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Review Article

Lateral trap-door window approach with maxillary sinus membrane lifting for dental implant placement in atrophied edentulous alveolar ridge

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Abstract

One of the most challenging and technically sensitive surgical procedures in conjunction with dental implant rehabilitation is sinus membrane lifting to increase the bone height or volume from the maxillary sinus floor. This important preprosthetic surgical technique has been available for >15 years, making possible the creation of bone volume in the edentulous posterior maxilla for the placement of dental implants in surgically compromised cases. Substantial literature exists regarding the most efficacious way to increase the predictability of this surgical procedure, and reduce its associated complications. In this article, we describe the regional anatomy of the maxillary sinus, the evolution of the sinus membrane lifting procedure, the current surgical technique, its survival rate and associated complications, the need for bone graft or bone substitutes, and current advances in the lateral approach through a trap-door window for sinus membrane lifting for dental implants.

Keywords: bone graft; dental implant; lateral approach; sinus lift

1. Introduction

The most challenging oral rehabilitation where dental implants are used is frequently found in severely surgically compromised atrophied edentulous alveolar ridges that are thin, sharp, and shallow. To meet the basic requirements for implant surgery in such conditions, the atrophic ridge could be rebuilt utilizing many well-known techniques.[1–5] The loss of maxillary molar teeth tends to have a rapid resorption in the alveolar bone below the maxillary sinus floor. Conventionally, placement and integration of endosseous implants in patients with such atrophic ridges requires elevation of the maxillary sinus floor. The process of sinus floor elevation, also called sinus lift procedure, is an internal augmentation of the maxillary sinus membrane, with or without grafts, in order to increase the vertical bony dimension of the sinus chamber in the lateral maxilla. This created space customarily allows the possibility of a dental implant to be inserted from the alveolar ridge to this chamber, to thereafter wait for osseointegration from the regenerating grafted bone.[6,7]

2. Anatomy of the maxillary sinus

The maxillary sinus has a multitude of conceivable functions. Some of these functions include adding resonance to the voice, participating in the olfactory process, warming and humidifying the inspired air, and reducing the weight of the skull. Typically, in the adult facial area of the skull, the maxillary sinus is a pyramidal-shaped bony cavity with its base at the lateral nasal wall and its apex extending into the zygomatic process of the maxilla. The whole sinus bony

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compartment is lined with a thin layer of mucosa and covered by the "ciliated" respiratory epithelium, and continuous with its counterpart of epithelium of the nasal cavity. In general, the mucosa of the maxillary sinus is thinner (about 1 mm thick) and less vascularized than other counterparts of the nasal mucosa. An important function of the healthy ciliated epithelium is its transport function for mucus fluids towards the internal ostium, which is the connection between the maxillary sinus and the middle meatus of the nasal cavity.[8–11]

The sinus epithelium is initially derived from the cranial end of the middle meatus of the nasal cavity in the embryological stage. At the 12th week of embryo development, the sinus epithelium moves in a descending manner with an anterior–posterior extension. In childhood, the size of the maxillary sinus is insignificant until eruption of the permanent dentition. The development of maxillary sinus by pneumatization increases its size until the end of its adult growth period. The size and shape of the maxillary sinus may vary widely, even within the same individual at different ages. In the adult, the average dimensions of the maxillary sinus are approximately 30 mm in width, 40 mm in height, and 40 mm in length. In general, the sinus floor is about 1 cm below the nasal floor in normal adults. The ultimate dimension of the sinus may anteriorly reach the canine/premolar region, with its deepest part reaching the first molar region. Therefore, it is apparent that roots from the canine, and premolars to molars easily cause convolutions in the floor of the sinus. In older people with atrophied edentulous alveolar ridge in the upper jaw, the maxillary sinus may further enlarge to an extreme by leaving a paper-thin cortical wall on its lateral side and bottom neighboring the oral cavity. The process of pneumatization of the sinus can substantially differ from person to person. The thin mucous membrane within the sinus is composed of a well-vascularized blood supply. The terminal branches with anastomoses from the infraorbital artery, the posterior superior alveolar artery, and the greater palatine artery contribute the major blood supply to the maxillary sinus.[12,13]

