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Review Article

Sinus Augmentation Procedures & Craniofacial Grafting Sources for Sinus lift Technique: A Review

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Abstract: Maxillary sinus floor elevation was initially described by Tatum at an Alabama implant conference in 1977 and subsequently published by Boyne in 1980. Two approaches have been described in literature for sinus floor augmentation: the direct approach/lateral approach/external sinus augmentation and the indirect approach/crestal approach/internal sinus augmentation. The aim of this review was to focus the various craniofacial grafting sources for the augmentation of the sinus floor.

Keywords: Maxillary sinus augmentation, Autogenous bone graft, Maxillary tuberosity and buttress, Mandibular symphysis, Mandibular ramus.

Introduction:

The success of osseointegrated dental implants has revolutionized dentistry. Earlier, patients who lost more than a few natural teeth often found it impossible to regain full, comfortable masticatory function and facial esthetics, no matter how much dental treatment they were willing to undergo. The earliest dental prostheses for replacement of single or multiple teeth, the removable partial dentures, were cumbersome, semi-esthetic and quasi-functional. Due to these limitations of removable prostheses, it was desired that all dental prostheses attach reliably and firmly to the jaws. Thus fixed partial denture came into being. A traditional three unit fixed partial denture to replace a single tooth however, removed the enamel on a completely healthy tooth and began a cascade of potential complications, which often led to loss of the tooth. Implant dentistry has become an excellent treatment modality since its inception into the modern era of dentistry. The ability to permanently replace missing teeth with a function and appearance close to that of the natural dentition has been possible due to advancement of implant dentistry. Implants are a conservative and esthetic alternative for treatment of partial edentulism and provide a stable foundation for treatment of complete edentulism. However, dental implants can be a viable treatment option only when there is sufficient quantity and quality of bone at the site of implant placement.

Sinus Augmentation Procedures:-

The optimal placement of dental implants requires adequate bone quantity and quality at the edentulous site. Postextraction alveolar bone loss can result from tooth extraction, infection, trauma, or pathology, preventing implant placement in favorable positions and angulations[1]. The morphology of the bony defect is an important factor in the selection of the bone augmentation method[2]. Sinus floor elevation in the atrophic maxillary posterior region to make implantation possible has been increasingly popular in recent years.

Two approaches have been described in literature for sinus floor augmentation: the direct approach/lateral approach/external sinus augmentation or the indirect approach/crestal approach/internal sinus augmentation, using either a one-stage or two-stage protocol. The most commonly used technique is sinus floor elevation through a lateral window, which was first presented by Tatum [3] and was first published by Boyne and James [4]. In this procedure, after the maxillary sinus was accessed by making a bony window on the lateral sinus wall, the sinus membrane was carefully lifted to create space to be filled by grafting material in order to achieve an increase in the vertical dimension of the alveolar ridge to allow implant placement. Over the last three decades, a number of authors have documented the anatomic concerns, technical considerations, and clinical and histologic results of the sinus augmentation procedure using lateral approach along with various grafting materials[5-6]. Particulate and block grafts including autogenous bone from extra-oral or a variety of intraoral sites[7-9]; freeze-dried bone allografts (mineralized or demineralized)[10-11], xenografts, hydroxyapatite (resorbable or nonresorbable) [12-13], resorbable tricalcium phosphate [14] or various combinations of these materials [15-16] have been used for sinus augmentation using lateral approach.

Sinus elevation through a crestal approach using osteotome was introduced by Summers in 1994[17]. Summers advocated the use of compressive osteotomes to lift the sinus membrane with a closed technique followed by implant placement, with or without sinus grafting. Several modifications of the osteotome technique have been suggested, which include nasal suction technique, piezoelectric ultrasonic osteotome technique, minimally invasive antral memebrane ballon elevation (MIAMBE) technique, hydraulic sinus elevation system and electric mallet for osteotome sinus elevation surgeries

Although maxillary sinus augmentation and implant procedures are compatible, with most patients recovering uneventfully, various intraoperative and postoperative complications have been reported in the literature. These complications are fairly common with both lateral and crestal approach. Recently, piezoelectric surgery has been introduced for sinus elevation procedures. The advantage of the piezoelectric osteotomy consists of cutting the bony window with great simplicity and precision, avoiding the risk of perforating the membrane. The subsequent use of the piezoelectric elevators lifts the membrane without heightened risk of perforation, even in anatomically complex situations.

