Anatomical and Surgical Findings and Complications in 100 Consecutive Maxillary Sinus Floor Elevation Procedures

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Purpose: To investigate the prevalence of anatomical and surgical findings and complications in maxillary sinus floor elevation surgery, and to describe the clinical implications.

Patients and Methods: One hundred consecutive patients scheduled for maxillary sinus floor elevation were included. The patients consisted of 36 men (36%) and 64 women (64%), with a mean age of 50 years (range, 17 to 73 years). In 18 patients, a bilateral procedure was performed. Patients were treated with a top hinge door in the lateral maxillary sinus wall, as described by Tatum (Dent Clin North Am 30:207, 1986). In bilateral cases, only the first site treated was evaluated.

Results: In most cases, an anatomical or surgical finding forced a deviation from Tatum’s standard procedure. A thin or thick lateral maxillary sinus wall was found in 78% and 4% of patients, respectively. In 6%, a strong convexity of the lateral sinus wall called for an alternative method of releasing the trapdoor. The same method was used in 4% of cases involving a narrow sinus. The sinus floor elevation procedure was hindered by septa in 48%. In regard to complications, the most common complication, a perforation of the Schneiderian membrane, occurred in 11% of patients. In 2%, visualization of the trapdoor preparation was compromised because of hemorrhages. The initial incision design, ie, slightly palatal, was responsible for a local dehiscence in 3%.

Conclusion: To avoid unnecessary surgical complications, detailed knowledge and timely identification of the anatomical structures inherent to the maxillary sinus are required.

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Maxillary sinus floor elevation with autogenous or synthetic grafting material has proven to be a reliable method that enables the insertion of endosseous implants in patients with a severely resorbed maxilla. The classical sinus floor elevation consists of a top hinge door in the lateral maxillary sinus wall, as invented by Tatum,¹ but first described by Boyne and James 1980.² The variety of anatomical modal-
ities in the shape of the inner aspect of the maxillary sinus defines the surgical approach. Van den Bergh et al described a number of anatomical considerations.

Several studies described separate anatomical findings, such as blood supply to the lateral wall, sinus shape, and sinus septa (Table 1). To the best of our knowledge of the literature, this is the first prospective study with regard to most of the anatomical findings during 100 consecutive maxillary sinus floor elevation procedures. To avoid unnecessary surgical complications, detailed knowledge and timely identification of the anatomic structures inherent to the maxillary sinus are required. The aim of the present study was to investigate the prevalence of different anatomical findings and complications in maxillary sinus floor elevation procedures, and to describe the clinical implications.

**Patients and Methods**

For this prospective study, 100 consecutive patients scheduled for maxillary sinus floor elevation were included. The patients consisted of 56 men (36%) and 64 women (64%), with a mean age of 50 years (range, 17 to 73 years). In 18 patients, a bilateral procedure was performed. All sinus floor elevations were performed by the same surgeon.

Only the first unilateral site was evaluated according to the anatomical findings and complications. All patients were treated in the Department of Oral and Maxillofacial Surgery, Free University Medical Center (Amsterdam, The Netherlands), or at the Rijnland Hospital (Leiderdorp, The Netherlands). Directly after each sinus floor elevation procedure, a standard checklist was filled out, according to predefined criteria.

Patients were treated with a sinus floor elevation technique according to Tatum, ie, an osteotomy of the lateral wall of the maxillary sinus. Patients treated with a less invasive surgical approach for maxillary sinus elevation (the transalveolar approach, as described by Summers) were excluded from this study.

In cases with a bilateral procedure, it was decided to evaluate only the first unilateral site. Patients were evaluated according to anatomical findings, with surgical relevance related to the maxillary sinus floor elevation, and to complications. Anatomical findings such as septa or perforations could only be counted once per patient. Surgical observations that called for unforeseen and additional measurements, such as membrane perforations or hemorrhages, were also counted as complications, regardless of eventual healing. In regard to complications, the follow-up period was restricted to an osseointegration time of 3 months after implant placement, and in this study, no observations were performed subsequent to implant failures.

