

Maxillary Sinus Floor Elevation: Review of Anatomy and Two Techniques

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Implant dentistry has become an excellent treatment modality since its inception into the modern era of dentistry. It not only allows for a conservative and esthetic alternative to treating partial edentulism, but it also provides a stable foundation for treating complete edentulism. Dental implants can be a viable treatment option when there is sufficient quantity and quality of bone.

However, when patients present with deficient alveolar ridges, it could jeopardize the application of implant dentistry. This problem is especially magnified in the posterior maxilla where ridge resorption and sinus pneumatization, compounded with a poor quality of bone, are often encountered. The procedure of choice to restore this anatomic deficiency is maxillary sinus floor elevation (sinus lift). The objective of this article is to review, and summarize, the relevant anatomy and current techniques of this procedure.

Historic Background

Maxillary sinus floor elevation was initially described by Tatum at an Alabama implant conference in 1976 and subsequently published by Boyne in 1980.^{1,2} Its need stemmed from the necessity to restore the posterior maxilla using implants. The procedure is one of the most common preprosthetic surgeries performed in dentistry today. Since its first description, numerous

A review of maxillary sinus floor elevation as an integral part of restoring the posterior maxilla is discussed. The related anatomy of the area and the current techniques available are reviewed. The classic lateral antrostomy pioneered by Tatum appears to be the most common sinus lift procedure. The more con-

servative crestal approach, advocated by Summers, provides another effective way of allowing implant fixture placement in the atrophic maxilla. (Implant Dent 2004;13:28–32)

Key Words: dental implants, posterior maxilla, lateral antrostomy, crestal approach

articles^{3–6} have been published in this field regarding different grafting materials, modifications to the classic technique, and comparisons between different techniques.

Anatomy of the Maxillary Sinus

The maxillary sinus is a pyramid-shaped cavity with its base adjacent to the nasal wall and apex pointing to the zygoma (Fig. 1). The size of the sinus is insignificant until the eruption of permanent dentition. The average dimensions of the adult sinus are 2.5 to 3.5 cm wide, 3.6 to 4.5 cm tall, and 3.8 to 4.5 cm deep.⁷ It has an estimated volume of approximately 12 to 15 cm³.⁸ Anteriorly, it extends to the canine and premolar area. The sinus floor usually has its most inferior point near the first molar region. The size of the sinus will increase with age if the area is edentulous. The extent of pneumatization varies from person to person and from side to side.⁷ Nonetheless, this process often leaves the bony lateral and occlusal alveolus paper-thin in the posterior maxilla.

The maxillary sinus bony cavity is lined with the sinus membrane, also known as the Schneiderian membrane. This membrane consists of ciliated epithelium like the rest of the respiratory tract. It is continuous with, and connects to, the nasal epithelium through

the ostium in the middle meatus. The membrane has a thickness of approximately 0.8 mm. Antral mucosa is thinner and less vascular than nasal mucosa.⁷

The blood supply to the maxillary sinus is primarily derived from the posterior superior alveolar artery and the infraorbital artery, both being branches of the maxillary artery. There are significant anastomoses between these 2 arteries in the lateral antral wall. The greater palatine artery also supplies the inferior portion of the sinus.⁹ However, because the blood supplies to the maxillary sinus are from terminal branches of peripheral vessels, significant hemorrhage during the sinus lift procedure is rare. Nerve supply to the sinus is derived from the superior alveolar branch of the maxillary (V₂) division of the trigeminal nerve.

Surgical Techniques

Currently, 2 main approaches to the maxillary sinus floor elevation procedure can be found in the literature. The first approach, lateral antrostomy, is the classic and the more commonly performed technique originally described by Tatum. More recently, Summers advocated a second approach: the crestal approach, using osteotomes.¹⁰ The crestal approach is

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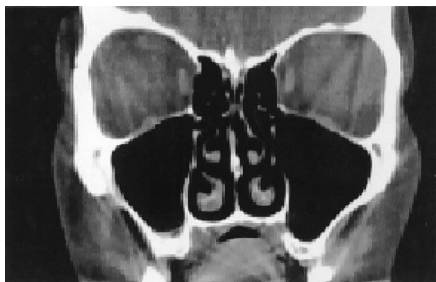


Fig. 1. Maxillary sinus shown in a computed tomography coronal view.

considered to be a more conservative method for sinus floor elevation.

