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Treatment rationale

Anatomical aspects of sinus floor elevations

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Inadequate bone height in the lateral part of the maxilla forms a contra-indication for implant surgery. This condition can be treated with an internal augmentation of the maxillary sinus floor. This sinus floor elevation, formerly called sinus lifting, consists of a surgical procedure in which a top hinge door in the lateral maxillary sinus wall is prepared and internally rotated to a horizontal position. The new elevated sinus floor, together with the inner maxillary mucosa, will create a space that can be filled with graft material. Sinus lift procedures depend greatly on fragile structures and anatomical variations. The variety of anatomical modalities in shape of the inner aspect of the maxillary sinus defines the surgical approach. Conditions such as sinus floor convolutions, sinus septum, transient mucosa swelling and narrow sinus may form a (usually relative) contra-indication for sinus floor elevation. Absolute contra-indications are maxillary sinus diseases (tumors) and destructive former sinus surgery (like the Caldwell–Luc operation). The lateral sinus wall is usually a thin bone plate, which is easily penetrated with rotating or sharp instruments. The fragile Schneiderian membrane plays an important role for the containment of the bonegraft. The surgical procedure of preparing the trap door and luxating it, together with the preparation of the sinus mucosa, may cause a mucosa tear. Usually, when these perforations are not too large, they will fold together when turning the trap door inward and upward, or they can be glued with a fibrin sealant, or they can be covered with a resorbable membrane. If the perforation is too large, a cortico-spongious block graft can be considered. However, in most cases the sinus floor elevation will be deleted. Perforations may also occur due to irregularities in the sinus floor or even due to immediate contact of sinus mucosa with oral mucosa. Obstruction of the antro-nasal foramen is, due to its high location, not a likely complication, nor is the occurrence of severe haemorrhages since the trap door is in the periphery of the supplying vessels. Apart from these two aspects, a number of anatomical considerations are described in connection with sinus floor elevation.

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The sinus floor elevation, or as formerly called, sinus lift procedure, is an internal augmentation of the maxillar sinus, which is intended to increase the vertical bony dimension in the lateral maxilla in order to make the use of dental implants possible.

The operation was conceived and introduced by Tatum at the Birmingham, Alabama implant meeting of 1976 (Tatum 1986; Chanavaz 1990). He modified the technique in due years. The first publication on this surgical technique was however by Boyne followed by Tatum himself (Boyne et al. 1980; Tatum 1986). The classical sinus lift operation consists of the preparation of a top hinge door in the lateral maxillary sinus wall. This door is luxated inward and upward together with the Schneiderian membrane to a horizontal position forming the new sinus bottom. The space underneath this lifted door and sinus mucosa is filled with graft material (Fig. 1).

Implants can either be inserted simultaneously, when there is sufficient bone height for primary stability (>4 mm), or can be inserted in a second procedure when bone-remodelling of the graft has

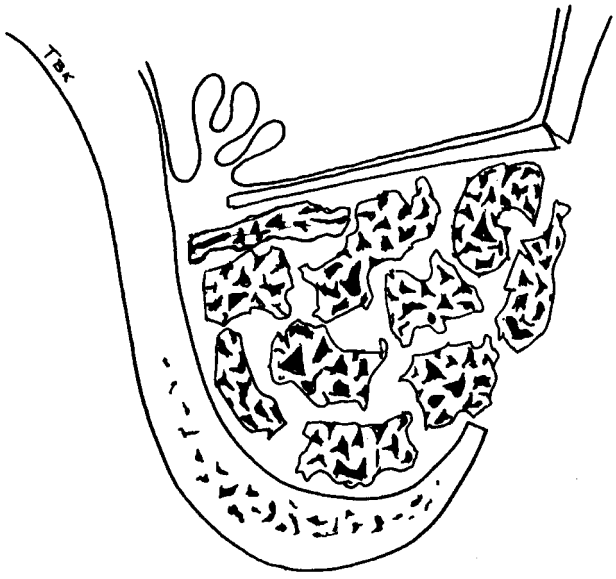


Fig. 1. Schematic drawing of the principles of sinus lifting according to the Tatum method. The transverse cut of the maxillary sinus shows the inward and upward rotated top hinge door in the lateral sinus wall. Underneath this door and the elevated Schneiderian membrane the bone graft can be placed.

taken place. This two stage procedure is indicated when no good primary stability can be expected (bone height$<$ 4 mm) (Misch 1987; ten Bruggenkate et al. 1998; van den Bergh et al. 1998; Hirsch & Erickson 1991).

The principle of the sinus floor elevation is simple, however, there are a number of anatomical aspects and considerations in connection with this type of surgery, that should be regarded.

Anatomy of the maxillary sinus

The function of the maxillary sinus is not clearly understood. Some functions might be adding resonance to the voice, some degree of olfactory function, to warm and humidify the inspired air or reducing the weight of the skull (Ritter & Lee 1978; Blanton & Biggs 1969).

The maxillary sinus in the adult consists of a pyramidal shaped cavity in the facial skull with its base at the lateral nasal wall and its apex extending into the zygomatic process of the maxilla (McGowan et al. 1993). The sinus is internally lined with a thin mucosa of "ciliated" respiratory epithelium which is continuous with that of the nose (Ritter & Lee 1978; McGowan et al. 1993). Normal antral mucosa, however, is thinner (approximately 1 mm thick) and less vascular than the nasal mucosa. The ciliated respiratory epithelium has a transport function for fluids like pus and mucus towards the internal ostium (Stamberger 1986). This ostium is situated at the cranial side and connects the maxillary sinus to the middle meatus of the nasal cavity (May et al. 1990).