Lateral / Direct / Open / External Technique:

The procedure was introduced by Tatum at an Alabama dental implant conference in 1976 and was subsequently described by Boyne & James in 1980. The classic sinus lift procedure consists of the preparation of a window in the lateral maxillary sinus wall. This window is then luxated inward and upward with the schneiderian membrane to a horizontal position, thus forming a new sinus floor. The space underneath the membrane is filled with different graft materials according to the specific case. When bone height is sufficient to achieve primary stability, implants can be inserted simultaneously.

This approach starts with a crestal (or paracrestal, slightly palatal to the midcrest) incision in the alveolar ridge[18]. A full-thickness flap is then raised to allow access to the lateral sinus wall. A round bur is used to create a U-shaped trapdoor on the lateral wall of the maxilla. A CT scan should verify that the height of this trapdoor does not exceed the width of the sinus. An antral curette is used to gently lift the sinus membrane from the bony floor in 3 directions (anteriorly, posteriorly, and medially); lifting proceeds from the apicodistal to the coronomesial direction in order to release the tension on the membrane. The space is then grafted. Implants are then placed either simultaneously (1-stage) or after a delayed period of up to 12 months (2-stage) if graft maturation is necessary. The recipient site should not be overfilled, as that may lead to membrane necrosis. The 1-stage procedure is less time consuming; however, it is more technique sensitive. The procedure's success relies heavily on the amount of residual bone. One of the drawbacks of the 1-stage technique is that it requires a large flap for surgical access

Fig-1: Showing marking of the osseous window Apicocoronal height - 8 mm mesiodistal width -10 mm

Fig-2: Showing Preparation of the osseous window using round bur

Fig-3: Showing bluish hue indicates visibility of the sinus membrane

Fig-4: Showing Fractured Osseous Window Tipped 90 Degrees Inwards And Upwards

Fig-5: Showing Implant Site Preparation Using Sequential Drilling

Fig-6: Showing Implant Site Preparation Using Sequential Drilling

Fig-7: Showing Tip of the implant supporting the osseous window

Fig-8: Showing Implant in position

Crestal / Indirect / Close / Internal / Trans-alveolar Technique:

The osteotome sinus floor elevation (OSFE) procedure is less invasive; access to the sinus membrane is achieved through a crestal approach with sinus-osteotomes. The OSFE procedure involves drilling or trephining the residual bone up to the last millimeter. Classically, a bone grafting material is introduced in the ostetomy site with the osteotomes. The sinus floor is broken by light malleting and the membrane can be delicately elevated without perforation. Membrane elevation is achieved by placing a bone grafting material with apical condensation. This results in a tented grafted area that may extend up to 6–8mm in the sinus cavity.

Recently, the relevance of placing a grafting material in sinus elevation procedures has been questioned [47]. It has been claimed that, according to the principles of guided bone regeneration, membrane elevation with space maintenance and blood clot formation might be sufficient to obtain a neoformation of bone in this newly created space treated 10 patients who presented an average RBH of 7mm. They placed 19 implants protruding in the sinus through a direct vestibular approach; this involved elevation of the sinus membrane and suturing it to the sinus wall, without introduction of a grafting material. After 6 months of healing in the submerged way, abutments were tightened and the prosthetic steps were undertaken. All implants achieved osseointegration and were stable after 1 year of loading. The authors reported that all implants gained endo-sinus bone; unfortunately, no measurement of bone gain was provided.

Fig-9: Pre-operative site

Fig-10: Implant site preparation using sequential drilling

Fig-11: Osteotome application

Fig-12: Bone graft Placement

Fig-13: Implant Placement

Fig-14: Implant in Position

Systematic reviews[19-21] of the different sinus-lift techniques showed that this type of approach resulted in good implant survival comparable to implants placed in a conventional way. The review by Wallace and Froum[19] in 2003 reported a survival rate of 93.5% to 98.3%. A meta-analysis by Emmerich et al.[20] on sinus-lift techniques performed with osteotomes reported a value of 90.9% 24 months after loading. Tan et al.[21] in a 2008 review of transalveolar approaches, showed a mean implant survival of 92.8% after 3 years of follow-up.

