Maxillary sinus vascular anatomy and its relation to sinus lift surgery

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Abstract

Objectives: To investigate the prevalence, location, size and course of the anastomosis between the dental branch of the posterior superior alveolar artery (PSAA), known as alveolar antral artery (AAA), and the infraorbital artery (IOA).

Material and methods: The first part of the study was performed on 30 maxillary sinuses deriving from 15 human cadaver heads. In order to visualize such anastomosis, the vascular network afferent to the sinus was injected with liquid latex mixed with green India ink through the external carotid artery. The second part of the study consisted of 100 CT scans from patients scheduled for sinus lift surgery.

Results: An anastomosis between the AAA and the IOA was found by dissection in the context of the sinus anterolateral wall in 100% of cases, while a well-defined bony canal was detected radiographically in 94 out of 200 sinuses (47% of cases).

The mean vertical distance from the lowest point of this bony canal to the alveolar crest was 11.25 ± 2.99 mm (SD) in maxillae examined by CT. The canal diameter was ≤1 mm in 55.3% of cases, 1–2 mm in 40.4% of cases and 2–3 mm in 4.3% of cases.

In 100% of cases, the AAA was found to be partially intra-osseous, that is between the Schneiderian membrane and the lateral bony wall of the sinus, in the area selected for sinus antrostomy.

Conclusions: A sound knowledge of the maxillary sinus vascular anatomy and its careful analysis by CT scan is essential to prevent complications during surgical interventions involving this region.
making its elevation far more difficult and interfering with placement of the graft material.

In such a context, the purpose of this cadaveric and CT scan study was to investigate the prevalence, location, size and course of the AAA located on the anterior lateral wall of the maxillary sinus, so as to provide indications for improving the safety of sinus floor elevation procedure, especially in cases of extreme atrophy of the alveolar process.

Material and methods

The first part of the study was performed on 30 maxillary sinuses, deriving from 15 human cadaver heads. The specimens belonged to subjects with an age range of 59–90 years (mean age 76 years) and equal sex distribution, who had donated their body for research purpose. The study obtained ethical approval from the Department of Anatomy at the Faculty of Medicine René Descartes of Paris 5 (Paris 5 University, Paris). Direct visualization of the AAA was obtained by fenestrating the anterior lateral wall of the sinus cavity and its dissection was carried out as far as the IOA and the PSAA were visible at its extremities (Fig. 1), in order to determine its course with respect to both the Schneiderian membrane and the buccal antral wall.

To detect such an artery, the vascular network afferent to the sinus was injected with liquid latex mixed with green India ink through the external carotid artery.

The second part of the study consisted of 100 CT scans from 100 patients scheduled for sinus lift surgery at the Dental Clinic of the IRCCS Istituto Ortopedico Galeazzi, Università degli Studi di Milano. The age range was 29–78 (mean: 53.5) years.

The CT scans were performed using a 2000 SOMATOM Volume Zoom 4 slice CT scanner (Siemens AG, Medical Solutions, Forchheim, Germany) with slices of 0.5 mm thickness. CT images were investigated for the presence of a bony canal, housing the AAA, in the context of the sinus anterolateral wall.

Coronal, axial and sagittal views of the maxillary sinus were obtained by means of a software for 3D reconstruction (OneScan 3D, 3D-MED s.r.l., Brescia, Italy), offering a photorealistic rendering quality and able to import Dicom formatted CT images.

The route of the AAA was assessed with coronal, axial and sagittal views of the maxillary sinus, so as to provide indications for improving the safety of sinus floor elevation procedure, especially in cases of extreme atrophy of the alveolar process.

The anatomical dissection confirmed that the PSAA divides into two branches along its course: an external [gingival] branch is directed towards the superior buccal fornx and the maxillary tuberosity; the other branch is internal [dental] and, after coursing below the zygomatic process, was found to point towards the inside of the orbit making a circular anastomosis with the IOA.

An intra-osseous anastomosis between the AAA and the IOA was found by dissection (Figs 1 and 5); it was strictly close to the Schneiderian membrane.

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sinusal or sub-periosteal) in the maxillary tuberosity area.

The vertical distance from the lowest point of the vessel, corresponding to the first molar area, to the alveolar crest averaged $11.25 \pm 2.99$ (SD) mm (range between 7.2 and 17.7 mm).

The residual ridge height ranged from 0.7 to 5.1 mm (mean height $3.60 \pm 1.28$ mm). A slight positive correlation between such a distance and the ridge height was observed ($r = 0.38$). When considering a threshold of 3 mm for the residual ridge height, the AAA-to-alveolar crest distance averaged $9.33 \pm 2.41$ ($n = 39$) and $12.45 \pm 2.71$ ($n = 55$) for cases with ridge height $< 3$ mm and $\geq 3$ mm, respectively.

**Discussion**

The anastomosis between PSAA and IOA provides blood supply to the sinus membrane, to the periosteal tissues, and especially, to the anterolateral wall of the sinus (Solar et al. 1999; Rosano et al. 2009).