3. Presurgical assessment

The ultimate goal of a sinus augmentation technique is to increase the sinus height to that level necessary for dental implant placement. This lateral approach through trap-door window access is performed by the sequential procedures of flap entry, window access to the sinus cavity, elevation of the sinus (Schneiderian) membrane to create a space, surrounded by either periosteum or by bone tissue of the maxilla, for the resulting placement of graft material and flap closure. This technically sensitive procedure of sinus lifting should be based on a thorough presurgical examination of the health status of the sinus so as to prevent major postoperative complications. A profound knowledge of the sinus anatomy can prevent many intraoperative complications. For these reasons, presurgical evaluation should be based on careful radiographic examination by panoramic film, conventional computed tomographic scan, or by cone-beam computed tomography. Presurgical tomograms have been useful in evaluating details of the focal area. These images revealed the height of the ridge along the axis of the implant fixtures. Any potential risk factors from smoking, periapical lesion, or compromised periodontal disease associated with the surgical pathway should be avoided or pretreated prior to surgery.[6,12,14]

4. Surgical procedure of lateral trap-door window approach

For safe access to the lateral sinus, a full-thickness mucoperiosteal flap originating from the midcrestal area or slightly toward the palate side is preferred, just in case the sinus wall is thin and close to the alveolar crest. A releasing incision at the anterior or posterior edge of this flap should be designed with a slightly flared out characteristic to ensure an appropriate blood supply from the base. On some occasions, a single anterior releasing incision is able to provide sufficient access for the sinus approach. Most importantly, the releasing incisions should be made distant to the proposed window site and the position of the overlapping barrier membrane in case further access is necessary. The surgical procedure for sinus lifting entails the preparation of a trap door from the lateral sinus wall to elevate the Schneiderian membrane. Under full exposure of the lateral maxillary wall, an antrostomy is made in the lateral sinus wall to gain access to the sinus membrane. In order to open the trap-door window, either the rotary technique or the piezoelectric technique can provide adequate access to obliterate the thin to thick cortical bone and to expose the thin sinus membrane, thereby allowing a space to be created to place the bone graft material. The membrane should be elevated across the sinus floor and up the medial wall to the level of the proposed graft placement. Furthermore, this elevation must extend anteriorly–posteriorly to provide the exposed sinus floor to allow for graft and implant placement. The elevation of sinus space created below the lifted sinus membrane is then grafted with different fillers consisting of autogenous bone, bone substitute, or a mixture of these materials. In general, implants can be placed at the same time with a minimal bone height of 4–5 mm for primary stabilization during the grafting procedure, or can be subsequently placed after a primary healing period of 9–12 months to permit bone regeneration. The wound of the raised flap is then closed with primary suturing to avoid exposure of the graft or implants. At the second stage for implant exposure, a partial thickness mucoperiosteal flap across the ridge crest to contain a safe zone of palatal keratinized mucosa could be raised and laterally positioned toward the buccal in order to preserve a keratinized zone of mucosa on the periphery of implant emergence area.[6,7,15]

5. Choices of augmentation with or without grafts

Autogenous bone has long been considered as the best option among all grafting materials. Scientific-based evidence supports the idea that bone formation occurs through the multiple pathways of osteoinduction, osteoconduction, and osteogenesis when a viable autogenous graft is placed in an