**Results**

In most cases, an anatomical or surgical finding forced a deviation from the standard procedure of Tatum. A thin or thick lateral maxillary sinus wall was found in 78% and 4% of patients, respectively.

In these cases, the initial trapdoor preparation differed. The lateral wall was defined as thin if, after reflection of the mucoperiosteum, the Schneiderian membrane already shone dark grayish-bluish through the sinus wall. A maxillary sinus wall was considered thick if it measured at least 2.3 mm, which was similar to the diameter of the stainless steel burr.

In cases of strong convexity of the lateral maxillary sinus wall, the inward and upward rotation of the fractured door can easily lead to a mucosa tear at the cranially placed trapdoor osteotomy. If the authors observed this risk factor when releasing the trapdoor, the lateral wall was scored as “convex.”

In 6% of patients, a strong convexity of the lateral sinus wall called for an alternative method of releasing the trapdoor. The same method was used in 4% of patients with a narrow sinus. The prepared door was converted into a hatch, mobilized on four sides and carefully lifted upward. A wide sinus, observed in 7% of patients, may lead to underfilling, so that the estimated bone height appears not to be the true bone height, leading to perforation of the implant into the sinus. The authors observed that the method of Tatum was hindered by septa in 48% of cases. Inversion of the bone plate was complicated by these septa. The septa were left intact, and the contour of the sinus was followed by making a W-shaped trapdoor preparation or 2 separated doors. In 5 cases, this alternative procedure resulted in a membrane perforation at the location of the septa. The perforations were then covered with a resorbable barrier membrane, and because of this proper surgical measurement, the perforations had no negative effect on the eventual outcomes of the procedures. In all 5 cases, the healing was not compromised. The prevalences of different anatomical findings are listed in Table 2. We found no significant differences with regard to gender or age.

With regard to complications, the most common complication, perforation of the Schneiderian membrane, occurred in 11% of patients. As already mentioned, 5 perforations occurred in relation to septa, and 4 additional perforations were the result of extension mesially when releasing the Schneiderian membrane, because of poor visibility. The direct connection between the sinus and oral mucosa was the cause in one case of a membrane perforation, occurring directly after
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<td>Prevalence 31.7% Most septa (73.3%) in bicuspid region</td>
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<td>Krennmair et al, 1997</td>
<td>65</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Prevalence 24%, prevalence significantly greater in edentulous maxillas; most in middle region, at mean heights of 7.59, 5.89, and 3.54 mm in lateral, middle, and medial areas, respectively</td>
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<td>Kim et al, 2006</td>
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<td>Prevalence and morphology of septa</td>
<td>CT scan</td>
<td>Prevalence 26.6%; 50.8% in the middle region; mean heights of 1.65, 2.44, and 5.46 mm in lateral, middle, and medial areas, respectively</td>
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Abbreviation: CT, Computed tomography.

reflection of the mucoperiosteum. Fortunately, this perforation remained relatively small. In 1 perforation, no anatomical explanation could be given. The perforations were all covered with a barrier membrane, and the eventual healing was uneventful.

In 2% of patients, visualization of the trapdoor preparation was compromised because of hemorrhages. In our study group, only 1 patient developed postoperative maxillary sinusitis. This patient had no preoperative risk factors, such as sinus pathology in the past, nor a perioperative perforation of the Schneiderian membrane.

The initial incision design, ie, slightly palatal, was responsible for local dehiscence in 3% of patients. In 2 patients with local wound dehiscence, graft infection was observed along with a purulent discharge, and was treated by antibiotic therapy and local debridement. The dehiscence healed by secondary granulation.

At the time of implantation in 1 patient, the sinus cavity was reached after drilling to a depth of 8 mm, indicating a partial loss of the graft. This patient showed no signs of infection, and in particular, no maxillary sinusitis in the time of healing after elevation. As an alternative explanation for this finding, the Schneiderian membrane was probably not elevated as far as the medial wall, resulting in underfilling with graft material of the created space.

