The maxillary sinus floor in the oral implantology

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Abstract
The aim of this study was to establish the mean distances between the maxillary sinus floor and the roots of the lateral maxillary teeth in dentate subjects, respectively the mean height of the available bone for oral implant placement in the corresponding area, in edentulous ones.

Material and Methods: We determined the maxillary sinus floor position in relation to morphoclinical alveolodental benchmarks on 50 dry skulls, dentate 30 and edentulous 20, and correlations were performed by use of 40 CT-scans of the targeted area. In addition, 20 human adult cadavers were bilaterally dissected in order to bring topographical evidence at that level.

Results: The data we obtained lead us to define three dentosinusal relations: tangent (close) relation 60.8%; distanced relation 25.6%; penetrating relation: 13.6%; three subantral classes in edentulous patients, emphasizing the direct relation of the age of the edentulism and the degree of bone resorption.
We discuss the results we obtained from the viewpoint of their application in the field of oral implantology.

Conclusions: The maxillary sinus floor represents the danger zone for the oral implantology.

Keywords: available bone, oral implant, the lateral maxillary teeth, the maxillary sinus floor.

Introduction
The alveolar process of the maxilla forms the maxillary sinus floor. If the sinus is of an average size, it is on a level with the floor of the nose; if the sinus is large, it reaches below this level. Projecting into the floor of the antrum are several conical processes, corresponding to the roots of the first and second molar teeth; in some cases, the fangs of the teeth perforate the floor [1].

The close anatomical relationship of the maxillary sinus with the roots of maxillary molars and premolars renders this anatomical region susceptible to morbid situations resulting from damage to, and therapeutic intervention in the dentoalveolar environment.

The loss of the teeth interrupts the cybernetic connections of the stomatognatic system, determining maxillary and mandibular structural changes that represent signs of inactivity atrophy due to functional unload. Modifications in the lateral area of the edentulous maxilla may affect more than 70% of its height and width.

The present study was performed in order to establish the mean distances between the maxillary sinus floor and the roots of the lateral maxillary teeth in dentate subjects, respectively the mean height of the available bone for oral implant placement in the corresponding area, in edentulous ones.

Material and Methods
Fifty dry skulls, dentate 30 and edentulous 20, were morphologically and morphometrically investigated for the study, and correlations were performed by use of 40 CT-scans of the targeted area. We investigated the dentosinusal relations on 125 teeth. In addition, 20 human adult cadavers were bilaterally dissected in order to bring topographical evidence at that level.

Results
The results obtained were processed for further use in the oral implantology. The floor of the maxillary sinus is oriented inferiorly and laterally toward the alveolar process of the maxillary bone. At this level, it can form recesses between the dental roots.

The alveolar recess – in the alveolar process, 52% of cases, the most frequent sinus extension, facilitates the violation of the antrum through endodontic or surgical therapy (Figure 1).

Normally, the sinus floor is placed at an average distance of 1.5 cm below the floor of the nasal fossa, on the horizontal line leaving the lower end of ala nasi.
The shape of the sinus floor was concave (rounded), mono- or two-concave in most of the cases (80%). In the remaining situations, the sinus floor had an irregular or a plane aspect. The interradiculo-antral bone of a uniform lamellar aspect, presents an antral contact surface in relation with the sinusal mucoperiosteum and a dental surface in relation with the periapical space. These limits of the sinusual floor are independent as orientation and relations between them and, rarely, on short distances, are parallel.

**The relations of the sinus floor and the root apices in dentate specimens**

We investigated the dentosinusal relations on 125 teeth (Table 1) and we set three types of vertical relations:

- **distanced relation**: between the apices and the sinus floor, there is a thick bony wall;
- **tangent relation**: between the apices and the sinus floor, there is a very thin bony lamella;
- **penetrating relation**: when the apices are covered by the sinusal mucosa.

The bony lamella separating the maxillary sinus and the teeth decreases in thickness from the upper canine (6.9 mm) to the 2nd molar (1.7 mm) and further increases to the 3rd molar (2.8 mm).