Craniofacial grafting Sources for sinus augmentation:-

Currently, several regenerative therapies, including synthetic bone grafts, allogenic and xenogenic bone matrix, and recombinant growth/ differentiation factors, have been used for maxillary sinus grafting. Modern bone tissue engineering techniques, through their use in combination with biomaterials and osteogenic cells, promise to obtain bone regeneration in difficult contexts, without harvesting autogenous bone from other anatomic sites. By manipulating 3 essential elements—biomaterials, growth factors, and osteogenic cells—bone tissue engineering seeks to construct the ideal bone graft material, characterized by the same biological and structural properties of native bone[22-23].

During the early development of the sinus bone-grafting procedure in the 1970s, autologous bone alone was used to augment the posterior maxilla for dental implants. Based on favorable outcomes in other types of maxillofacial reconstruction, cancellous bone from the ilium was used to graft the sinus floor through a Caldwell-Luc approach[24-25]. Surgeons were knowledgeable about the biology, safety, and healing capabilities of autografts, but little was known about the ability of bone substitutes to help develop supporting bone around endosteal dental implants. Tricalcium phosphate was the first bone substitute used successfully in sinus grafts[25]. Over the years, allografts, alloplasts, and xenografts of many types have been used alone and in combination with autologous bone for sinus grafting. The 1996 Sinus Consensus Conference evaluated retrospective data on various graft materials and concluded that all of them seemed to perform well.3 However, the data analysis did not factor in the amount of residual bone below the sinus. Bone substitutes have since been suggested for use in the posterior maxilla with modest resorption or sinus pneumatization. For the severely atrophic maxilla, autologous bone is still preferred and has been shown to provide very predictable results.

Autogenous bone Graft:-

The use of autologous bone in sinus grafts offers many advantages, especially when minimal bone remains below the sinus floor. Cancellous autologous bone grafts contain viable cells that proliferate and contribute to new bone growth. Autologous bone grafts have bone morphogenetic proteins (BMPs), which are capable of inducing osteocompetent cells in the surrounding tissues to produce bone. They also contain other growth factors integral to the process of graft healing and incorporation. Cortical bone provides an osteoconductive scaffold for bone formation and is replaced by creeping substitution. Several studies have reported increased bone formation when autologous bone is used alone or in combination with other graft materials in sinus grafts.

Healing of autologous bone grafts is faster compared with that of allografts, xenografts, and alloplasts, especially in larger pneumatized sinuses. This offers a significant advantage, since patients often object to extended treatment. The healing period for sinuses grafted with autologous bone can be as short as 3 to 4 months versus the 8 to 10 months often recommended for bone substitutes2[26-31]. Adding autologous bone to other graft materials also can shorten healing times. Froum et al[48] found a mean vital bone formation of 27.1% at 6 to 9 months after sinus grafting with 80% bovine hydroxyapatite and only 20% autogenous bone. Misch found an average of 36.5% vital bone at 4 to 6 months when autogenous bone was used in equal proportions with bovine hydroxyapatite.

Advantages of using autologous bone in sinus grafting:

1. Increased bone formation
2. Shorter healing time requirements than for bone substitutes
3. Possibility for simultaneous lateral augmentation
4. Low operator costs
5. No risk of disease transmission

Indications for using autogenous Bone graft:-

The use of autologous bone should be considered when treating large, pneumatized sinuses. When minimal bone is present below the sinus floor, a staged approach to maxillary reconstruction is preferred. If a shorter treatment period is a priority, then the use of autologous bone is indicated.

The donor sites that can be used for harvesting bone for sinus bone grafting in the maxillofacial region include the maxillary tuberosity, zygomaticomaxillary buttress, zygoma, mandibular symphysis, mandibular body, and ramus, all of which are accessible intraorally. Bone may be removed in block sections, milled, or harvested in a particulate form. Bone can also be collected during implant osteotomies or alveoloplasty following tooth removal. The primary risk of harvesting autogenous bone is morbidity at the bone harvest site. However, intraoral donor sites are associated with minimal complications, and the many benefits of using autologous bone generally outweigh the risks.

