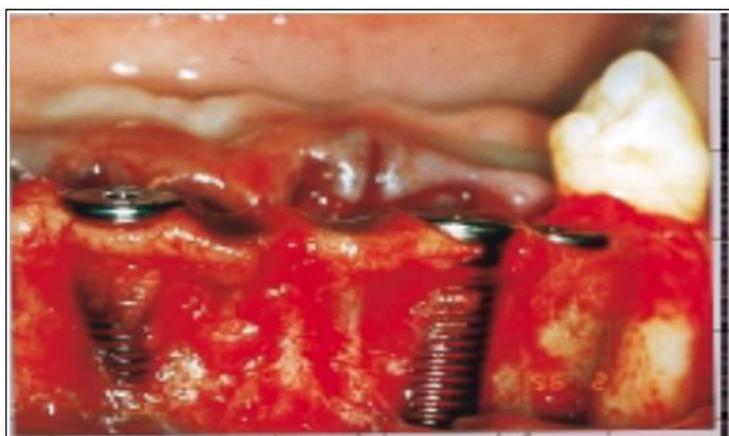


Fig-10: A large dehiscence with many exposed threads on the implant on the Patient's left side. The implant on the patient's right side has a moderate sized Fenestration. Augmentation of the bone at the dehiscence site is indicated, whereas the fenestration could be left untreated

Extraction Socket

- Most extraction sockets heal perfectly without interference.
- However, a large defect may be produced if the buccal plate is lost or in cases of long standing apical or periodontal infection.
- These defects can be repaired using a variety of techniques including small bone grafts, GBR or a combination of two.
- It is important that any residual infection is eradicated before the implant is placed.
- Removal of the offending tooth with curettage of the socket prevents infection.

While it may be possible to improve socket infill at the time of extraction by placing graft material, an alternative is to place an implant immediately into the socket. In this situation the amount of grafting material is significantly reduced by the implant taking up most of the space. A prerequisite for this technique is that sufficient bone is present to produce initial stability of the implant i.e., the graft plays no stabilizing role at implant placement. Stability is normally achieved in these situations by engaging sound bone apical to the socket. With the immediate placement

technique soft tissue coverage at implant placement can be difficult or impossible to achieve. While this may not be so important for non submerged implants, it is desirable for submerged systems and cases where grafts, particularly in combination with membranes, are employed.

Where soft tissue coverage is considered important, the technique of 'delayed immediate placement' may be employed. In such situations the extraction site is left for about 4 to 6 weeks to allow soft tissue healing before an implant is placed. This period can also be useful to allow infections to completely resolve.

MANAGEMENT OF LARGE DEFICIENCIES

Larger bone deficiencies arise because of longstanding progressive resorption following tooth loss and trauma, developmental anomalies, and pathological conditions (tumor resection, cysts, etc). Ridge resorption in the vertical plane may require grafting to allow placement of adequate length implants and to reduce the crown to implant ratio of the prosthesis. Techniques to overcome these problems, which may involve the entire edentulous jaw, aim to improve the height and or width of the bone available as

well as providing bone of sufficient quality to provide implant anchorage are

- Onlay grafts
- Ridge expansion
- Sinus lifts
- Inlay grafts combined with maxillary osteotomies

Only grafts (Fig 11)

- Onlay graft is a bone graft applied to the outside of the recipient bone.
- Onlay grafts are versatile in that they are able to augment the bone in either the vertical or lateral dimension or a combination of the two [19].

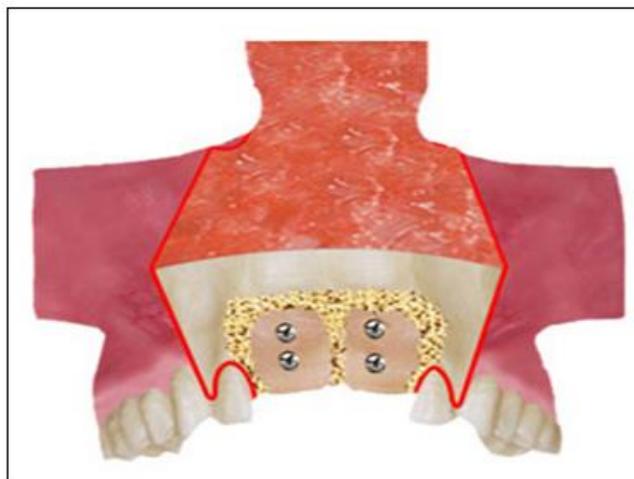


Fig-11: Only grafts

Small grafts harvested from

- Chin
- Retromolar area

Large cortico-cancellous grafts

- Iliac crest

Grafts should be secured to the recipient bed using mini screws and plates or wires.

