THE PREVALENCE, COMPLICATIONS AND MANAGEMENT OF MAXILLARY SINUS SEPTA

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ABSTRACT

Objectives: Historically, maxillary posterior teeth have demonstrated a high incidence of periodontal bone loss and consequently tooth loss. The result is often a loss of vertical height in the posterior maxilla due to sinus pneumatization. This study was carried out to evaluate the incidence and clinical implications of maxillary sinus septa to sinus augmentation procedures.

Methods & Materials: A total of 100 patient CBCT scans were examined, of whom 50 were male and 50 females. Patients in this study were either edentulous or partially edentulous and were referred to the Misch International Implant institute (MIII) specifically for possible sinus surgery related to future implant placement. For the purposes of this study, a minimum height of 3mm was used to classify bony lamellae as septa.

Results: We found a total of 37 septa in 200 sinuses (18.5%). This corresponds to 29% of the subjects. We can break down the results based on sex, finding the incidence of 30% in females and 28% in males. The majority of the subjects with septa were in the 60+ age bracket. Additionally, all of the septa in our study were oriented in a bucco-palatal direction.

Conclusions: Detailed information about the sinus anatomy / pathology and specifically the presence of septa (their location and morphology) with the aid of CT
scan analysis may provide crucial information to reduce unnecessary complications associated with maxillary sinus surgery i.e. sinus floor elevation.
ACKNOWLEDGEMENTS

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CHAPTER 1
INTRODUCTION

The maxillary sinus lift procedure has for some time been an excellent therapy to address a vertically deficient posterior maxilla. However, surgical complications during sinus lift surgeries include but are not limited to infection and loss of the bone graft, sequestration, cyst formation and most commonly membrane perforation. By definition a septum is “a wall or partition dividing a body space or cavity” (medical-dictionary.com). This structure can be cartilaginous, membranous or osseous in nature. The presence of septa in the floor of the sinus can complicate sinus related procedures, complicating not only the creation of a window in the antral wall, but an increased risk of tearing the Schneiderian membrane during elevation (Ulm., 1995, Katranji et al., 2008). In order to better understand septal involvement, we ought to have a basic review of the maxillary sinus.

The body of the maxilla is occupied by a hollow pyramidal shaped cavity referred to as the maxillary sinus or antrum, which is lined by a pseudostratified columnar epithelium often referred to as the Schneiderian membrane (Garg., 1999). The maxilla itself is comprised of a pair of bones that extend horizontally (palatine process) and meet at the midline intermaxillary suture. Additionally, the maxilla has three other processes: the alveolar process, which contains the sockets for the upper teeth; the zygomatic process, which extends laterally from approximately the
first molar region and determines the depth of the vestibular aspect; and the frontal process, which ascends and fuses with the frontal bone. The inferior portion of the maxillary sinus is often separated from the apices and roots of the maxillary posterior teeth by a thin bony lamellae (Ulm et al., 1995)

Figure 1. Anatomy of the human maxilla and zygoma

However, the challenge faced by surgeons pertains to the devastating and irreversible resorptive process observed in cases of prolonged partial / complete edentulism. The atrophic maxilla not only presents concerns such as poor bone quality, but also a loss of vertical bone volume partially due to progressive sinus
pneumatization that varies from one individual to another, leaving inadequate bone for the placement of endosseous implants (Katranji et al., 2008). Careful examination of the maxilla and the maxillary sinus is of the utmost importance when planning for dental implants in this specific region.

Sinus elevation techniques to augment a deficient maxilla have long been successful in implant therapy and allowed for a means to anchor implants in a previously untreatable area. The literature has shown that implants placed in sinus grafted sites have similar long-term survival rates to those placed in native bone. The technique for a lateral wall sinus elevation was first described by Tatum in 1977 and the published by Boyne in 1980. This technique involves creating an osteotomy / window in the lateral antral wall, allowing direct access to the Schneiderian membrane to be carefully elevated from the sinus floor. Subsequent placement of either autogenous bone graft or bone substitutes leads to augmentation of a future implant site (Smiler, 1992). If there is an adequate amount of residual bone height, for primary stability, implants may be placed simultaneously, if not, the graft is allowed to mature followed by delayed implant placement (Kan et al., 2002, Peleg et al., 1998).