**Table 1 – Dentosinusal relations**

<table>
<thead>
<tr>
<th>Teeth</th>
<th>No.</th>
<th>Distanced relation to the antral mucosa</th>
<th>Tangent (close) relation under the antral mucosa</th>
<th>Penetrating relation</th>
<th>Medium thickness of the alveolar sinus wall [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>17</td>
<td>14</td>
<td>3</td>
<td>–</td>
<td>6.9</td>
</tr>
<tr>
<td>P1</td>
<td>16</td>
<td>5</td>
<td>9</td>
<td>2</td>
<td>3.8</td>
</tr>
<tr>
<td>P2</td>
<td>18</td>
<td>2</td>
<td>12</td>
<td>4</td>
<td>1.9</td>
</tr>
<tr>
<td>M1</td>
<td>20</td>
<td>1</td>
<td>15</td>
<td>4</td>
<td>1.8</td>
</tr>
<tr>
<td>M2</td>
<td>33</td>
<td>2</td>
<td>26</td>
<td>5</td>
<td>1.7</td>
</tr>
<tr>
<td>M3</td>
<td>21</td>
<td>8</td>
<td>11</td>
<td>2</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Total tangent (close) relation: 76 (60.8%); Total distanced relation: 32 (25.6%); Total penetrating relation: 17 (13.6%).

From the data obtained it results that the second molar has the most intimate antral relation (the lowest point of the sinus floor is placed on its level), so 93.9% of the second molars showed close relations with the maxillary sinus floor, tangent and penetrating. Furthermore, from the all teeth having close relations with the sinus floor, the second molar represented 27.6% (Figure 2).

**The sinus floor in edentulous specimens**

The mechanism of the alveolar crest atrophy is incompletely elucidated, several theories: functional unload, ischemia, pressure, and local inflammation, have been developed.

Misch CE (2005) [2], defined four subantral classes in what regards the average height of the available bone in the edentulous maxilla.

The measurements we performed leaded us to establish only three subantral classes (SAC 1–3) for the subantral residual bone, depending on the osseous height and the age of the edentulism, the latter not being considered in classifications at this time.

**SAC 1**

Bone height minimum 10 mm, what allows to apply an endosseous implant if the bone width is adequate, minimum 5 mm. We encountered this type in 56% of the cases, no edentulism being older than five years (Figure 3).

**SAC 2**

Bone height of 5–10 mm, which necessitate either a sinus lifting if the bone width is adequate, minimum 5 mm, or osseous augmentation if bone width is
2.5–5 mm, to be performed before implant placement. We encountered this type in 32% of the cases, the edentulism being 5–10 years old, without prosthetic treatment (Figure 4).

**SAC 3**

Bone height of 0–5 mm, making necessary the sinus lifting / healing period / graft maturation / delayed implant placement. This type was present in 12% of the cases, the edentulism being older than 10 years, without prosthetic treatment (Figures 5 and 6).

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**Discussion**

The anatomical relation between the maxillary sinus and the teeth is a complex one, due to the variable extension of the sinus.

The relations between the dental roots apices and the sinus floor are critical elements for the diagnosis and surgical treatment of antral pathology. The results obtained in this study are useful both in endodontics and in oral surgery. In what concerns the latter field, the antrum–teeth relations interfere with teeth removal and immediate placement of dental implants in the lateral maxillary region. Identification of the distance between the dental roots apices and the sinus floor and the establishment of the available bone thickness are imperative requirements in case of surgical procedures of this area. This importance is also emphasized by Yoon HR and Park CS (1998), who described similar vertical dento-antral relations, but proposed a complicated classification, with little clinical relevance. The buccal roots of the second maxillary molar showed close relations with the sinus in 40.5% of their studied specimens [3].

Several studies have reported the relative positions of the roots with respect to the sinus [4, 5].

We consider the classification into three types of the vertical dento-antral relations, simpler and much useful with regard to oral surgery than the classification of Kwak HH et al. [6] that presents five types of these relations. Kwak HH et al. found that the most frequent vertical relationship was a sinus floor that did not contact the dental roots.

The maxillary height in the region of the first premolar and first molar in our study was significantly higher in men than in women, and the most lower zone of the maxillary sinus floor was the most frequently at the level of the 2nd molar, at 50% in men and 56% in women.

The frequency of close proximity (0.5 mm or less) between the roots of the posterior maxillary teeth and the sinus floor is 45.5% for the second molars, 30.4% for the first molars, and 19.7% for the second premolars [5].

The buccal roots of the molars may present a vertical or slightly externally oblique, para-sinusal or internal-antral orientation, and when the variations of length and radicular direction are superposed with a lower sinus floor, we frequently evidence penetrating and perforating relations, more frequent than for the palatal roots.