Lateral Antrostomy. Lateral antrostomy is started with a crestal incision made on the alveolar ridge. Sometimes, this incision is made slightly palatal to the crest to preserve a wider band of keratinized attached gingiva for a more solid wound closure and to avoid wound dehiscence. A full-thickness flap is then raised to allow access to the lateral antral wall. Once the flap has been raised to a desired level, antrostomy is performed with a round bur to create a U-shaped trapdoor on the lateral buttress of the maxilla (Fig. 2). The height of this trapdoor should not exceed the width of the sinus (it can be measured in computerized tomogram) to allow for a final horizontal position of the new floor. The sinus membrane is then gently lifted from the bony floor by means of an antral curette. Marx and Garg suggested using a cottonoid soaked with a carpule of 2% lidocaine with 1:100,000 epinephrine and left in the space created for 5 minutes so as to

limit bleeding and allow for better visualization for further dissection.¹¹ It is important to free up the sinus membrane in all directions (anteriorly, posteriorly, and medially) before attempting to intrude the trapdoor medially.

A space is created after the sinus membrane has been elevated by the intruded trapdoor. This space is then grafted with different materials to provide the platform for implant placement (Fig. 3). Numerous research projects have been published to evaluate the prognosis of implants under different grafting materials.^{12,13} Autogenous bone remains the gold standard in bone grafting.¹⁴ Iliac crest, chin, anterior ramus, and tuberosity have all been mentioned as common autogenous donor sites in maxillary sinus lift. Hydroxyapatite mixed with autogenous bone or used alone has also been shown to be viable alternatives.¹⁵ Care should be taken not to overfill the recipient site, because it will cause membrane necrosis.

Implants are placed either simultaneously with the graft (1-stage lateral antrostomy) or after a delayed period of up to 12 months to allow for graft maturation (2-stage lateral antrostomy). The initial bone thickness at the alveolar ridge seems to be a reliable indicator in deciding between these 2 methods. If the bone thickness is 4 mm or less, initial implant stability would be jeopardized. Therefore, a 2-stage lateral antrostomy should be carried out. The reverse holds true for a 1-stage procedure.¹⁶ A 1-stage procedure is less time-consuming for both

the clinician and the patient. However, it is more technique-sensitive and its success relies heavily on the amount of residual bone.

Crestal Approach. One of the drawbacks of the lateral antrostomy is that it requires the raising of a large flap for surgical access. Summers proposed a conservative crestal approach using osteotomes for maxillary sinus floor elevation in 1994.¹⁰

This technique begins with a crestal incision. A full-thickness flap is raised to expose the alveolar ridge. An osteotome of the smallest size is then tapped into place by a mallet or drill into the bone. Preoperative bone height underneath the sinus is measured to determine the desired depth for osteotome extension. The goal is to extend the instruments just shy of the sinus membrane. Osteotomes of increasing sizes are introduced sequentially to expand the alveolus. With each insertion of a larger osteotome, bone is compressed, pushed laterally and apically (Fig. 4). Summers stated that the very nature of this technique improves the bone density of the posterior maxilla where type IV bone is normally found.¹⁷ Once the largest osteotome has expanded the implant site, a prepared bone mix is added to the osteotomy as the grafting material. Summers suggested a 25% autogenous bone with 75% hydroxyapatite mix; however, a variety of graft materials have also been used. The final stage of sinus floor elevation is completed by reinserting the largest osteotome to the implant site with the graft material in place. This causes the added bone mix to exert pressure onto the sinus membrane and to elevate it (Fig. 5). Additional grafting material can subsequently be added and tapped in to achieve the desired amount of elevation. Once this height is gained, the implant fixture is inserted. The implant fixture should be slightly larger in diameter than the osteotomy site created by the largest osteotome. It becomes the final osteotome, "tenting" the elevated maxillary sinus membrane (Fig. 6).