Often referred to as Underwood septa, based on the pioneering work of Underwood in 1910 who examined human skulls for their prevalence and found a 33% prevalence in 90 maxillary sinuses. Several theories exist with regards to the formation of septa. Garg hypothesized that septa may be the result of different phases of maxillary sinus pneumatization of the empty alveolar process following
tooth loss / extraction (Garg, 1999). On the other hand, Misch suggested that septa might be “bone reinforcement pillars from parafunction when the teeth were present” (Misch, 1993). Neivert in 1930 proposed that septa were derived from fingerlike projections produced by the embryologic out-pouching of the ethmoid infundibulum, where the contiguous walls did not resorb. Krennmair further subdivided septa into primary septa as those arising from the development of the maxilla and secondary septa arising due to irregular sinus pneumatization (Krennmair, 1997).

Several studies have looked into the prevalence of the septa as well as their location within the sinus. Ulm et al. conducted a cadaver study of 41 edentulous maxilllas and observed that 31.7% had septa present. Additionally, they found 26.8% had a single septum, while 4.9% had 2 septa. Regarding location, Ulm found that 93.2% were in the premolar and first molar region, with the overwhelming majority localized to the premolar sites (Ulm et al., 1995). These results also appear to support the findings of Garg. All of the septa were oriented in a buccal-lingual direction. Kim et al., in 2006, looked specifically at a Korean population, and noted an overall septal prevalence of 26.5%, with a slightly higher incidence in males versus females (32% and 18.29% respectively). Their investigation of location also supports the above-mentioned studies. Several of the previous studies that have investigated the septum have included a patient population including both dentate and edentulous subjects. Based on the concept of secondary septa, the aim of this article is to investigate the incidence of sinus septa in a population of patients.
referred to the Misch International Implant Institute (MIII) specifically for restoration of the posterior maxilla with dental implants.
CHAPTER 2

METHODS & MATERIALS

To date, a total of 100 patient CBCT scans have been examined, of whom 50 were male (ages 17-91) and 50 were female (ages 15-74) patients, enabling us to further investigate septum incidence with regards to sex. Patients in this study were either edentulous or partially edentulous and were referred to the Misch International Implant institute (MIII) specifically for implant related rehabilitation and their CT scans taken during the treatment-planning phase. The scans were selected at random (from a total of 500 scans taken between 2007 and 2011) and evaluated using the “SimPlant Pro” treatment planning software (Materialise, Glen Burnie, MD). Only those bone lamellae that showed a height of at least 3mm would be classified as septa. Thus, enabling us to exclude uneven portions of the alveolar recess, which can be observed in any sinus floor. Additionally, only those septa that originated from the sinus floor were included in the study.
CHAPTER 3
RESULTS

Of the total number of subjects included in this study, sinus floors with at least one septum were observed were observed in 29 of the 100 subjects, for an overall incidence of 29%. If we take a look at the total number of sinuses examined (N=200), a total of 37 sinuses exhibited septa (18.5%). Additionally, only 1% of the patients had more than 1 septum in a sinus. If we breakdown the results further based upon sex:

Table 1

The Prevalence of sinus septa based on sex

<table>
<thead>
<tr>
<th>SEX</th>
<th>% of patients w/ septa</th>
<th>% of sinuses w/ septa</th>
</tr>
</thead>
<tbody>
<tr>
<td>MALE</td>
<td>28% (15/50)</td>
<td>21% (21/100)</td>
</tr>
<tr>
<td>FEMALE</td>
<td>30% (15/50)</td>
<td>16% (16/100)</td>
</tr>
</tbody>
</table>
Figure 2. Prevalence among the entire patient pool

Figure 3. Prevalence of septa among male and female patients
a. Incidence among female patients
Figure 3 b. Incidence among male patients

Figure 4. – Distribution of septa with regards to age
CHAPTER 4
DISCUSSION

The internal structures of the maxillary sinus have long been investigated. But it was not until sinus augmentation via the lateral window (SALW) approach was introduced that they gained further attention, such as the septum, as it pertains to our study. A summary of articles related to the maxillary sinus septum is summarized in the table below taken from Chan et al. 2011.

Table 2.