In its embryological stage the epithelium derives from the cranial end of the middle meatus of the nasal cavity. The sinus epithelium descends during the 12th week downwards, forwards and backwards. Until eruption of the permanent teeth its size is insignificant. Its pneumatization seems to complete at the end of the growth to approximately 12–15 cm^3 at adolescence (Chanavaz 1990; McGowan et al. 1993). The average dimensions of the adult maxillary sinus are 25–35 mm (width), 36–45 mm (height) and 38–45 mm (length) (Eckert-Mobius 1954). The floor of the antrum is in dentate adults approximately 1 cm below the nasal floor (McGowan et al. 1993). Anteriorly the sinus extends generally to the canine premolar region. The convex sinus floor usually reaches its deepest point at the first molar region. There is however a large variety in size and shape of the sinuses even within the same person. Roots of the maxillary teeth frequently cause convolutions in the floor of the sinus.

At the edentate stage of life the size of the maxillary sinus will increase further, often filling a large part of the alveolar process, leaving sometimes only a paper thin bone wall on the lateral and occlusal sides. This process of pneumatization of the sinus varies greatly from person to person and even from side to side. The blood supply of the maxillary sinus derives from the infra-orbital artery, the greater palatine artery and the posterior superior alveolar artery (Chanavaz 1990; Pernkopf 1963; McGowan et al. 1993; Uchida et al. 1998; de Mol van Otterloo 1994). According to Solar et al. usually several anastomoses of the posterior superior alveolar artery and the infra orbital artery can be found inside the bony lateral antral wall, which also supplies the Schneiderian membrane as well as in the epiperiosteal vestibular tissues. The mean distance between these intra osseous anastomosis and the alveolar ridge was 19 mm. The epiperiosteal vestibular anastomosis were situated at a more cranical level (Solar et al. 1999).

The lymph drainage occurs via the infra-orbital foramen and the ostium. The ciliated epithelium transports the mucus to the ostium at the cranial side in the superior part of the sinus.

The two important walls of the maxillary sinus for the sinus floor elevation are the anterior or buccal wall and the internal or nasal wall. The anterior wall is usually made of thin compact bone, containing the neurovascular canals to the anterior teeth if present. The posterior teeth are supplied by neurovascular branches coming from the maxillary tuberosity (de Mol van Otterloo 1994). Obviously this anatomical aspect has its repercussions for the

small gaps where sinus lifting is indicated. Surgical approach apically of vital neighbouring teeth might devitalize them. The lateral sinus wall is on the facial aspect covered by musculo-periosteal tissue, containing the facial artery and vein, the lymphatic system and the infra orbital nerves (Chanavaz 1990; de Mol van Otterloo 1994).

The internal wall has a rectangular shape and forms the bony septum between the nasal and maxillary sinus. The inferior part of this wall corresponds with the inferior meatus of the nasal cavity, marked by the tuberosity of the inferior concha at the top. In the middle of this wall a rather fragile bony structure, the so-called sinus hiatus, can be recognized (Chanavaz 1990).

Masticatory forces are distributed to the skull via four major structures. They are the anterior fronto-maxillary pillar (I) (or fronto-nasal pillar), the lateral zygomatico-maxillary pillar (II), the pterygo-maxillary pillar (III) and the palatine arch (IV), including the septum and the lateral nasal walls and pterygoid process of the sphenoid bone to the base of the skull (Watzek 1996).

Apart from the inner expansion of the maxillary sinus, the outer aspect of the alveolar process also decreases due to atrophic bone loss (Cawood 1988; Starshack 1971).

There are a number of these mentioned anatomical aspects that have surgical relevance in connection with the sinus floor elevation procedure.

Surgical considerations with regard to the anatomy

The flap design

The flap design should be such that the disturbance of blood supply is restricted to a minimum and that sufficient coverage of the surgical wound is ensured. Usually the incision is made on the top of the alveolar ridge, or slightly on the palatal side, through the keratinized, attached mucosa. This way the wound closure can be solid and with sufficient overlap to deal with a possible dehiscency.

The infra-orbital foramen

One structure to be avoided cranially is the infra-orbital foramen. Not only might the preparation of the door be a threat to the neuro-vascular bundle but also the possibility of mechanical damage by the wound retractor should be regarded. Normally however there is no reason for such high preparations, because there is no need for such a high "door". It might even cause the door being too large for the width of the sinus, making it impossible to raise it to a horizontal level. This problem may also be encountered with the combination of "normal" sized doors and very narrow sinuses.

The sinus floor

Normally the shape of the door should ideally follow the inner shape of the maxillary sinus which usually is curved. This means that the pre-operative planning with the use of an orthopantomogram is essential for this type of surgery.

However, also the clinical aspect of the lateral sinus wall will provide information of the extent of the maxillary sinus. In most patients the lateral sinus wall is quite thin and looks greyish-blue showing the circumference of the sinus (Fig. 2). The shape of the door therefore may be determined by the combination of the orthopantomogram (OPG) and the clinical surgical aspect. Normally this means rounded corners with a usually wide cranial hinge base (Fig. 2).