Maxillary tuberosity and buttress:-

It is located in the same surgical field as the sinus, the maxillary tuberosity should routinely be considered as a donor site when a lateral approach to sinus grafting is used[32-33]. Because of thick mucosa over the tuberosity, however, it is often difficult to assess the amount of bone that may be obtained. Therefore, a periapical or panoramic radiograph is used to assess available bone. In addition, computerized tomography (CT) scans of the maxillary sinus region allow for three-dimensional quantification of the area. Generally, about 2 mL of bone can be harvested from this area. The anatomic limits of the tuberosity bone harvesting site include the maxillary sinus, the pterygoid plates, the molar teeth, and the greater palatine canal.

To harvest bone from the zygoma, [34] the mucoperiosteal flap used to gain access to the sinus is reflected higher to expose the inferior aspect of the zygoma. Just above the inferior border of the zygomatic rim, lateral from the maxillary sinus, cores or small blocks of bone are removed using a trephine bur or carbide fissure bur. The drill is kept parallel to the lateral maxilla, and penetration is limited to 12 to 14 mm to avoid the infratemporal fossa and orbital floor. Additional cancellous bone can sometimes be removed with a curette. Inadvertent sinus exposure is common and should not be cause for concern.

A bone scraper may also be used to remove bone from the tuberosity area as well as from the lateral maxilla and the zygomaticomaxillary buttress region.

Mandibular symphysis:-

The symphysis of the mandible, which offers the greatest volume of intraoral bone, has been used extensively for sinus and onlay bone grafting in the maxilla. The average interforaminal distance is approximately 5.0 cm, and the depth of the anterior mandible usually exceeds 1 .0 cm.[35]. A panoramic radiograph is used to evaluate the available bone in this donor site. A lateral cephalometric radiograph is also useful to determine the anteroposterior dimension of the anterior mandible. Periapical radiographs provide a more accurate measurement of the root lengths. Ease of access is one of the main advantages of the symphysis region. Bilateral mandibular anesthetic blocks and local infiltration in the anterior mandible are accomplished by administering 2 % lidocaine with 1 :100,000 epinephrine. Exposure of the symphysis can be obtained through a sulcular or a vestibular incision. A vestibular approach allows easy access but produces more bleeding and intraoral scar formation. The vestibular incision is made in the mucosa distal to the canine teeth approximately 1 cm from the mucogingival junction. Block bone grafts may be harvested using a carbide fissure bur (no. 557 or 701) or sagittal saw. Following an osteotomy through the outer cortex and into the cancellous bone, the graft is removed with an osteotome. The block bone may be used for sinus floor grafting or onlay grafting of the residual ridge. Alternatively, it may be particulated in a bone mill. Additional cancellous bone may be procured with a curette, chisel, ronguer, or trephine after the block is removed, but the volume is meager. Following the removal of the block graft, hemostatic materials such as collagen or gelatin may be placed over the cancellous bone. When larger bone grafts are harvested, the donor site should be filled with a bone substitute such as resorbable hydroxyapatite to maintain facial contour. Smaller or particulate bone grafts are procured using trephine burs, bone collection traps, or bone-scraping instruments, closure of the donor site is typically performed 'after sinus grafting to minimize the time between graft harvest and placement. The vestibular incision is closed in layers using resorbable sutures. Postoperative pressure dressings are placed over the chin to reduce edema, hematoma formation, and incision line opening.

Altered sensation of the anterior mandibular teeth is a relatively common complication following harvesting of bone blocks or trephine cores[36-39]. The contents of the incisive canal that innervate the teeth are disrupted during bone harvest. Patients describe dullness in sensation of the incisors, which usually resolves within 6 months. The need for endodontic treatment of anterior teeth is very rare. The incidence of mental nerve paresthesia for symphysis graft patients has been found to be as high as 43%[40]. Although no postoperative alteration in soft tissue chin contour has been reported, patients are frequently concerned with the possible esthetic consequences of bone removal from this area. Radiographic evidence of incomplete bony regeneration has been reported in elderly patients. Filling the donor site with a resorbable bone substitute, such as allogeneic or bovine bone, can help alleviate the patient's concerns.