Summary of articles investigating maxillary sinus septa

<table>
<thead>
<tr>
<th>Study</th>
<th>N [Subjects]</th>
<th>Methods</th>
<th>Dental Status</th>
<th>Septum Definition</th>
<th>Prevalence/Sinus [%]</th>
<th>Location [%]</th>
<th>Direction</th>
<th>Size [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Um et al</td>
<td>41</td>
<td>Cadavers</td>
<td>Edentulous</td>
<td>&gt;2.5 mm</td>
<td>31.7</td>
<td>Premolars: 13.3; 1st molar: 19.2; 2nd molar: 6.6</td>
<td>NA</td>
<td>7.9</td>
</tr>
<tr>
<td>Kiem et al</td>
<td>165</td>
<td>Clinical examination and CT</td>
<td>Both</td>
<td>NA</td>
<td>Clinical: 27.7; CT: 16; dentate: 13.2; edentulous: 25.8</td>
<td>NA</td>
<td>6.6 (caudal); 6.1 (CT)</td>
<td></td>
</tr>
<tr>
<td>Kim et al</td>
<td>102</td>
<td>CT</td>
<td>Edentulous</td>
<td>&gt;2.5 mm</td>
<td>Total: 26.5; edentulous: 31.8; dentate: 22.8</td>
<td>NA</td>
<td>1.63 (lateral); 3.55 (middle); 5.46 (medial)</td>
<td></td>
</tr>
<tr>
<td>Shindler et al</td>
<td>1024</td>
<td>Panoramic radiographs</td>
<td>Edentulous</td>
<td>NA</td>
<td>21.6</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Neugbauer et al</td>
<td>1029</td>
<td>CBCT</td>
<td>Both</td>
<td>NA</td>
<td>33.2</td>
<td>1st molar: 31.6; 2nd molar: 17.6; 3rd molar: 17.1</td>
<td>Medial-lateral: 74.7; 7.3 (medial-lateral); anterior-posterior: 25.3</td>
<td></td>
</tr>
<tr>
<td>Rosano et al</td>
<td>30</td>
<td>Cadavers</td>
<td>Edentulous</td>
<td>&gt;3 mm</td>
<td>33.3</td>
<td>2nd premolar-1st molar: 25.4; 1st and 2nd molar: 50.8; 3rd molar: 23.7</td>
<td>NA</td>
<td>7.6</td>
</tr>
<tr>
<td>Park et al</td>
<td>200</td>
<td>CT</td>
<td>Edentulous</td>
<td>NA</td>
<td>27.7</td>
<td>1st and 2nd premolar: 22.3; 1st and 2nd molar: 40.5; 3rd molar: 31.5</td>
<td>NA</td>
<td>8.72</td>
</tr>
</tbody>
</table>


The prevalence of the septum from the above-mentioned studies varies from 16-33.3% depending on several factors such as the method of identification, patient’s ethnic background and dentate status. In our study all of the septa were
found to be oriented in a buccopalatal direction, however there are reports of septa in a saggital direction as well (Park et al., 2011). The results of our study show the prevalence of maxillary sinus septa was similar to that reported in previous studies. Overall, 29 of the 100 patients had maxillary sinus septa (29%), while 37 were observed among the 200 sinuses (18.5%). If we recall, Underwood's cadaver study reported 30 septa among 90 sinuses in 45 skulls (33%). Similar results were reported by Ulm et al (1995) who reported 15 septa amongst 82 sinuses (18.3%) and 13 septa in 41 skulls (31.7%). Krennmair et al (1997) noted 21 septa in 100 patients (21%) and 32 septa among the 200 sinuses (16%). A follow up study by the same group (Krennmair et al., 1999) noted differences incidence based on CT scan analyses versus anatomic evaluation, results being 28.5% and 36.5% respectively. Additionally, Velasquez-Plata et al (2002) reported a total of 75 septa among 312 maxillary sinuses (24%). In order to understand the importance of the results of our study, we must have an understanding of the SALW technique and thus how the septum’s presence may impact our surgical approach.

The two approaches for sinus floor elevation (SFE) that exist are as follows; a trans crestal approach or the SALW approach. The amount of residual bone width, and more importantly, height to the sinus floor are crucial to deciding the correct technique for the clinician. Though the trans crestal approach is a less invasive method involving sinus elevation via the implant osteotomy created at the crest, one is limited to the amount the sinus membrane can be lifted and grafted, generally this amount is accepted to be in the range of 2-4mm and thus this requires a greater
amount of native bone for primary stability. Several classifications exist to aid the clinician in the decision making process regarding which SFE technique to employ and when (see table 3, Misch Chapter 14)

Table 3

*Misch Subantral Augmentation classification system*

<table>
<thead>
<tr>
<th>TIME TREATMENT</th>
<th>HEIGHT (mm)</th>
<th>PROCEDURE</th>
<th>HEALING TIME (MONTHS): GRAFT</th>
<th>HEALING TIME (MONTHS): IMPLANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA-1*</td>
<td>&gt;12</td>
<td>Division A root form placement</td>
<td>—</td>
<td>4-6</td>
</tr>
<tr>
<td>SA-2</td>
<td>10-12</td>
<td>Sinus lift; simultaneous Division A root form placement</td>
<td>—</td>
<td>6-8</td>
</tr>
<tr>
<td>SA-3</td>
<td>5-10</td>
<td>Lateral wall approach sinus graft; delayed Division A root form placement</td>
<td>2-4</td>
<td>4-6‡</td>
</tr>
<tr>
<td>SA-4</td>
<td>&lt;5</td>
<td>Lateral wall approach sinus graft; delayed Division A root form placement</td>
<td>6-10</td>
<td>4-10†</td>
</tr>
</tbody>
</table>

* Subantral augmentation option.
† Evaluate at implant insertion.