The rounded corners have also the surgical advantage of a reduced chance of damaging the Schneiderian membrane. This membrane is the fragile and important structure to be dealt with. In principle this membrane, which is under normal circumstances thin, should be kept intact, in order to avoid loss of graft material into the sinus and to have a graft covering material for vascular function.

Lateral sinus wall preparation

As mentioned the preparation of the door is only possible in those areas where the bone is thin. If the lateral sinus wall consists of thick bone the whole lateral sinus wall should be thinned out (Fig. 3 a,b). Otherwise it is extremely difficult to free the Schneiderian membrane from the inner aspect of the bony sinus since instruments can not reach this tissue due to a deep cleft-like approach.

The preparation of the door should be wide enough to handle the instruments. Therefore the start of the preparation is normally with a large round steel burr (∅+3 mm). The preparation is finished with a large round diamond burr, that can not easily damage the membrane or perforate the bony wall.

The healthy membrane will look dark greyish-blue. In smokers the Schneiderian membrane may look atrophic and be extremely thin and fragile to touch. Anamnestic data should therefore be regarded.

Chronic sinusitis is recognized by a thick, spongy Schneiderian membrane. In fact this condition forms a (temporary?) contra-indication for sinus lifting and should be determined during preoperative radiological investigation (OPG and computertomogram scanning (CT) or conventional sinus radiographs). Allergic conditions may also lead to chronical reactive mucosa changes and can therefore also form a contra-indication. It

should be stressed that not only thorough pre-operative radiographic investigation should be performed, but also relevant anamnestic information should be gathered.

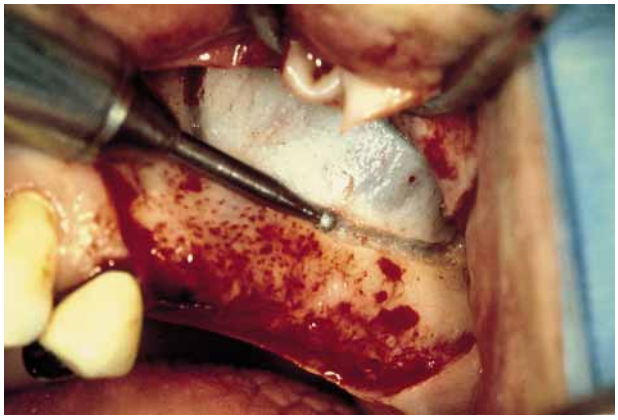
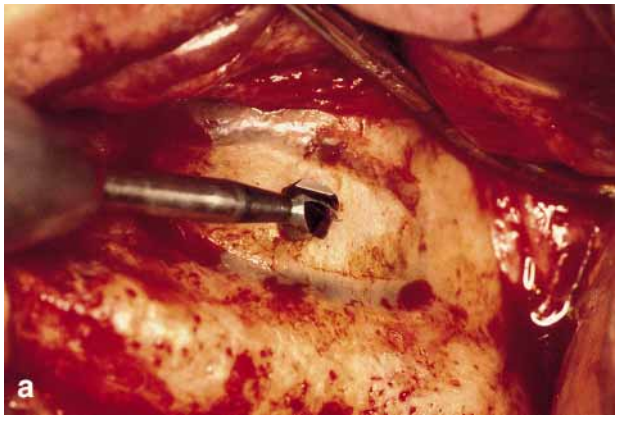


Fig. 2. Clinical aspect of a thin lateral anterior sinus wall showing an almost transparent dark aspect. The preparation contours are marked following the radiological and clinical landmarks.



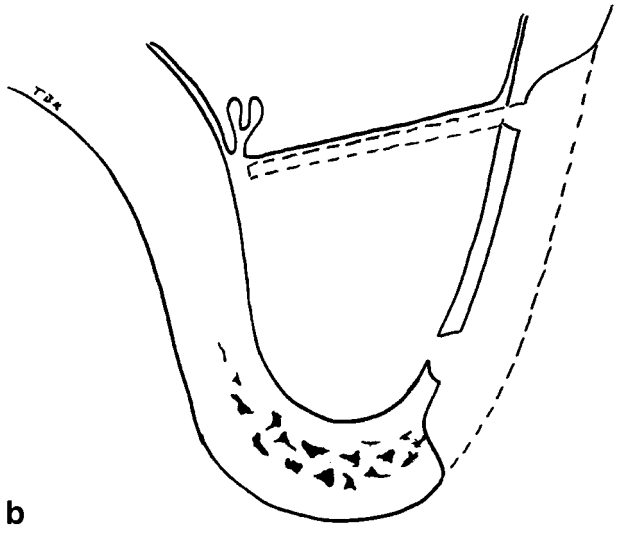


Fig. 3.(a, b) Clinical picture and schematic drawing of thinning out a thick lateral sinus wall in order to acquire favourable conditions for preparation of the door and Schneiderian membrane.