Koppe T et al. (2005) [7] found in 50% of the examined skulls, that the apices of the upper first and second molars gave rise to prominences on maxillary sinus floor and Ariji Y et al. (2006) [8], showed that the roots of the maxillary first molar were close to the sinus floor in 60% of the studied specimens.

The smallest thickness of the alveolar sinus wall was in our study 1.7 mm at the level of the second molar. The mean high in the region of the antral teeth was 1.8 mm, the value being depended on the dental status.
Ariji Y et al. (1996) found a medium high of 3.7 mm for the bone below the sinus [9]. In this study, the value did not depend on the dental status, but it was negatively correlated with the antral volume.

Regarding the shape of the sinus floor, Yoon HR et al. (2001), presents the following frequent shapes: plane (54.5%) and round (21.2%). Yuichiro S et al. (2000) found the following shapes of the sinus floor: mono-concave (37.8%), two-concave (32.3%), three-concave (16.2%), and four-concave (13.7%) [10, 11]. Takahisa N (2002) showed that the sinus floor could be round in case of a small antral volume, plane and irregular in case of a bigger sinus volume, situation when the distance between the Schneider membrane and the teeth apices was reduced. He found the smallest distance at the level of the second molar buccal roots [12].

These observations demonstrate the various anatomical relations between the sinus floor and the surrounding structures and the importance of their knowledge in patients’ clinical management. In the situations with bone septa inside the sinus, the possibility of antral membrane perforation through sinus lifting procedures is very high [13, 14].

Variations of the sinus floor’s depth can depend on sinuses dimensions, their size and pneumatization being functions of the skull, and a great degree of pneumatization is accompanied by a closeness of the lateral teeth apices to the sinus floor. Variations of the pneumatization of the maxillary alveolar process could take place due to the craniofacial morphological modifications through evolution. Sinuses development is influenced by dentition, chewing force, breathing movements and craniofacial growth, factors that also control the pneumatization of the maxillary alveolar processes.

The antral floor depends upon the dental scaffold that constitutes the main factor during development and will transform in relation with the normal/pathological status of the dento-periodontal apparatus. Together with the antral volume and high, the surface of the sinus floor can constitute a criterion for the maxillary sinuses classification [15].

Relations of the teeth with the sinus floor can be accurately assessed on bucco-lingual slides obtained through 3-D CT-scan.

Knowledge of the distances between the sinusal roots and the sinus floor is useful for evaluation of the diameter and length of the dental implants, especially for immediate implant placement.

Wiltfang J et al. (2000), shows that a maintaining ratio of the subsinus bone of 4–8 mm is very unfavorable for the prosthetic treatment [16]. Endoscopic and ultrasonographic evaluations of the sinus floor can reduce the complications after surgical therapy [16–18].

Radiologically comparing the depth of the sinus floor, Ohba T et al. (2001) did not observe statistical differences between the right and the left sides [19].

In our opinion, the asymmetry between left and right antrum sides is a demand for the radiological assessment of each sinus.

Under normal clinical use and without a standardized method of film positioning, the average alveolar bone level measurements varied significantly between conventional radiographs and digital images in multiple regions of the mouth. In addition, the digital images revealed a higher number of sites with early-to-moderate bone loss than did the conventional images. These findings suggest that evaluation of alveolar bone loss using intraoral digital radiographs is not comparable with that of conventional radiological film under normal clinical use.

The available bone is lost from the inferior expansion of the sinus after tooth loss, involving the residual ridge region. The bone density in this area is the smallest one registered for any mandibular and maxillary regions and decreases very fast. The width of the available bone placed below the sinus is important for the establishment of the diameter of the implant and for the crestal approach in case of sinus floor lifting, which is more conservative than the lateral approach. Woo I and Le BT (2004) also agrees with this affirmation [20].

The quantity and quality of the available bone placed below the sinus and the local topographic conditions are decisive factors for the implant-prosthetic treatment in the lateral maxillary region [21].

Conclusions

The danger of the antral penetration is greater at the level of the buccal roots of the first and second molars and of the second premolar – these roots can be considered sinusal roots.

The lateral maxillary area is the less predictable for the implant–prosthetic treatment and we consider that the main factor leading to osseous resorption in this area is the functional unload determined by the lack of teeth or lack of prosthetic treatment.

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