Vascular Connections of the Lateral Wall of the Sinus: Surgical Effect in Sinus Augmentation

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Purpose: *There are several vascular vessels that supply the maxillary sinus, such as the posterior superior alveolar artery, the anterior superior alveolar artery, and the infraorbital artery (IOA). These vessels have to be taken into consideration during a sinus augmentation because of the potential risk of bleeding during the procedure. The objective of this investigation was to study variations in maxillary sinus artery connections with the potential surgical effect during a sinus floor elevation by the lateral wall.* ***Materials and Methods:*** *The first part of the study was done in 32 anatomical specimens embedded in 10% formaldehyde solution and aged between 55 and 70 years (mean, 61.3 years). The second part of the study was a radiographic study using computerized tomographic (CT) scan images in 35 randomized patients treated in odontology and maxillofacial surgery departments.* ***Results:*** *Results were recorded for 134 sinuses. In most cases, there was no vessel visible or no vessel present with a diameter less than 0.5 mm after dissection or CT-scan analysis: 120 sinuses (89.5%). In 14 cases (10.5%) there were vessels in the lower two thirds of the anterolateral wall. In 10 sinuses (71.4% of the 14 cases), there was an intraosseous or intrawall artery and in 2 sinuses (14.3%) they were in the intrasinusal position. In 8 of the 14 sinuses (57.1%, about 6% of overall sinuses) the diameter was between 1 and 2.5 mm.* ***Conclusion:*** *Knowledge of the arterial supply is essential for surgical treatment in the sinus area. A CT scan is recommended and the radiologist must be advised to search for intraosseous or extraosseous vessels in the lower two thirds of the maxillary sinus.* Int J Oral Maxillofac Implants 2008;23;1047–1052

Keywords: *maxillary sinus, sinus augmentation, vascular vessels*

There are several surgical techniques for oral implanted-supported prostheses in patients with major bone resorption of edentulous maxilla. Elevation of the sinus membrane using the lateral or crestal approach is usually performed to obtain an adequate implant vertical host.[1-4] However, this type of surgery can be complicated because of intrasinusal anatomic structures.[4,5] There are several vascular vessels that supply the maxillary sinus, such as the posterior superior alveolar artery (PSAA), the anterior superior alveolar artery (ASAA), and the infraorbital artery (IOA). These vessels have to be taken into consideration during a sinus augmentation because of the potential risk of bleeding during the procedure.

The objective of this investigation was to study variations in maxillary sinus vascular connections with the potential surgical effect during a sinus floor elevation.

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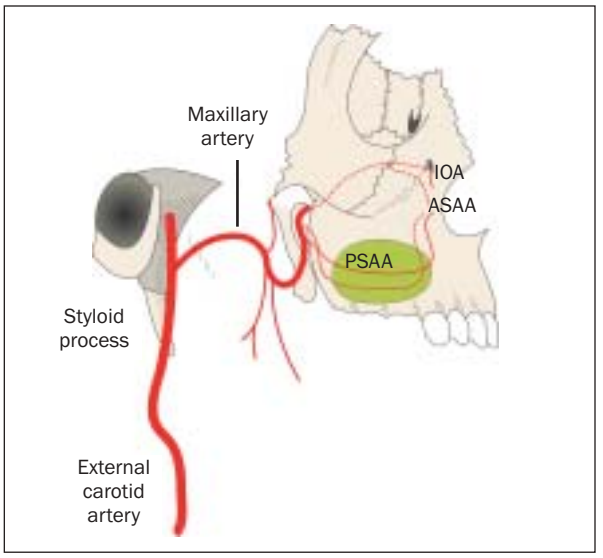

Fig 1 Origin of the arteries of the sinus.