The door luxation is best performed with finger pressure. Not only can the surgeon feel the resistance and the fracture of the door hinge, but also it will prevent any sharp instrument from perforating the sinus mucosa. The aim is to bring the trap-door in a horizontal position. In order to ac-

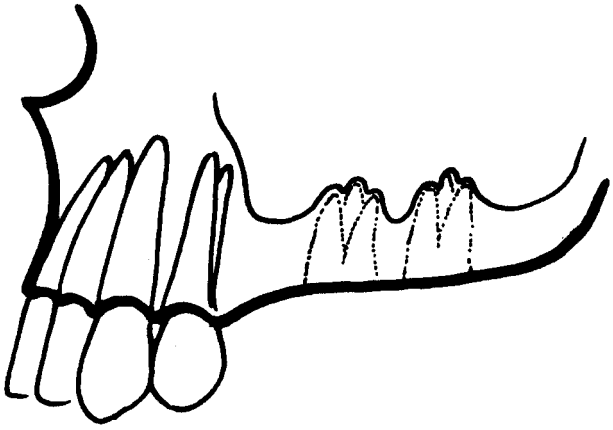


Fig. 4. Schematic drawings of dental root shaped configurations, that makes preparation of the mucosa difficult.

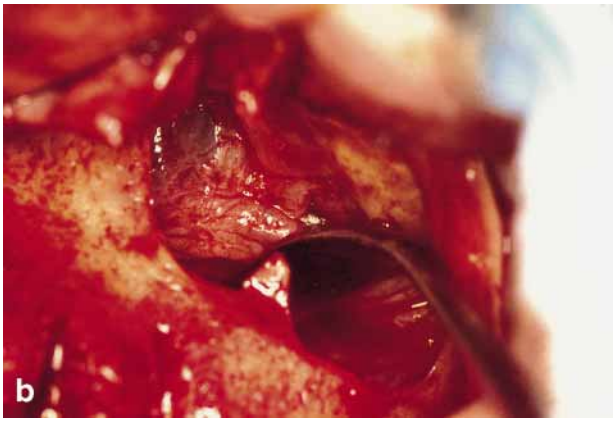


Fig. 5. (a) W-Shape of the trap-door in case of an antral septum. (b) The top of the septum is the most difficult place to prepare. Perforations of the Schneiderian membrane are likely to occur at this point.

complish this, the antral mucosa must be prepared from the inner aspect of the sinus bottom.

The Schneiderian membrane

The normal anatomy of the sinus will allow the door to turn in an up-into horizontal position, however, only if the Schneiderian membrane is sufficiently lifted. Freeing this membrane is a delicate procedure which is performed with special sinus floor elevation instruments (designed by Tatum) that work in different directions with different angles and blades. One starts at the caudal edge slowly and carefully working towards the mesial and distal sides of the sinus. Especially on the distal side the sinus might extend considerably, making the preparation quite difficult.

Only when the whole caudal membrane is prepared free from the sinus bottom can the door be totally lifted to a horizontal position. The door will more or less remain in that position showing that all mucosa-tissue is lifted to that level up to the medial part of the sinus. This may be surprisingly deep. Nevertheless it should be performed to that extent, since the graft material must be placed until this level. Overfilling may cause necrosis of the Schneiderian membrane with loss of graft into the sinus, resulting also in sinusitis (Tidwell et al. 1992; Raghoebar et al. 1997; Timmenga et al. 1997). The position and support of the dental implants requires bony structures in the region of the lateral nasal wall as the, already described, important fourth pillar (Watzek 1996).

Luxating the Schneiderian membrane from septa can be difficult, but can be even more difficult at longitudinal rims sinus floor convolutions and root tip expressions, even when the teeth have been extracted many months before (Figs 4, 5a,b).

Previous sinus surgery sometimes forms a contra-indication for sinus floor elevation since scar tissue does not allow preparation of an intact healthy mucosal tissue. Also when the alveolar bone is totally absent in some places (due to resorption or traumatic bone loss after tooth extractions, e.g. sinus perforation) the sinus mucosa can

Fig. 6. (a) Axial CT scans of several septa dividing the maxillary sinus in more divisions. (b) In contrast to rectangular running septa, slanted septa are not always clearly recognizable on an orthopantomogram.

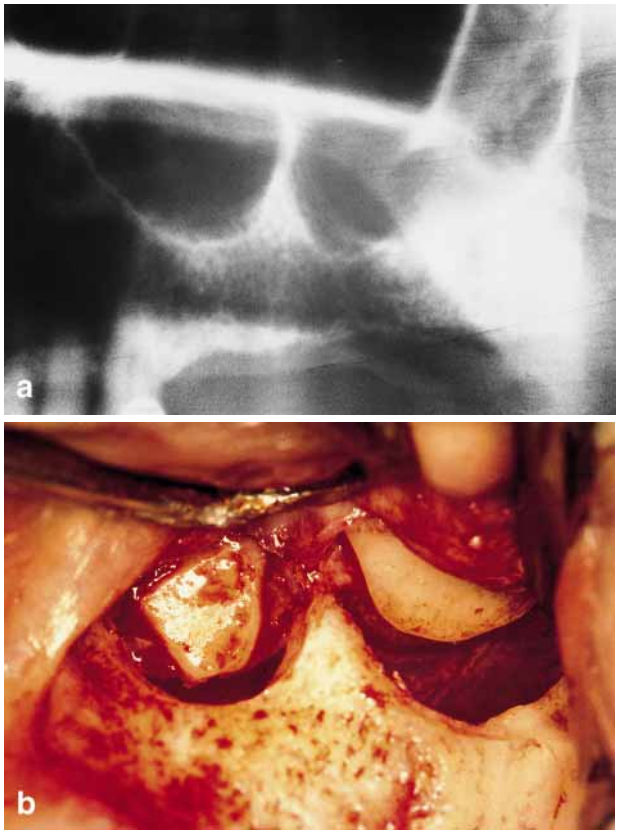


Fig. 7. (a, b) Large sinus septum necessitating two separate trap-doors.

be in immediate contact with the oral mucosa. This is a very difficult condition, where mostly the Schneiderian membrane can not be kept intact. It may lead to large perforations at very difficult sites, making further preparation impossible.

Schneiderian membrane perforations

As mentioned before, a perforation of the Schneiderian membrane forms a frequent complication and always threatens the coverage of the bone graft. These perforations are most likely to happen at sharp edges and ridges like Underwoods septa and at spines (Chanavaz 1990) (Figs 5a,b).

When the perforation is small and located in an area where the elevated mucosa folds together when lifting the door there is no need for further measurements. For security biological glues might be considered.

If the perforation is larger and located in an unfavourable area, the perforation needs to be closed and covered in order to prevent loss of the graft. This can be achieved by covering the defect with a resorbable (e.g. demineralized laminar bone) membrane and bioglues. In case the membrane perforation is really large, further sinus lift should be abandoned.

Re-entry might be considered. According to Chanavaz this second procedure should not be performed until 6 to 8 weeks after the first surgical attempt (Chanavaz 1990).

Perforations do, however, not necessarily mean that the graft is lost. In orthognatic surgery bone grafts are frequently placed in regions where there is not a mucosal coverage to the sinuses. The bone graft blocks are usually not lost or do not cause major problems. Consequently particulate grafts are to be avoided in connection with large perforations, that cannot be closed or covered.

Maxillary sinus septa

Especially in the younger adult, septa can be recognized in the maxillary sinus (Underwood 1910). The incidence of antral septra varies between 16% and 58% according to the literature (Underwood 1910; Ulm et al. 1995; Jensen et al. 1992; Betts & Miloro 1994; Krennmair et al. 1997). They divide the caudal part of the sinus in multiple compartments known as recesses. They may even be complete, dividing the sinus in smaller accessory sinuses (Miles 1973) (Figs 6a,b). These septa act as a masticatory force carrying struts during the dentate phase of life and seem to disappear slowly when teeth have been lost.

Apart from the inner contour of the sinus, also the presence of septa determines the shape of the door. If the septum is only located at the bottom of the sinus the door can be of a normal shape since it will not be blocked by the septum if the door is luxated and turned inward and upward. If the septum is higher the door must either follow the contour making a W-shape (Fig. 5) or two trap doors (Figs 7a,b) or it must be located on one side of the septum (mostly the mesial side), if only implants are desired at that site (Fig. 8). Another option would be to use an antrostomy approach (Bruggenkate et al. 1998). After preparing the sinus mucosa the septum can (partially) be removed if required.

This is also the case when the outer aspect of the lateral sinus wall (the zygomatic process of the maxilla) is too convex for the door base to function as a hinge. In convex situations the hinge line would cause a membrane tear when luxating the door. This tearing can be avoided when also the hinge side preparation is made complete, and the whole bone fragment is dislocated into a cranial direction (similar as described in cases of a narrow sinus).

The narrow sinus

A narrow sinus, although rare, can only be recognized on a CT scan. This suggests pre-operative CT scanning for sinus grafting (Figs 9a,b). One way to get around the problem of a narrow sinus is to do an antrostomy on the lateral sinus wall instead of a door preparation. In this case, however, the sturdy bone support and new bottom of the sinus will be absent and one bone-inductive element for the bone graft will fail. Alternatively the prepared door can be converted into a hatch mobilized on all 4 sides and carefully lifted (peduncu-

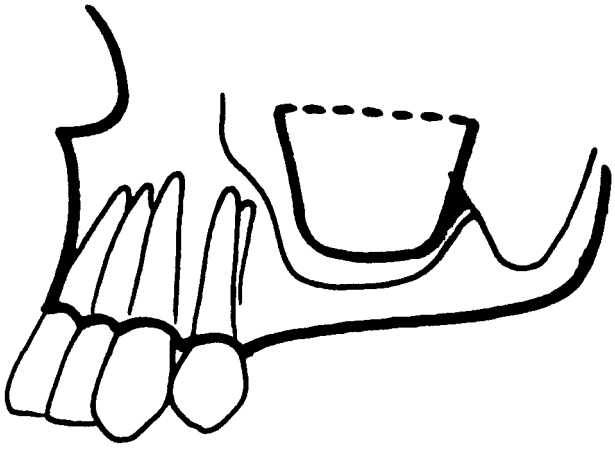


Fig. 8. If implants are only required on the ventral side of the maxillary sinus, a trap door can also only be made on the mesial side of the septum (schematic drawing).

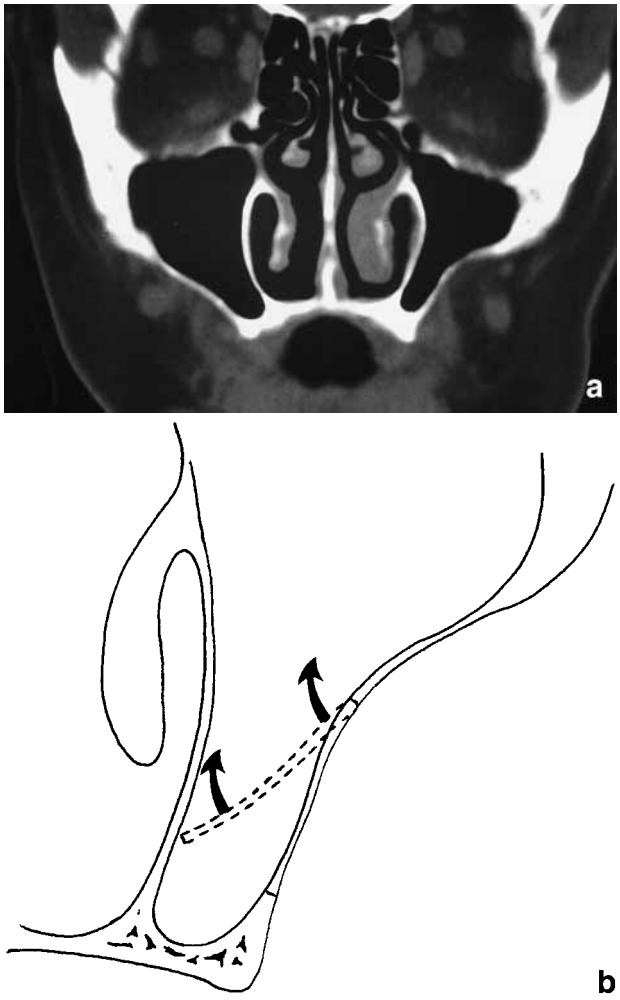


Fig. 9. (a, b) CT scan and schematic drawing of a narrow maxillary sinus bottom, luxation of the trap door into a horizontal position is not possible, due to the lack of sinus width. If the total "door" is luxated and brought into a more cranial position, this problem can sometimes be solved.

lated only by the sinus mucosa) upward to a higher position in the maxillary sinus, where the lateral sinus dimensions are larger (Fig. 9b).

The para-nasal ostium

Sinus physiology could be threatened if the function of the ciliated epithelium of the ostium is impaired. Due to the high (cranial) position of the ostium the drainage of the sinus is not likely to be blocked mechanically (Timmenga et al. 1997) (Fig. 10). Clinical evidence for changed antral mucosal function can so far not be found in the literature.

Haemorrhages

The blood supply of the maxillary sinus derives from 3 arteries; they are: the infra orbital artery, the posterior superior alveolar artery and the greater palatine artery. Haemorrhages during sinus grafting are rare, since the main arteries are not within the surgical area. However, small vessels might be damaged. If they are located in the exposed Schneiderian membrane, they should best be left to stop spontaneously or stopped by slight gauze pressure. Electro-surgery will cause necrosis of the membrane and therefore threaten the coverage of the graft.

Bone grafting, bone healing and remodelling

After bringing the trap door in a horizontal position and lifting also the sinus mucosa, the graft is applied. The amount of graft material required may vary considerably according to the level of the door axis in respect to the sinus floor. Also the sinus size will show a great variety between different persons and even between different sides in 1 person (Uchida et al. 1998; Chanavaz 1990; Mc Gowan et al. 1993).

The healing and remodelling of the graft material depends on the vascularization of the Schneiderian membrane and the buccal muco periosteal flap and the bone segments of the former sinus floor and the elevated lateral sinus wall. It seems therefore an advantage to save the bony trapdoor as described by Tatum (1986) for sinus floor elevation instead of an antral antrostomy approach, which is used by some clinicians.

One could argue to make cortical perforations in the inner aspect of the former sinus bottom to create a bone-inductive stimulant from the bone marrow. On the other hand the surgical approach is not all that easy.

Primary alveolar bone height and width

The decision to insert the implant simultaneously with the sinus lift or in a second stage procedure, is a debatable one.

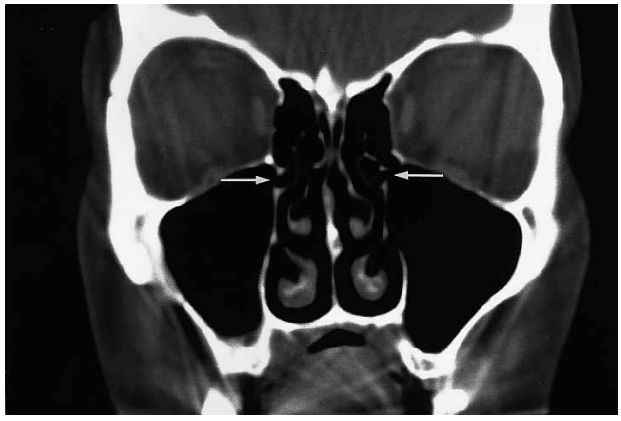


Fig. 10. CT scan showing the high position of the paranasal ostium in the middle nasal meatus (white arrows).

Essential is the primary stability of the implant. Literature recommends at least 4 mm of bone height of the original alveolar process for a one stage procedure (Misch 1987; Watzek 1996; Ulm et al. 1995). This means that if there is insufficient bone quality or quantity for a primary stable implant, the implant should be placed in a second stage procedure 4 to 6 months after sinus floor grafting.

The width of the alveolar crest is obviously also of importance for the placement of dental implants. If a minimal width of 5 mm is not available, additional augmentation is necessary.

Implant surgery

The local anatomy after sinus floor elevation is normally very favourable for implant surgery since the cranial base of a "lifted" sinus is very wide allowing for any desired implant position, length and direction. Even in bilateral cases, disparallelism is seldom seen. The "elevated" sinus floor normally allows implants with a length of 12 mm. However, in a number of cases the atrophic bone loss of the alveolar process may cause an additional problem for the suprastructures, requiring an additional local augmentation to avoid unfavorable crown-root ratios or even make implants possible. Steps in gingival level are not only aesthetically undesirable but may also present difficulties with hygienic procedures. Augmentation can be a buccal onlay technique in cases of a narrow alveolar ridge or vertical and horizontal augmentation in cases of insufficient alveolar height and width.

It must, however, be mentioned that this simultaneous augmentation and sinus floor elevation can be a difficult procedure requiring considerable amounts of bone especially when performed bilaterally. Another problem can be mobilization of sufficient soft tissue to cover tension free the grafted area.

Understanding of the anatomy is essential for successful performance of the fragile types of surgery.

Résumé

Une hauteur osseuse inadéquate dans la partie latérale du maxillaire est une contre-indication pour la chirurgie implantaire. Cette condition peut être traitée avec un épaississement interne du plancher sinusal. Cet épaississement consiste en un processus chirurgical dans lequel une porte d'entrée dans la partie latérale du maxillaire est préparée et poussée par rotation interne dans une position horizontale. Ce nouveau plancher sinusal avec la muqueuse maxillaire interne crée un espace qui peut être rempli par du matériel de greffe. Les processus d'épaississement sinusaux dépendent beaucoup de structures fragiles et de variations anatomiques. La variation des modalités anatomiques dans la forme de la partie interne du maxillaire du sinus maxillaire définit l'approche chirurgicale. Des conditions comme des circonvolutions du plancher sinusal, le *septum* sinusal, la tuméfaction passagère de la muqueuse et un sinus étroit peuvent former une contre-indication, souvent relative; pour un épaississement du plancher sinusal. Les contra-indications absolues sont les maladies du sinus maxillaire (tumeurs) et des chirurgies qui ont précédemment détruit le sinus comme les opérations de Caldwell-Luc. Le mur sinusal latéral est souvent un fin plateau osseux qui est pénétré facilement par des instruments rotatifs ou tranchants. La membrane fragile de Schneiderian joue le rôle important de contenant pour l'os greffé. Le processus chirurgical de préparer une porte d'entrée et de la luxer avec la préparation de la muqueuse sinusale peut causer une déchirure de la muqueuse. Habituellement, lorsque ces perforations ne sont pas trop importantes, elles vont se plier avec la trappe interne ou peuvent être collées avec une colle de fibrine ou peuvent être recouvertes par une membrane résorbable. Lorsque la perforation est trop importante, une greffe en bloc d'os spongieux-cortical peut être considérée. Cependant, dans la plupart des cas l'élévation du plancher sinusal devra être reportée. Les perforations peuvent également se produire vu les irrégularités dans le plancher sinusal ou même vu le contact immédiat entre les muqueuses sinusale et buccale. L'obstruction du *foramen* antro-nasal est dû à sa localisation haute; il ne représente pas une vraie complication comme ne l'est pas non plus l'apparition d'hémorragies sévères puisque la porte est dans la périphérie des vaisseaux d'alimentation. A part, ces deux aspects, un nombre de considérations anatomiques sont décrites en connection avec l'épaississement du plancher sinusal.

Zusammenfassung

Ungenügende Knochenhöhe in den lateralen Anteilen der Maxilla stellt eine Kontraindikation für die Implantatchirurgie dar. Dieser Zustand kann mit einer internen Augmentation des Sinusbodens verändert werden. Die Anhebung des Sinusbodens, früher Sinuslift genannt, besteht aus einem chirurgischen Verfahren, bei welchem ein Knochendeckel mit einem Scharnier im oberen Bereich in die laterale Sinuswand präpariert wird, den man dann nach innen in eine horizontale Position rotiert. Der neu angehobene Sinusboden zusammen mit der inneren maxillären Mukosa begrenzt einen Hohlraum, welcher mit Transplantatmaterial gefüllt werden kann. Die Verfahren zur Anhebung des Sinusbodens hängen stark von empfindlichen Strukturen und anatomischen Variationen ab. Die Vielfältigkeit der anatomischen Bedingungen in der Form der inneren Anatomie des maxillären Sinus definieren das chirurgische Vorgehen. Verhältnisse wie Konvolutionen des Sinusbodens, ein Sinusseptum, vorübergehende Schwellungen der Schleimhaut und enge Kieferhöhlen können eine (meist relative) Kontraindikation für die Anhebung des Sinusbodens darstellen. Absolute Kontraindikationen sind Erkrankungen der Kieferhöhle (Tumore) und frühere destruktive Kieferhöhlenchirurgien (wie z. B. die Caldwell-Luc-Operation). Die laterale Sinuswand ist meist eine dünne Knochenplatte, welche einfach mit rotierenden oder scharfen Instrumenten penetriert werden kann. Die empfindliche Schneidersche Membran spielt eine wichtige Rolle für die Aufnahme des Knochentransplantats. Der chirurgische Eingriff zur Präparation der Falltür und deren Luxtion zusammen mit der Präparation der Sinusmukosa kann zu Verletzungen der Kieferhöhlenschleimhaut führen. Wenn diese Perforationen nicht zu gross sind, fallen sie normalerweise zusammen, wenn die Falltür nach innen und oben gedreht wird oder sie können mit Fibrinkleber verschlossen werden oder man kann sie mit einer resorbierbaren Membran abdecken. Wenn die Perforation zu gross ist, kann ein kortiko-spongiöses Blocktransplantat in Betracht gezogen werden. Jedoch wird in den meisten Fällen die Anhebung des Sinusbodens verunmöglicht. Perforationen können auch auftreten, wenn Unregelmässigkeiten im Sinusboden

bestehen oder sogar bei unerwünschtem Kontakt der Kieferhöhlenschleimhaut mit der oralen Mukosa. Die Obstruktion des naso-antralen Foramens ist dank der hohen Lage eine selten auftretende Komplikation. Schwere Blutungen treten kaum auf, da die Falltür in der Peripherie der versorgenden Blutgefässe liegt. Neben diesen zwei Aspekten wird eine Vielzahl von anatomischen Ueberlegungen in Zusammenhang mit der Anhebung des Sinusbodens beschreiben.