The scientific literature reports that this vessel is located at an average distance of 19 mm (Solar et al. 1999; Traxler et al. 1999), 16.4 mm (Elian et al. 2005) and 16.9 mm (Mardinger et al. 2007) from the alveolar crest of the posterior maxilla. Nevertheless, such data can be misleading because the height of the residual bony ridge, the maxillary atrophy class and the presence of teeth play a relevant role in determining the location of the vessel.

In the present study, the average distance of the AAA from the alveolar ridge in atrophic maxillae of Cawood & Howell class V and VI was $11.25$ mm. For the most atrophic cases, in which the ridge height is inferior to 3 mm, such a distance was significantly lower with respect to lesser atrophic cases. This would confirm that the more resorbed the bone crest, the higher the risk of violation of such a vessel during sinus augmentation procedure.

These results are substantially in agreement with the study by Mardinger et al. (2007), which found that this vessel was located at a mean distance of 10.9 mm from the crest in classes D, E [Lekholm & Zarb 1985] and at a distance greater than 15 mm in classes A, B and C.

Differences concerning the mean distance from the vessel to the crest, with the studies by Solar et al. (1999), Traxler et al. (1999) and Elian et al. (2005) are probably due to the more strict inclusion criteria considered in the present study, where only highly atrophic ridges have been examined.

Moreover, because a well-distinguished bony wall between the intra-osseous maxillary anastomosis and the maxillary sinus has never been found by anatomic dissection (Fig. 1), it could be speculated that the lowest border of such a vessel...
could often be completely adherent to the sinus membrane (that means not radiographically visible) instead of being located inside the buccal wall cortex.

This would justify the contradiction between a 100% prevalence of this artery found by dissection and an only 47% prevalence detected by CT scan in the present study.

The authors’ opinion is that such contradiction may not depend on the AAA small diameter, which makes it radiographically undetectable in some cases, as suggested by Elian et al. [2005] and Mardinger et al. [2007], but on an entirely intra-sinusal location of the vessel.

The course of the AAA, as identified in this study, is in agreement with the CT study by Ella et al. [2008] where intra-osseous, intra-sinusal and sub-periosteal courses of this artery were detected.

As stated by Ella et al. [2008], a “superficial” location of such anastomosis, which is under the perosteum of the sinus lateral wall should also be considered. In the present study, such sub-periosteal course was identified by means of both CT scan analysis and anatomical dissection in the maxillary tuberosity area but never in the area usually selected for sinus antrostomy.

When carrying out sinus lift surgery, the bony window height should be almost 13 mm from the ridge if the purpose is to place 11–13 mm dental implants. Thus, in patients with severely atrophic posterior maxillae [classes V, VI], the possibility of lacerating the AAA must be considered, especially when the residual ridge is <3 mm high.

The diameter of the anastomosis was ≥2 mm in a very few cases [3.3% by dissection and 2% by CT scan], anyway, this eventuality, even if infrequent, is worthy to be taken into serious consideration.

As a matter of fact, if the damage of a bony vessel <2 mm can be barely relevant under a clinical point of view, the transection of an AAA with a diameter over 2 mm is likely to produce bleeding and impairment of vision, which may lead to a potential membrane perforation, thus prolonging the overall operation time, interfering with the placement of bone graft and constituting a true surgical complication.

In addition, the haemorrhage from this artery [a] may displace the grafting material due to a “washing” effect caused by the blood pressure, thus reducing or compromising the filling of the space below the Schneiderian membrane after sinus floor elevation, and [b] may produce relevant haematomas of the cheek area causing discomfort to patients and creating an ideal “pabulum” for bacteria growth and consequent infection.

It is the authors’ opinion that the excision of a large diameter AAA in combination with the inadvertent tearing of the sinus membrane has the potential to induce sinus mucosa swelling, extrusion of blood into the sinus cavity as well as a postoperative sinusitis as a major drawback.

In fact, if the maxillary sinus is, even partly, filled up by mucosal oedema, haematoma or seroma, a delay of maxillary sinus clearance may occur because of the reduction of maxillary ostium patency, and maxillary sinusitis may develop as well, compromising the success of the grafting procedure [Timmenga et al. 2003].

The preservation of such anastomosis is important not only to avoid bleeding complications but also to support bone graft neoangiogenesis [Taschieri & Rosano 2010]; in this perspective, its concomitant reflection with the Schneiderian membrane during sinus augmentation procedures, if possible and especially when its diameter is consistent, should be seriously considered.

In conclusion, the authors recommend to rely upon CT scan imaging, which has been proved to be the most appropriate radiographic method for detecting any anatomical variation within the sinus [Schwarz et al. 1987; Quirynen et al. 1990; Alder et al. 1995; Dula et al. 2001], before sinus lift surgery is performed, in order to pre-surgically evaluate the location, size and thus the clinical relevance of this anastomotic vessel. Extreme caution should be taken when the residual ridge height is <3 mm.

References