MATERIALS AND METHODS

Anatomic Background

Arterial vascularization of the maxillary sinus is supplied by the maxillary artery (Fig 1), the larger terminal branch of the external carotid artery. Within the pterygopalatine fossa, the maxillary artery gives off many branches for the maxillary sinus[5–10]:

- After entering the pterygopalatine fossa, the maxillary artery gives off the PSAA. This artery enters the posterior superior alveolar foramina on the maxillary tuberosity and gives off dental branches and alveolar branches. The dental branches of this artery supply the pulp tissue of the posterior maxillary teeth by way of each tooth's apical foramen, and the alveolar branches supply the periodontium of the posterior maxillary teeth. Dental and alveolar branches also supply the maxillary sinus.
- The IOA artery shares a common trunk with the PSAA in the pterygopalatine fossa. The IOA enters the orbit through the inferior orbital fissure. The artery travels in the infraorbital canal, provides orbital branches, and gives off the ASAA.
- The ASAA arises from the IOA and gives off dental and alveolar branches. The dental branches supply the pulp tissue of the anterior maxillary teeth. The alveolar branches supply the periodontium of the anterior maxillary teeth.

These vessels anastomose together, with the formation of an intraosseous or intramaxillary and extraosseous or extramaxillary network. Extraosseous anastomoses are made up of the alveolar branches of the PSAA, the inferior branches of the IOA, and the alveolar branches of the ASAA. Intraosseous anastomoses are formed by the dental branches of the ASAA and PSSA.

Venous drainage is ensured by the posterior alveolar vein and the inferior alveolar vein. These veins are usually symmetrically located and receive branches from the same areas of the maxillary zone as are supplied by the artery network.

Study

The first part of the study was carried out on 32 anatomic specimens embedded in 10% formaldehyde solution, from subjects between 55 and 70 years (mean, 61.3 years). Because most of the cadavers available in the Laboratory of Anatomy were men, it was decided to retain only men for the study. Sixty-four sinuses were dissected and analyzed. The dissection began with a crestal incision in order to expose the maxillary sinus region. The periosteum was dissected. A window was made on the lower two thirds of the anterolateral wall of the maxillary sinus, and the Schneiderian membrane was exposed. Then the vessels adjacent to the anterolateral surgical flap or to the sinus floor and nerve branches were dissected from the anterior to the posterior region. All dissections were done using a lens, and only vessels with a diameter greater than or equal to 0.5 mm were taken into consideration.

The markers used to define the level of the artery on the wall, from back to front and from top to bottom, were situated 2 cm behind and 2 cm in front of the axis of the zygomatic process of maxillary bone on the bony crest (Figs 2a and 2b).

The second part of the study was a radiographic study using CT scan images in 35 randomized patients treated in the departments of Odontology and Maxillofacial Surgery, Bordeaux University. The CT scans were performed using a Siemens Sensation 16 scanner (Siemens, Munich, Germany). A tridimensional analysis (coronal, axial, and sagittal views) was performed to analyze vessel distribution around the lower third of the anterolateral wall and the floor of the maxillary sinus (Fig 3). Because all patients in the first part of the study were men, all the subjects of this CT scan study were male too. Vessel diameter was determined using a pair of compasses and a ruler, and only arteries with a diameter of more than or equal to 0.5 mm were taken into consideration.

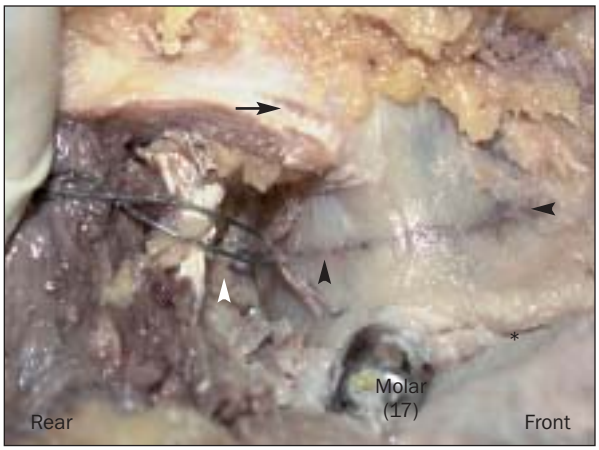

Fig 2a Lateral view of the dissection of the antral artery in the external wall of a right sinus. The artery follows the sinus wall in its middle third from rear to front, included in the bone. Maxillary process of the zygomatic bone *(arrow)*; ASAA inside the sinus wall *(black arrowheads)*; alveolar crest *(asterisk)*; pterygomaxillary region *(white arrowhead)*.