### Table 2. ANATOMIC FINDINGS IN 100 CONSECUTIVE MAXILLARY SINUS FLOOR ELEVATION PROCEDURES

<table>
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<th>Anatomical Feature</th>
<th>Percentage</th>
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<tr>
<td>Thin lateral sinus wall</td>
<td>78%</td>
</tr>
<tr>
<td>Thick lateral sinus wall</td>
<td>4%</td>
</tr>
<tr>
<td>Convex lateral sinus wall</td>
<td>6%</td>
</tr>
<tr>
<td>Connection of Schneiderian membrane and</td>
<td></td>
</tr>
<tr>
<td>oral mucosa</td>
<td>2%</td>
</tr>
<tr>
<td>Narrow sinus</td>
<td>4%</td>
</tr>
<tr>
<td>Wide sinus</td>
<td>7%</td>
</tr>
<tr>
<td>Sinus septa</td>
<td>48%</td>
</tr>
<tr>
<td>Longitudinal sinus septum</td>
<td>2%</td>
</tr>
<tr>
<td>Root-shape configurations</td>
<td>4%</td>
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</tbody>
</table>


In 4 different patients, 4 implants were lost during the osseointegration period of 3 months. In a total of 243 implants placed, this was equivalent to 1.6%. We could not find any relationship to the remaining crest

### Table 3. COMPLICATIONS IN 100 CONSECUTIVE MAXILLARY SINUS FLOOR ELEVATION PROCEDURES

<table>
<thead>
<tr>
<th>Complication</th>
<th>Percentage</th>
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<tr>
<td>Perforation of Schneiderian membrane</td>
<td>11%</td>
</tr>
<tr>
<td>Perioperative hemorrhages</td>
<td>2%</td>
</tr>
<tr>
<td>Postoperative hemorrhages</td>
<td>0%</td>
</tr>
<tr>
<td>Postoperative maxillary sinusitis</td>
<td>1%</td>
</tr>
<tr>
<td>Local wound dehiscences</td>
<td>3%</td>
</tr>
<tr>
<td>Graft infections</td>
<td>2%</td>
</tr>
<tr>
<td>Loss of graft</td>
<td>1%</td>
</tr>
<tr>
<td>Loss of implants</td>
<td>4%</td>
</tr>
</tbody>
</table>


**FIGURE 1.** Pneumatization of maxillary sinus after tooth loss, probably caused by reinforcement of osteoclastic activity of the Schneiderian membrane.


**FIGURE 2.** A, In cases of a thin maxillary sinus wall, after reflection of the mucoperiosteum, the Schneiderian membrane already shines a dark grayish-blush through the lateral sinus wall. B, The lateral door preparation is made directly with a round diamond burr, without use of a stainless-steel burr.

of the native maxilla. In none of these patients did any other complication, as mentioned in this study, occur. Complications are listed in Table 3.

Discussion

ANATOMICAL FINDINGS

Thin or Thick Lateral Maxillary Sinus Wall

After loss of the maxillary teeth and reduction of the masticatory forces acting on the maxilla, the sinus wall gradually becomes thinner as a result of the increased size (or volume) by pneumatization of the maxillary sinus. Increased antral pneumatization starting after tooth loss seems to result especially from the basal bone loss caused by a reinforcement of osteoclastic activity of the Schneiderian membrane (Fig 1). In extreme cases, only a paper-thin lamella of bone separates the maxillary sinus from the oral cavity after long-term edentulism.