The host bed is perforated with a small bur to allow clot to form between the bone surfaces, and to allow communication with the cancellous bone which contains osteoprogenitor cells. A modification of this technique has been described where implants are used to stabilize large onlay grafts. In these cases an iliac graft is taken in one piece which is the same dimension as the proposed dental arch by using a

surgical template. The graft is secured to the residual ridge using six or more implants. This is a useful technique to alter jaw relations and simultaneously place implants but requires that the residual alveolus is capable of stabilizing the implants and graft.

Ridge Expansion

- Lack of bone in the buccal-lingual direction can be dealt by mid-crustal expansion, in which a central cleft is created with standard osteotomies and the ridge split longitudinally. (Fig 12)
- Once expanded to the desired width the void can be grafted or a combination of implants and graft material may be placed.
- Case selection using these techniques is critical as brittle bone may fracture causing further bone loss.

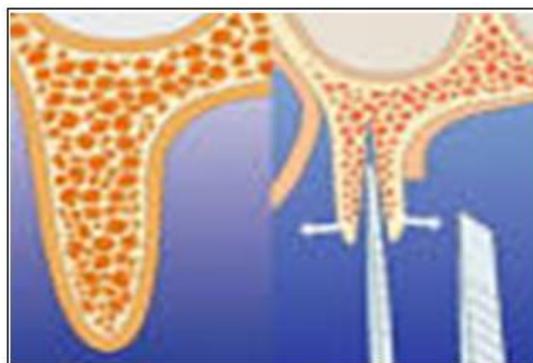


Fig-12: Ridge Expansion

- As a one stage technique problems may arise because of poor initial stability of the implant.
- Further accurate positioning and orientation of the implants may be difficult to achieve.

Sinus lifts (sub-antral grafting)

The sinus lift or sinus floor elevation is similar to a Caldwell-Luc procedure combined with grafting of the floor of the maxillary sinus. (Fig 13) It is a procedure that can be performed under local anesthesia and involves carefully cutting a window in the lateral

antral wall using surgical burs but retaining the integrity of the sinus membrane. The technique is commonly used as a pre-implant procedure when the residual alveolar ridge has resorted to a point where initial stability is compromised. It is surgical procedure which aims to increase the amount of bone in the posterior maxilla, by lifting the lower Schneiderian membrane (sinus membrane) and placing a bone graft [20]. A window has been carefully cut in the lateral wall of the maxillary sinus. The membrane has been kept intact and the bone window has been pushed inwards, hinging on the intact membranes. A self-contained cavity has thus been created to accept graft material.

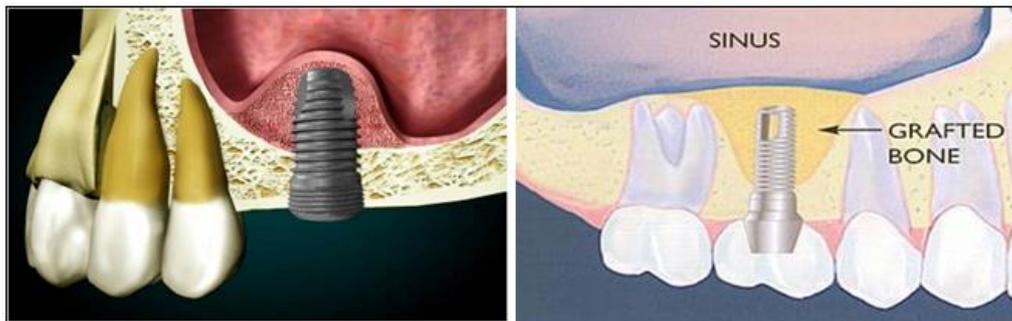


Fig-13: A window has been carefully cut in the lateral wall of the maxillary sinus. The membrane has been kept intact and the bone window has been pushed inwards, hinging on the intact membranes. A self-contained cavity has thus been created to accept graft material

- If the sinus membrane is torn it is not advisable to graft particulate material although blocks of cortical-cancellous bone can be secured
- The Maxillary ridges with less than 5mm of available bone height should be augmented at least 3 months before implant placement.
- Sinus lifts may be employed to allow installation of a longer implant without it entering the sinus proper [21].