appropriate aseptic environment with sufficient blood supply. Therefore, autogenous bone was initially considered as the first choice of filling material for maxillary sinus augmentation. Considering of the relatively large volume of grafting material required, extraoral donor sites from the hip, tibia or cranium were additional sourcing choices to provide an adequate amount of autogenous bone for sinus augmentation. However, use of such supplemental autogenous bone donor site may be accompanied by various transient or permanent donor site morbidity. Donor site morbidity is often considered a drawback when contemplating the use of autogenous bone for implant surgery. In the past, using bone substitutes for this procedure was limited due to their poor regenerative capacity as compared to natural autogenous bone.[15–17] Currently, additional evidence-based updated reviews have reported on the efficacy of all forms of graft material, noting that allografts, alloplasts, and xenografts can be effective in indicated clinical situations. These reviews are in agreement that more favorable results have been achieved with bone replacement grafts than with autogenous bone.[6,7,15–25] By contrast, regarding the use of bone grafts or bone substitutes, one literature series reported on a case of sinus lift without graft. Based on their findings with an experimental animal model, Linde et al[18] proposed that bone may regenerate *in situ* after an isolated space is created and maintained between the periosteum and the calvarial cortex. The isolated space, which was filled initially with clotted blood, was occupied later by newly formed bone. This observation is consistent with the possibility that fillers of the newly created space for sinus lifting may not be necessary if adequate time were allowed for regeneration of new bone.[18] Numerous clinical articles and research papers in the past 10 years also have described their evidence-based results regarding use of the sinus lift without the need for bone grafts or substitutes.[26–31]

6. Improvement of surgical techniques

The sinus augmentation procedure was initially described by Tatum,[1] and subsequently published by Boyne and James.[15] Using the lateral approach technique for entry to the sinus wall, a window access was then created for the membrane lifting, with or without placing the autogenous bone graft or other fillers. A variety of technical modifications have been proposed in the past 10 years. In 1998, Wood and Moore[32] described using either surgical hand pieces or modified high-speed hand pieces for the window access, as well as harvesting autogenous bone graft from the intraoral donor site. In 1997, Smiler[33] further reported multiple technical modifications relating to enhancing the convenience or safety within the scope of the rotary method. In contrast to the conventional drilling method, a breakthrough was introduced by Vercellotti et al[34] in 2001, who successfully used the piezoelectric technique to enable window access with a greatly decreased chance of membrane perforation. Lozada et al[35] in 2011 first described the advanced sinus kit of instruments for window access, and further demonstrated transcrestal approaches to the sinus using osteotomes, special safe-cutting drills, hydraulic pressure, piezoelectric surgery, and balloon elevation techniques. The osteotome technique later developed into a convenience method for sinus lifting commonly used in outpatient dental clinics.[27–29] In contrast to the transcrestal approach with osteotome technique, creation of the sinus space with the trap-door, open window method results in an enclosed bone chamber surrounded by the periosteum on the flap side laterally, the sinus membrane periosteum with a cortical plate superiorly, and the maxillary bone in other aspects. An immediate placement of dental implant provides a vertical stop for the upwardly positioned cortical bone on the lifted membrane so that the space is maintained with clotted blood. This approach ensures that newly regenerated bone will be easily guided into place after the surgical procedure is completed. Two main intraoperative complications that can easily occur are profuse bleeding and sinus membrane perforation, which may result in procedural failure and, ultimately, implant survival. The risk of complications is greatly reduced by using the piezoelectric technique for window access during the lateral approach.[36–40]

In conclusion, the maxillary sinus elevation procedure has been proposed as one of the most useful preprosthetic surgical techniques for successful oral rehabilitation by dental implants in the maxilla, where the maxilla has been compromised by its atrophied alveolar ridge and low sinus floor. Considerable improvement regarding the flap design, method of surgical approach, specially designed instruments, and various bone grafts or bone substitutes had been proposed for over a decade. The evolution of the surgical technique in the lateral approach through trap-door window access to the maxillary bone for sinus membrane lifting is aimed at reducing the complications that may jeopardize the outcome of procedural success or implant survival. Piezoelectric surgery has demonstrated its advantageous capability to reduce the perforation rate dramatically, thereby increasing the overall success rate of sinus lift. Future prospects for improvement or advancement in the procedure might be the endorsement by tissue engineering concept from the utility of more active allograft or bone substitutes as the filler in the created bone chamber after sinus membrane lifting.

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