In cases of a very thin maxillary sinus wall, careful reflection of the mucoperiosteum is recommended, while the Schneiderian membrane already shines dark grayish-bluish through the sinus wall (Fig 2A). Reflection of the mucoperiosteum with sharp instruments can already cause a perforation of the sinus wall and the Schneiderian membrane. In the present study, after reflection of the mucoperiosteum, this transparent, dark aspect was observed in 78% of cases. Because of the risk of perforation of the Schneiderian membrane during lateral door preparation in these cases, it is advised not to begin the lateral door preparation with a round stainless-steel burr, but to use a round diamond burr directly, and thus reduce the risk of a membrane perforation (Fig 2B).

If the lateral wall consists of thick bone, the whole lateral wall should be thinned out (Fig 3). When the stainless-steel burr, with a diameter of 2.3 mm, totally filled the lateral osteotomy (Fig 3), this alternative procedure was followed. Otherwise, it would be extremely difficult to mobilize the Schneiderian membrane from the inner aspect of the bony sinus, because instruments cannot reach this tissue due to a deep cleft-like approach.

Convex Lateral Sinus Wall

In 6% of the patient population in this study, the convexity of the lateral maxillary sinus wall called for
an alternative trapdoor luxation (Fig 4). In normal cases, the procedure consists of the preparation of a top hinge door in the lateral maxillary sinus wall. In cases of a convex lateral sinus wall, the inward and upward rotation of the fractured door can easily lead to a mucosa tear at the cranially placed trapdoor osteotomy. Therefore, in cases of profound convexity of the maxillary sinus wall, an alternative approach is advisable, in which the prepared door is converted to a hatch, mobilized on 4 sides and carefully lifted upward to a horizontal position in the maxillary sinus (Figs 5A,B). Alternatively, the trapdoor preparation can be placed medial to the convexity of the lateral sinus wall, tunneling farther in a distal direction, although this creates a higher risk of perforating the Schneiderian membrane.

**Connection Between the Schneiderian Membrane and Oral Mucosa**

When the alveolar bone is totally absent in some places (because of resorption or traumatic bone loss after tooth extraction, eg, sinus perforation), the sinus mucosa may be in immediate contact with the oral mucosa. This is a very difficult condition, in which the Schneiderian membrane cannot usually be kept intact (Fig 6). It may lead to large perforations at very difficult sites, making any further preparation impossible.3

Previous sinus surgery (eg, a Caldwell-Luc procedure) sometimes constitutes a contraindication for maxillary sinus floor elevation, because anatomical disconfigurations do not allow for the preparation of intact, healthy mucosal tissue (Fig 7). In cases of previous sinus operations, a preoperative computed tomography (CT) scan can be helpful in demonstrating this condition.

**The Narrow and Wide Sinus**

Until the eruption of permanent teeth, the sinus cavities are insignificant in size. The development of the maxillary sinus is a dynamic, active procedure when 2 conditions apply: a slight, positive intrasinus pressure, and good physiology of the mucosal sinus
membrane, which should be supple and easy to expand, as well as capable of bone resorption and thinning the sinus wall. This is in line with the presence of osteoclasts found in the maxillary sinus, as the osteoclastic activity is jointly responsible for the resorption and thinning of the sinus wall.15

There is a wide range in sizes and shapes of maxillary sinuses. In a study by Uchida et al,7 maxillary sinus volumes were measured using CT images of 38 sinuses and a 3-dimensional reconstruction system. The average total maxillary sinus volume was 13.6 ± 6.4 cc. The minimum maxillary sinus volume was 3.5 cc, and the maximum was 31.8 cc.7

The size of the sinus, and especially the angulation between the medial and lateral walls of the maxillary sinus, seemed to exert a large influence on the incidence of membrane perforation during maxillary sinus floor elevation. The sharper angles observed at the inner walls of the sinus at the sites of the second upper bicuspid presents a higher risk of perforation. The angulation will influence the feasibility of the sinus floor during elevation. Group 1 of Cho et al17 consisted of specimens with an angle of 30° or less, group 2 consisted of specimens with angles between 31° and 60°, and group 3 consisted of specimens with angles of 61° or greater. The different groups demonstrated significant correlation with the observed perforations. The perforation rates were 37.5% (group 1), 28.6% (group 2), and 0% (group 3).17 The sites of the first upper molars are the least difficult areas.8,17 In the present study, 4 patients had a narrow maxillary sinus that required an alternative surgical approach.