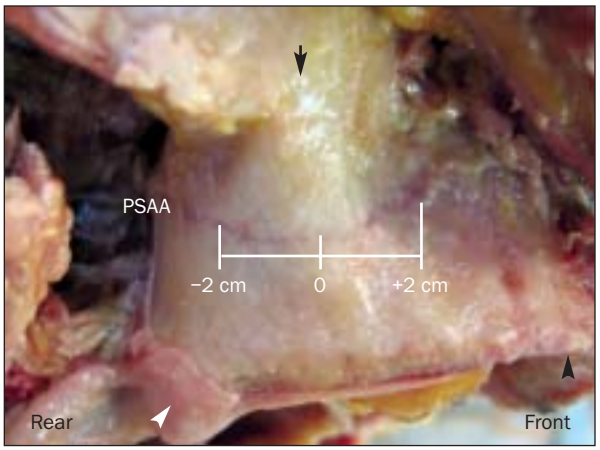

Fig 2b The indication of the 3 points which will allow description of the artery from front to rear. The zygomatic process *(arrow)* is the central mark from which the other 2 marks are made: 2 cm behind (−2 cm) and 2 cm in front (+2 cm). Maxillar tuberosity *(white arrowhead)*; alveolar crest *(black arrowhead)*.

RESULTS

Results were recorded for 134 sinuses. In most cases, there was no vessel visible or no vessel present with a diameter less than 0.5 mm after dissection or CT-scan analysis (ie, 120 sinuses or 89.5%).

In 14 cases (10.5%) there were vessels in the lower two thirds of the antero-lateral wall. Of these cases, 12 (85.7% of the 14 sinuses) had vessels in the middle third of the sinus. In 10 sinuses (71.4% of the 14 cases) distribution of the vessels was bilateral.

In 10 sinuses (71.4% of the 14 cases), there was an intraosseous or intrawall artery (Figs 4a and b) and in 2 sinuses (14.3%) they were in the intra-sinusal position (Fig 4c).

Among the 14 sinus arteries with a diameter of more than 0.5 mm, in 6 sinuses (42.9%) the diameter was between 0.5 and 1 mm, and in 8 sinuses (57.1%) the diameter was between 1 and 2.5 mm. The mean diameter of the vessels overall was 1.20 mm (0.5 to 2.5 mm).

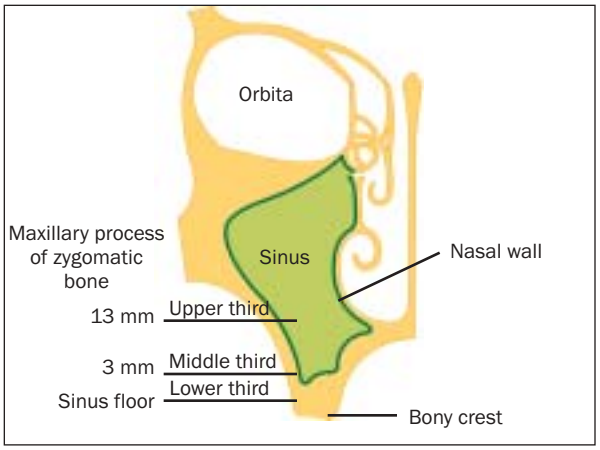

Fig 3 Frontal view of a sinus in the region of the zygomatic arch. Indication of the different regions describing the sinus cavity. The lower third of the sinus goes from the sinus floor to 3 mm above. The middle third goes from the inferior third to 13 mm above the sinus floor. The upper third is the rest of the sinus, 13 mm above the sinus floor and up.

DISCUSSION

This study demonstrates that there are variations in maxillary sinus vascular connections with respect to potential risks of surgical hemorrhage.[5-8,10] The greater the diameter of the artery, the greater the risk of hemorrhage. There are 2 surgical approaches for elevation of the maxillary sinus membrane in dental preimplant surgery: the crestal or inferior way and the antero-lateral way.[1–4] