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Review

A comprehensive clinical review of maxillary sinus floor elevation: anatomy, techniques, biomaterials and complications

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Abstract

Several systematic reviews have shown that maxillary sinus augmentation is a predictable and effective procedure for augmentation of an atrophic posterior maxilla. However, we know of no reviews that have covered all the clinical aspects. We searched the PubMed, EMBASE, Cinhal, and Cochrane databases up to January 2015 to select relevant studies that cover the different objectives of this review, including the anatomy of the maxillary sinus, surgical techniques, biomaterials used in the sinus augmentation, and potential complications.

Keywords: Sinus augmentation; Bone grafting; Sinus lift; Membrane perforation; Septa; Piezosurgery

Anatomy

The maxillary sinus is the largest of the paranasal sinuses and in adults contains roughly 12-15 ml of air.[1] It is a pyramidal structure with its base close to the nasal cavity, the superior portion forming the floor of the orbit, and the apex towards the zygomatic bone.[2] The ostium is an oval or slit-shaped drainage port that acts as an overflow drain located in the superior aspect of the medial wall.[2,3] The distance between the nasal floor and the semilunar hiatus varies between 18 and 35 mm (mean 25.6 mm).[4] The fact that the ostium is high in the medial wall reduces the likelihood of a blockage during augmentation.[5]

The floor of the sinus extends anteriorly to the premolar or canine region and posteriorly to the maxillary tuberosity with in many cases its lowest part close to the area of the first molar.[6] The floor of the maxillary sinus is the thickest wall in dentate adults, and is about the same level of the nasal floor. In an edentulous patient it is 1 cm below the nasal floor. Septa are made of cortical bone and are located on both horizontal and vertical planes in the sinus floor.[7,8] Several authors have noticed the presence of septa in 25% to 31.7% of maxillary sinuses,[9,10] which can vary between 2.5 and 12.7 mm in length and can be found in any area of the maxillary sinus.[10], There were considerably more septa in edentulous or atrophic ridges than in partially edentulous or non-atrophic arches.[7,9]

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Table 1
Innervation of the maxillary sinus.

Nerve	Area of coverage
Posterior and middle superior alveolar nerves	Posterior wall of the sinus
Anterior superior alveolar nerve	Anterior wall of the sinus
Infraorbital nerve	Superior wall and part of medial wall
Greater palatine nerve	Ostium and inferior wall of the sinus

Vasculature and innervation

The posterior superior alveolar artery, inferior orbital artery, greater palatine artery, and sphenopalatine artery are the main branches of the maxillary artery that provide blood supply to the bony walls and membrane of the sinus. The sites of the inferior orbital artery and the posterior superior alveolar artery are important in surgical planning, as damage to these arteries can cause bleeding.[11,12] The two arteries reconnect with each other and form a double arterial arcade, which encompasses the maxillary sinus.[13] This anastomosis is either extraosseous (23-26 mm away from alveolar ridge) or endosseous (16.4 -19.6 mm from the alveolar margin).[12] The dental branch of the posterior superior alveolar artery has an endosseous anastomosis with the inferior orbital artery in all dissected anatomical cases, but this anastomosis is found radiographically in only 50% of cases.[13–15]

Innervation of the maxillary sinus is summarised in Table 1. It is important, because there is a specific connection between the maxillary sinus venous system and the cavernous sinus that can be a route for the spread of infection from the sinus to the brain.[16–18]

Surgical techniques

The sinus augmentation procedure is a successful and predictable approach for augmentation of the posterior maxilla with deficient crestal bone.[19] The surgical procedure was first described by Tatum and subsequently, Boyne and James in 1980.[6,20,21] There are two main techniques: the transalveolar (crestal), and the lateral window. However, several authors have published modifications of these techniques.[22,23]

The lateral window technique

The surgical steps of this technique are summarised in Fig. 1. Local anaesthesia is achieved through a combination of local infiltration and greater palatine and posterior superior alveolar nerve blocks.[3] A buccal vertical incision on the mesial, distal, or both sides may be necessary, depending on the amount of reflection needed. [3,6]

The inferior border of the window in the lateral wall should be about 3 mm from the floor of the sinus. The posterior extension of the window can be over the tuberosity, while the anterior border should be about 3 mm from the anterior wall of the sinus (Fig. 1a).[24]The osteotomy can be prepared using a high-speed handpiece or piezoelectric instruments. Using a piezoelectric tip during preparation of the bony window will considerably reduce the risk of perforation of the membrane.[25,26]

The "incomplete fracture" and "wall-off" techniques are two ways to prepare the lateral window osteotomy. The "incomplete fracture" technique includes tapping of the bony island over the graft materials as a roof, which cannot be achieved easily in the narrow sinuses.[27] The "wall-off" technique offers complete removal of the bony island, which results in better access to the sinus (Fig. 1b). For both techniques, it is important to raise the sinus membrane from the surrounding bony walls, and to be sure to reach the medial wall to obtain adequate horizontal space for grafting materials. After adequate space has been created, grafting materials should be delivered to the site and all areas should be carefully filled (Fig. 1c).[3,24]

Several authors have suggested that coverage of the window with a membrane after placement of the grafting materials for bone grafting results in increased formation of vital bone (Fig. 1d).[26–28] However, a recent meta-analysis showed that the amount of vital bone formation is not affected by the presence of a membrane over the window.[29] The final step in the procedure is closure of the flap, which is essential to minimise contamination of the graft by oral microorganisms (Fig. 1e).[24]

Crestal osteotome technique

The crestal osteotome technique was first described by Summers in 1994 as a less invasive technique for raising the sinus floor through compression of the bone apically towards the sinus, and lifting of the Schneiderian membrane.[30] He modified this technique with the addition of bone graft particles into the osteotomy. This is a well-established option for patients with more than 5 mm residual bone height.[24] Various studies have reported good survival rate (ranging from 93.5%-100%) for implants placed in the sinus using this technique.[31]

After the osteotomy area has been exposed by either raising a flap or using a flapless technique, a 2 mm twist drill is used to remove bone until 1 mm from the sinus floor.[32] The osteotomy is expanded to 0.5-1.2 mm less than the size of the implant with either osteotomy drills or a series of osteotomes. Subsequently, particles of bone are inserted into the osteotomy and pushed towards the sinus by tapping lightly. Fracture of the sinus floor can be detected by change in the resistance between the osteotome and the bone, or a change in the sound of the tapping. Advancement of the osteotome into the sinus should be avoided, as it increases the risk of perforation of the membrane.[30,32]