The most reliable method in terms of being preoperatively informed about the size and shape of the maxillary sinus is a CT scan. With a preoperative CT scan, a narrow maxillary sinus can be anticipated. One way to circumvent the problem of a narrow sinus is by performing an antrostomy in the lateral wall instead of a door preparation. In this situation, however, the sturdy bone support and a new floor of the sinus will be absent, and the 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 (pedunculated only to the sinus mucosa) upward to a higher position in the maxillary sinus, where the lateral sinus dimensions are larger (Figs 8A,B).3 In such cases, it is advised to make an all-around preparation, to minimize the risk of perforating the Schneiderian membrane. In all 4 cases in the present study, this alternative surgical method was chosen.

In cases of a wide maxillary sinus, it is recommended to make a large door preparation, and lift the door to a high position cranially. However, without a preoperative CT scan, the surgeon is mostly uninformed about this possibility. Especially in a wide sinus, there is a risk of underfilling the recipient site with grafting material if elevation of the membrane has not been continued as far as the medial wall. This underfilling might lead to later complications, if the estimated bone height appears not to be the true bone height during implant surgery, leading to perforation of the implant into the sinus (Fig 9).

**Maxillary Sinus Septa**

The presence of septa increases the risk of sinus membrane perforation during sinus floor elevation procedures. This anatomic variation was first described by Underwood in 1910,11 and therefore is sometimes referred to as Underwood’s septa. In an anatomical study, Underwood11 found 30 septa in 90
maxillary sinuses, showing a prevalence of 33%. The incidence of antral septa varies between 16% and 58%. The prevalence of septa was significantly greater in atrophic edentulous regions than in dentate regions. Krennmair et al hypothesized that if teeth are gradually lost, atrophy begins at different times in different regions. They classified septa into primary (which arise from the development of the maxilla) and secondary (which arise from irregular pneumatization of the maxillary sinus floor after tooth loss). Because maxillary molars are often lost earlier than premolars, the different phases of maxillary sinus pneumatization result in the formation of antral septa. Hence Krennmair et al stated that 70% of antral septa were found in the anterior region. Stover criticized these conclusions, stating a greater prevalence of septa in the posterior segments results from remnant interradicular bone between adjacent maxillary molars.

The prevalence of primary septa was found to be significantly higher. The average height of medial insertions was greater than that of the lateral insertions. In other words, septal height increased from lateral to medial insertions. This can complicate the inversion of the bone plate or lateral door.

Panoramic radiography has less sensitivity and specificity than CT scanning for the detection of sinus septa (Fig 10). Krennmair et al reported a false-positive or negative diagnosis regarding the presence of antral septa in 21.3% of cases.

In instances where septa are encountered on the sinus floor, Boyne and James recommended cutting them with a narrow chisel and removing them with a hemostat, so that the bone graft can be placed over the entire antral floor. Tidwell et al subdivided the bony wall into an anterior and a posterior part of the hinge door, and inverted both trapdoors.

The present authors suggest following the contour of the sinus floor by making a W-shaped preparation in smaller septa, or 2 separate doors (Figs 11A-C).

Another option would involve an antrostomy approach.

**Longitudinal Septum**

Elevation of the Schneiderian membrane is a time-consuming procedure. In most cases, upon reaching the floor of the maxillary sinus, visibility improves, accelerating the procedure.

However, in 2 cases, a horizontal and longitudinal rim was encountered, in mesiodistal or sagittal direction instead of the usual transversal septa, halfway between the sinus floor and medial wall. Because of this unexpected rim, there was a risk of perforating the membrane while shooting out with an elevation instrument. In contrast to a root-shape configuration, this rim is located along the full length of the sinus floor (Fig 12).