Mandibular ramus

The posterior mandible is an excellent donor site for harvesting bone and offers several advantages over the symphysis[41-42]. Compared with the symphysis, the ramus area is associated with a much lower incidence of complications. A mandibular anesthetic block and buccal infiltration of the posterior mandible is accomplished by administering 2% lidocaine with 1:100,000 epinephrine. The incision design for access to this region depends on the type of graft harvested (block or particulate). When harvesting a block graft or trephine cores, the incision is similar to one used in third molar removal. A sulcular incision is made along the posterior teeth and continues posteriorly and lateral at a 45-degree angle from the distobuccal aspect of the second molar (or from the base of the retromolar pad if no molar is present). A mucoperiosteal flap is then reflected to expose the lateral ramus and body of the mandible. The masseter muscle may be reflected laterally with a specially designed retractor (Misch ramus retractor, Salvin Dental) to form a large open pocket. Additional local anesthesia is often required in this area to block cervical innervation. The limits of the ramus area are dictated by clinical access in addition to the coronoid process, molar teeth, and inferior alveolar canal. The average anteroposterior dimension of the mandibular ramus is 30 mm, with the lingula typically in the posterior third[43]. To harvest a block bone graft, four osteotomies are made, one each to the external oblique, superior ramus, and anterior and inferior body of the mandible. The cortical cuts are made with a carbide fissure bur (no. 557 or 701) in a straight handpiece or a saw under sterile saline irrigation. The external oblique cut is made along the anterior border of the ramus approximately 4 to 6 mm medial to the external oblique ridge. This osteotomy can extend posterosuperiorly to the coronoid process and anteriorly to the first molar area, producing a graft of up to 40 mm in length. The superior ramus cut is made through the lateral cortex of the ramus and perpendicular to the external oblique cut. It may extend as far posteriorly on the ramus as the opposing lingula on the medial ramus. However, the length of this cut is typically about 10 mm. The anterior body cut will often extend over the path of the mandibular canal. Although the buccolingual position of the mandibular canal varies, the distance from the canal to the medial aspect of the buccal cortical plate (medullary bone thickness) has been found to be greatest at the distal half of the first molar (mean, 4.05 mm)[44]. Therefore, the anterior body cut should be made in this area and not in the third molar region, where the canal is closer to the buccal surface. This anterior body cut is progressively deepened until bleeding from the underlying cancellous bone is observed. The inferior osteotomy is only a partial-thickness cut made with a round carbide bur (no. 8). It connects the superior ramus and anterior body cuts inferiorly. This osteotomy on the lateral aspect of the ramus parallels the external oblique cut and creates the base of the rectangular bone block. It extends only partially through the cortex and creates a line of fracture. The block graft is then removed with an osteotome wedged within the external oblique osteotomy.

Potential damage to the inferior alveolar nerve, like that to the peripheral mental branches when harvesting from the chin, is a matter of concern with the ramus graft technique. For this reason, it is important to plan osteotomies in the posterior mandible to avoid the mandibular canal. In contrast to the common complaint of altered sensation of the incisors with chin bone harvest, no ramus graft patients have noted numbness of their molar teeth[45]. Although the posterior incision along the external oblique ridge could possibly damage the long buccal nerve, sensory loss in the buccal mucosa is rare and most likely goes unnoticed[46]. Ramus graft patients appear to have fewer problems in managing postoperative edema and pain compared with chin graft patients. Those who experience trismus following surgery should be placed on postoperative glucocorticoids and nonsteroidal anti-inflammatory medications to reduce dysfunction.

Autologous bone grafts procured from the maxillofacial region offer several advantages in sinus bone grafting and reconstruction of the maxilla for implant placement. These include increased bone formation, shorter healing time requirements, low operator costs, no risk of disease transmission, and the ability to simultaneously perform onlay augmentation. The surgical procedures may be performed in an office setting and do not require general anesthesia. Intraoral donor bone is readily available, and several techniques are available for harvesting particulate or block bone grafts. The tuberosity and zygomatic buttress are routinely accessible during sinus graft surgery through a lateral window approach. The posterior mandible has some advantages over the mandibular symphysis as a remote donor site. Nonetheless, most intraoral donor sites are associated with minimal morbidity and offer significant benefits for sinus grafting.

Future directions

In the future more studies should be carried out to correlate the clinical outcome of autogenous bone block with its biologic mechanisms which opens novel applications of this sinus augmentation procedure. There are only limited studies in the literature on the effect of autogenous bone block for sinus augmentations. Therefore, more studies should be conducted which open newer strategies for the use of autogenous bone block for sinus augmentation procedures.

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