Resumen

Una altura inadecuada en la parte lateral del maxilar crea una contraindicación para cirugía de implantes. Esta condición puede ser tratada con un aumento interno del suelo del seno maxilar. Esta elevación del suelo del seno, formalmente llamada elevación del seno, consiste en un procedimiento quirúrgico en el cual se prepara una puerta de bisagra en la pared lateral del seno maxilar y se rota internamente a una posición horizontal. El nuevo suelo del seno elevado, junto con la mucosa maxilar interna, crearán un espacio que puede ser rellenado con material de injerto. Los procedimientos de elevación del seno, dependen en gran medida de estructuras frágiles y variaciones anatómicas. La gran variedad de modalidades anatómicas y formas del aspecto interno del seno maxilar definen el acceso quirúrgico. Condiciones tales como convulsiones del suelo del seno, septums del seno, inflamaciones transitorias de la mucosa y senos estrechos pueden crear una contraindicación (generalmente relativa) para la elevación del suelo del seno. Contraindicaciones absolutas son las enfermedades del seno maxilar (tumores) y cirugías previas destructivas del seno (como la operación de Caldwell-Luc). La pared lateral del seno es generalmente una placa de hueso fino, que puede ser fácilmente penetrada con instrumentos rotatorios o afilados. La frágil membrana Schneideriana juega un papel importante para la contención del injerto óseo. El procedimiento quirúrgico de preparar la puerta trampa y luxarla, junto con la preparación de la mucosa del seno puede causar una rotura de la mucosa. Generalmente, cuando estas perforaciones no son demasiado grandes, se superponen al girar la puerta de trampa hacia dentro y hacia arriba, o pueden ser pegadas con un sellante de fibrina, o pueden ser cubiertas por una membrana reabsorvible. Si la perforación es demasiado grande se puede considerar la utilización del un bloque de injerto cortico-esponjoso. De todos modos, en la mayoría de los casos la elevación del suelo del seno puede ser descartada. Las perforaciones también pueden ocurrir debido a irregularidades en el suelo del seno, o incluso debidas a contacto inmediato de la mucosa del seno con la mucosa oral. La obstrucción del foramen antro-nasal debido a su alta colocación, no es una complicación frecuente, tampoco lo es la ocurrencia de hemorragias severas dado que la puerta de trampa está en la periferia de los vasos principales. Aparte de estos dos aspectos, se describen un número de consideraciones anatómicas en conexión con la elevación del seno del suelo.

要旨

上顎側方部で骨の高径が不足しているとインプラントの禁忌となるが、このような状態は上顎洞底の内部増多術によって対処することができる。かつてサイナス・リフトと呼ばれた上顎洞底挙上術は、上顎洞の側壁上方に蝶番ドアを形成し、水平位置になるまで内側へ回転させるという外科処置である。上顎洞内側粘膜と共に挙上されてできた新たな上顎洞底によって生じた空隙は、移植材料で埋めることができる。

サイナス・リフトの手順は、脆い構造と多様な解剖学的形状に依存するところが大きく、上顎洞内面の解剖学的な形状によって、外科的なアプローチが決定される。

上顎洞底の重畳、上顎洞中隔、一過性の粘膜腫脹や上顎洞の狭窄などの条件は、禁忌（通常は相対禁忌）となりうる。絶対禁忌は上顎洞の疾患（腫瘍）と、過去に行われた上顎洞の破壊度の大きい手術（Caldwell-Luc 術など）である。上顎洞側壁は通常薄い骨板で、回転インスツルメントや鋭利なインスツルメントで容易に穿孔される。脆いシュナイデル膜は移植骨を包容するのに重要な役割を果たす。トラップドアを形成し、それを脱臼させる外科的処置は、上顎洞粘膜の形成と共に、粘膜の裂傷を生じる可能性がある。そのような穿孔がそれほど大きくない場合は、通常トラップドアを上内側に回転させることによって折り重ねるか、フィブリンのシーラントで接着するか、吸収性メンブレンで被覆することで対処できる。穿孔が非常に大きい場合は、皮質骨海綿骨のブロック移植を考慮することができる。しかし大半の場合には上顎洞底挙上術は中止となるだろう。穿孔は上顎洞底の不規則な形状や、上顎洞粘膜と口腔粘膜が直接接触することによっても生じうる。上顎洞鼻腔孔の閉塞はその高い位置によるものだが、可能性の高い合併症ではない。また重篤な出血も、トラップドアは供給血管の末梢にあるので、起きる可能性は低い。これら二つの点以外にも、上顎洞底挙上術に関する数多くの解剖学的考慮点に言及する。

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