As mentioned earlier, the sinus elevation technique was first described in 1977 by Tatum and has since been modified. The SALW technique involves creating an osteotomy / window in the lateral antral wall (see Figure 5 below). The bone within the window may be separated from the membrane entirely and used as part of the bone graft or simply kept in place attached to the membrane to form the new floor of the sinus. The membrane is then carefully elevated using a series of curettes and subsequently augmented (Smiler, 1992)
Figure 5

a. Flap design
b. Flap elevation
c. Separation of bony window
d. Exposed Schneiderian membrane
e. Membrane lifted off antral wall
f. Elevation using Freer elevator
The presence of septa complicates not only the sinus window preparation, but also increase the risk of membrane perforation during the surgery. They may either be complete or incomplete on the sinus floor, depending on whether the divide the floor of the sinus into separate compartments, often extending from the lateral wall towards the medial wall.

Figure 6 a. Case example 1 a. Panoramic view
Figure 6. b – Case example 1

Figure 6. c – Case example 1

Figure 7. Case example 2 a. Panoramic view

Figure 7. b – case example 2

Figure 7. c - case example 2
Accurate diagnosis and evaluation of septa with the aid of CT scans before surgery enables the surgeon to plan any necessary modifications to the SALW procedure. Such modifications vary based on the location of the septa. We can divide the sinus into 3 sections; the anterior, middle and posterior regions. When septa are found in the anterior third, the surgery is modified to create 2 distinct windows; one in front of the septum and one distal to it (see Figure 8 a-c, Misch textbook P 961). The surgeon can then access the membrane and elevate it from each section in such a manner to minimize perforating the membrane.

Figure 8 a.  

b.  

c.
When the septum is located in the middle third, the 2 window approach is not as feasible due to limited direct vision. Thus, the recommended technique involves making one window anterior to the septum, elevating the membrane from that window above the apex of the septum and onto the other side of it extending approximately 1-2mm. Using a firm pulling action towards the anterior, one can fracture the apical portion of the septum. Repeating similar curette actions gradually advancing towards the base of the septum, one can completely disconnect the septum from the floor of the sinus, and proceed with elevating further distally and medially as needed (see Figure 9 a-d, Misch text book P961).

![Figure 9 a.](image)

![Figure 9 b.](image)

![Figure 9 c.](image)

![Figure 9 d.](image)
Lastly, if the septum is located in the posterior third of the sinus, it is usually distal to our last implant position. In this scenario, we can treat the septum as the posterior wall of the sinus. A single window approach is utilized and the membrane elevated and sinus graft is placed against and anterior to the septum.

Membrane perforation is the most common complication encountered during sinus grafting surgery, and the risk is increased in the presence of septa. Small perforations (<5mm) can generally be repaired with a resorbable collagen membrane alone e.g. Collatape. Perforations between 5-10mm can be addressed by using a slower resorbing collagen e.g. Biomend in conjunction with sutures or a freeze dried human lamellar bone sheet. In both cases it is important to elevate the membrane from all sides around the perforation without widening its size. The SALW technique reduces the overall size of the antrum, essentially causing the membrane to fold over on itself reducing the size of the perforation. For larger perforations (>10mm), it is generally recommended to terminate the surgery due to lower implant survival rates in cases where membrane repair was attempted.
CHAPTER 5

CONCLUSION

In conclusion, our study has confirmed a fairly high incidence of septa present in edentulous patients of 29% based on CT scan analysis. As has been well documented, the ability to augment vertically deficient posterior maxilla via SALW technique is a proven method but requires an extensive presurgical evaluation of a patient’s CT scan for the presence of septa to help guide the clinician in making appropriate surgical management of the sinus lift and thereby reducing the risks of surgical complications.
REFERENCES CITED


3. De Souza Nunes et al. Anatomical characteristics and dimensions of edentulous sites in the posterior maxillae of patients referred for implant therapy. *Quintessence.* 2013