The main advantage of the crestal osteotome technique is that it is a less invasive procedure. It improves the density of the maxillary bone, which allows greater initial stability of implants. It also has the potential for the use of less autogenous grafting mate-

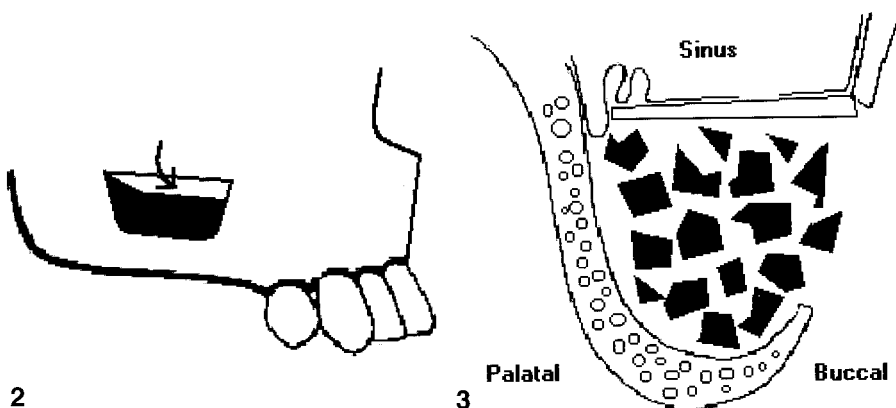


Fig. 2. Intruding the U-shaped trapdoor. Note that the corners of the trapdoor should be rounded.

Fig. 3. Lateral antrostomy with intruded trapdoor and graft materials.

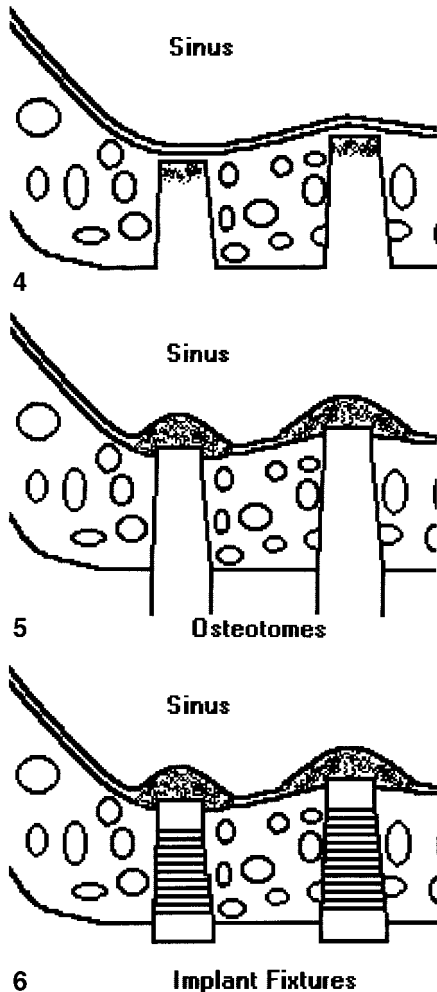


Fig. 4. Osteotomes of increasing size are used to compress bone laterally and apically just shy of the sinus membrane.

Fig. 5. Reinserting the largest osteotome with the graft material in place causes elevation of the sinus membrane.

Fig. 6. Implant fixtures act as the final osteotomes tenting the sinus membrane in the elevated position.

rial. Summers suggested the crestal incision to be extended distally to the tuberosity area where autogenous bone can be harvested.¹⁷ The disadvantage of the crestal approach is that the initial implant stability is unproven if the residual bone height is less than 6 mm. The chances of achieving a sufficiently high elevation with the osteotome technique is limited.¹⁶ With this approach, there could also be a higher chance of misaligning the long axis of the osteotome during the sequential osteotomy.