- Once the Le Fort I down fracture is complete a bone inlay of predetermined thickness is placed in the void and sandwiched between the two sections and secured using mini-plates.
- The size of the inlay required necessitates the use of cortical-cancellous bone from the iliac crest for this procedure.

Inlay grafts combined with maxillary osteotomies

- Gross resorption of maxilla leading to a class III skeletal relationship can be treated using an inlay graft combined with an Effort I type osteotomy.
- Useful in pseudo class III edentulous maxilla or in partially dentate individuals requiring orthognathic surgery [15].
- This will improve the skeletal jaw relationship and available bone height.

Bone deficiencies in the posterior mandible

Alveolar resorption in the posterior part of the mandible eventually reduces the available bone height above the inferior dental canal to a point where implants cannot be placed without risk of injury to the inferior dental bundle. (Fig. 14) It is important to emphasize that due consideration has to be given when planning not only for the implant length but for the fact that the drills used usually prepare the osteotomy site 1–2 mm deeper than the actual implant. It is therefore imperative that the surgeon is familiar with the system and drills being used when planning surgery close to important anatomical structures [19].

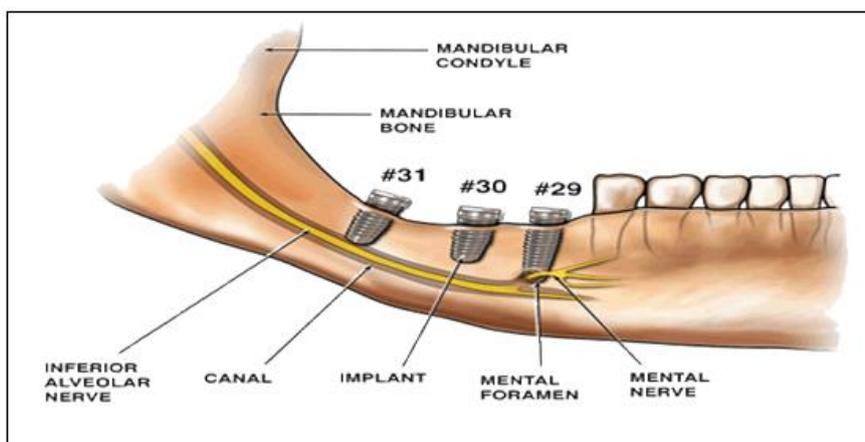


Fig-14: Implant impinging on the mandibular canal

DE roofing the nerve and dissecting the neurovascular bundle from the body of the mandible as far distally.

Lack of height above the ID canal can be overcome by only grafts or alternatively the nerve bundle itself may be surgically transposed. This is a difficult technique involving reroofing the nerve and dissecting the neurovascular bundle from the body of the mandible as far distally as is required. Implants may then be placed spanning the entire height of the mandible while avoiding the nerve. Once the implants are in place, the bony window which was removed from over the nerve may be replaced in a more mesial position with the nerve emerging from the more distal aspect. This technique carries a potentially high morbidity and should be used rarely and by experienced surgeons. In the edentulous mandible it may be preferable to place multiple fixtures anterior to the mental foramen and construct prosthesis with a distal cantilever [19].

Recent Advances

Bone morphogen protein (BMP)

BMP's are members of the family of transforming growth factors. 15 different BMP's have been identified all having different degrees of cellular activity, including cartilage or bone inducing properties [21].

Platelet rich plasma (PRP)

PRP is a source of platelet derived growth factor (PDGF) and transforming growth factor beta (TGF-b) that is obtained by sequestering and concentrating platelets by a process of gradient centrifugation. They have the ability to stimulate osteoblastic deposition of the collagen matrix of wound healing and bone. In addition TGF-b inhibits osteoclast formation thus favoring bone formation over resorption [22].

CONCLUSION

It can be seen therefore that a myriad of solutions exist to overcome anatomical problems. It is

important to remember the desired treatment outcome and to explore all the possible solutions. The extensive need for bone grafts has introduced a number of different possible materials that can be used. A large amount of research has been, and is continuously being done to provide a variety of options that substitute as grafts. With the successful use of Allografts and Allopath in recent years, it is only a matter of time before their limitations can be overcome. They have the potential of becoming the material of choice in cases of all bony deficiencies.

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