**Root-Shape Configurations**

Root-shape configurations, found in 4 patients of the study group, can be expected when teeth have been extracted recently (Fig 13). In 2 of 4 cases, the separation of the Schneiderian membrane caused a perforation at this particular location. If possible, sinus floor elevation should be delayed for at least 6 months after extraction of the teeth when root-tip expressions in the maxillary sinus are clearly visible on a panoramic radiograph.
SURGICAL FINDINGS

Maxillary Sinus-Membrane Perforation

Sinus-membrane perforation is the most prevalent complication of sinus floor elevation procedures (10% to 60%). Anatomic as well as technical factors have been implicated in membrane perforation. The integrity of the sinus membrane is essential in maintaining the healthy, normal function of the maxillary sinus. The mucociliary apparatus protects the sinus against infection by removing organisms trapped in mucus through the ostium. The membrane also acts as a biologic barrier, and an increased chance of infection results if the biologic barrier (the membrane) perforates because a greater number of bacteria can invade the graft. Possible causes of perforation include tearing of the membrane during window osteotomy or with an infracture of the bony window, elevation of the membrane, the presence of septa, and overfilling with graft material. Documented risk factors include irregularities of the sinus floor, root formations, previous sinus surgery (scar tissue), and a lower height of the residual alveolar crest. Ardekian et al reported that in residual ridges of 3 mm, a perforation of the sinus membrane occurred in 85% of cases, whereas in residual ridges of 6 mm, a perforation was observed in 25% of cases. In most studies, no statistical difference was observed in the success rates of implants placed with sinus bone grafting in patients whose Schneiderian membrane was perforated versus those patients in whom the membrane remained intact. However, a histomorphometric study according to a split-mouth design, and with regard to sinus perforation during surgery, suggested that repairing the perforated site of the sinus membrane with a resorbable collagen membrane may result in reduced bone formation and a reduced implant survival rate. When the perforation is small (<2 mm) and located in an area where the elevated membrane is folded together, it will heal by itself. However, even with a small perforation or a very thin Schneiderian membrane, the present authors prefer to use a resorbable collagen membrane to cover and support the weak spot. Larger perforations are almost always managed by the use of a barrier membrane. In the present study, a freeze-dried human lamellar bone sheet (Lambone; Pacific Coast Tissue Bank, Los Angeles, CA) was applied after it was shaped and cut for proper fit. The large size of a sheet is chosen to provide a customized fit within the bony sinus walls. The corners are rounded off, and the

FIGURE 11. A, B, The suspected sinus septa on the antral floor is left in situ and visualized by making 2 trapdoors. C, When elevated, the Schneiderian membrane is at risk of being torn, particularly at the cranial edge of the septum. A membrane is placed to cover the perforation.

membrane is rehydrated before placement in the maxillary sinus (Figs 14A-C). Other treatment options include the use of an autogenous block graft instead of a cancellous graft, suturing, or abandonment of the surgical procedure.

With regard to the prevention of a perforation, the present authors make some additional small holes in the suction device, to diminish the suction power. Furthermore, the prevention of direct contact of the suction device with the Schneiderian membrane can be achieved by placing an elevation instrument between them.