CONCLUSIONS

Restoring edentulism with dental implants requires careful treatment planning. This is especially true with the posterior maxilla when pneumatized maxillary sinuses could limit the amount of alveolar bone for implant placement. Maxillary sinus floor elevation offers one of the most common preprosthetic procedures to solve this problem. Two technique procedures, the classic lateral antrostomy and the more conservative crestal approach, were discussed in this article. Lateral antrostomy allows for a greater amount of bone augmentation to the atrophic maxilla but requires a larger surgical access. The crestal approach is minimally invasive but permits only a limited amount of augmentation. Therefore, practitioners should select the type of procedure appropriate to the particular clinical needs. In addition, all relevant anatomic structures in the vicinity should be respected to minimize surgical complications.

Disclosure

The authors claim to have no financial interest in any company or any of the products mentioned in this article.

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Anhebung des Sinusbodens im Oberkiefer: Überblick zu Anatomie und zwei Behandlungsansätzen

ZUSAMMENFASSUNG: Im vorliegenden Artikel wird die Methodik zur Anhebung des Oberkiefersinusbodens als wesentlichem Bestandteil der Wiederherstellungsbehandlung im hinteren Oberkieferbereich untersucht. Es erfolgt eine Prüfung der direkten Umgebungsanatomie sowie der aktuell verfügbaren Behandlungsmethoden. Die klassische laterale Antrumöffnung wurde von Tatum erstmals praktiziert und scheint heutzutage die am weitesten verbreitete Methode zur Sinusanhebung zu sein. Auch durch den konservativeren Ansatz durch Zugriff auf den Knochenkamm, mit Summers als Vorreiter, kann die Implantierung von Zahnimplantatsbefestigungen im atrophischen Oberkiefer ermöglicht werden.

SCHLÜSSELWÖRTER: Zahnimplantate, hinterer Oberkieferbereich, lateral Antrumöffnung, Knochenkamm-Methodik

Elevación maxilar del piso del seno: Una evaluación de la anatomía y dos técnicas

ABSTRACTO: Se explica una evaluación de la elevación maxilar del piso del seno como parte integral de la restauración del maxilar posterior. Se analizan la anatomía relacionada del área y las técnicas disponibles. La antrostomía lateral clásica creada por Tatum parecer ser el procedimiento de elevación del seno más común. El método crestral más conservador, sugerido por Summers, ofrece otra manera eficaz de permitir la colocación del implante en el maxilar atrofiado.

PALABRAS CLAVES: implantes dentales, maxilar posterior, antrostomía lateral, método crestral

Elevação do Soalho do Seio Maxilar: Uma Revisão de Anatomia e Duas Técnicas

RESUMO: É discutida uma revisão da elevação do soalho do seio maxilar como parte integrante da restauração da maxila posterior. A anatomia relacionada da área e as técnicas atuais disponíveis são revistas. A antrostomia lateral clássica introduzida por Tatum parece ser o procedimento mais comum de elevação do seio. A abordagem da crista, mais conservadora, defendida por Summers, proporciona outro meio eficaz de permitir a colocação do dispositivo de implante na maxila atrofica.

PALAVRAS-CHAVE: Implantes dentários, maxila posterior, antrostomia lateral, abordagem da crista

上顎上顎洞底挙上：解剖学的研究と2件の技術の評価

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要約：上顎後部修復の主要部分を構成する上顎上顎洞底挙上法について考察し、関連部位の解剖学的考察と現在使われる技術の評価が行われる。Tatumによって始められた古典的なlateral antrostomyが³、上顎洞挙上法としてもっとも一般的なようだ。Summersが提唱したより保守的なcrestal法も、上顎委縮部へのインプラント埋入を可能にする効果的な方法である。

キーワード：デンタル・インプラント、上顎後部、lateral antrostomy、crestal 法

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