Hemorrhages

Knowledge of the blood supply to the maxillary sinus is of importance in sinus floor elevation procedures, in terms of both vascularization of the sinus graft and the location of that blood supply relative to the position of the required lateral osteotomy. The surgical severance of one of the vessels may not be a life-threatening event, but may complicate the procedure, because of the more difficult visualization of the Schneiderian membrane. Although the maxilla is very densely vascularized in young and dentate populations, the blood supply to the bone is permanently reduced with age and progressing atrophy, and the number of vessels and their diameters decrease, while tortuosity increases. Three arteries supply the maxillary sinus: the posterior superior alveolar, infraorbital, and posterior lateral nasal arteries, all of which are ultimate branches of the maxillary artery. The posterior superior alveolar artery supplies the lining of the antrum, posterior teeth, and superficial branches to supply the maxillary gingivae and mucoperiosteum. The dental branch of this artery courses intraosseously, halfway up the lateral sinus wall, and forms a horizontal anastomosis with the infraorbital artery. The infraorbital artery runs through the infraorbital canal and, before emerging from the infraorbital foramen, it gives off 1 or 2 branches that course caudally along the anterior antral wall. An intraosseous anastomosis was found in all specimens in an anatomic study of cadavers, and was visualized in 53% of the CT scans in a radiographic study. In the 2 studies, the mean distance of the intraosseous anastomosis to the alveolar crest was 19 mm and 16 mm, respectively. If the goal is to place implants 12 mm in length, the superior osteotomy cut will be made approximately 14 mm from the alveolar crest. According to CT scan data, 80% of the arteries are located more than 15 mm from the crest, and are at no risk regarding a potential surgical complication. But in cases where the alveolar ridge has been severely resorbed, the vessel will be closer to the crest than the reported average.

In the present study, a hemorrhage during preparation of the trapdoor was encountered in 2 patients (Fig 15). In both patients, it reduced the visualization and hindered the surgical procedure, but had no negative influence on the treatment outcome. Bleeding can usually be controlled by pressure with a mist gauze pad.
Electrocautery should be avoided, because there is a risk of perforating the Schneiderian membrane.

Solar et al\(^5\) reported on an extraosseous anastomosis of the same arteries mentioned in 44\% of the cases. It is located at a mean distance of 23 mm from the alveolar ridge. The anastomosis is in close contact with the bone. Vertical incisions should therefore extend cranially as little as possible, and the periosteum should be prepared with the utmost care, to minimize vascular trauma.

In addition to anastomosis in the lateral wall of the maxillary sinus, a third artery can be a potential risk for severing an intraosseously located artery during a vigorous curettage for sinus elevation in the posterior medial wall of the sinus. The posterior lateral nasal artery can be found close to, or within, the medial wall of the sinus, and because of the proximity of the sphenopalatine artery, it may produce a problematic flow of blood if severed.\(^5\)

Another form of perioperative or postoperative bleeding that can occur is an epistaxis, indicating a membrane perforation.

**Postoperative Maxillary Sinusitis**

The rather low complication rate of 1\% for postoperative maxillary sinusitis is somewhat surprising. A transient or persisting effect on the ciliated antral mucosa would be expected as a result of maxillary sinus floor elevation raising the Schneiderian membrane. When the maxillary sinus is filled with blood, a delay of maxillary sinus clearance is thought to occur, because it is generally assumed that a reduction of the patency of the osteomeatal unit creates a potential

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risk for the development of maxillary sinusitis. However, the results of a human study by Timmenga et al.\(^3\) in regard to the effects of maxillary sinus floor elevation on maxillary sinus physiology suggest that the maxillary sinus mucosa is capable of adapting adequately to the changes induced by elevation procedures, especially in cases of noncompromised sinus clearance.

**Local Wound Dehiscences**

In 3 cases, a local wound dehiscence occurred in the first 2 weeks postoperatively. This was probably because, in the first treated patients, the incision on the top of the crest was made slightly palatal (Figs 16A,B). The main course of the supplying arteries is from posterior to anterior, the main vessels run parallel to the alveolar ridge in the vestibulum, and the crestal area of the edentulous alveolar ridge is covered by an avascular zone with no anastomoses crossing the alveolar ridge. This argues in favor of midline incisions on the alveolar ridge and avoidance of incisions crossing the alveolar ridge, hence eliminating the risk of cutting anastomoses or cutting out avascular areas of the mucosa.\(^3\)

The relatively low rate of complications in this patient group was probably attributable to the performance of all procedures by 1 skilled surgeon. In maxillary sinus floor elevation procedures, it is essential to have good knowledge of the different anatomical and surgical findings, to minimize perioperative and postoperative complications. The results of this study contribute to a better understanding of this preimplant procedure.

**References**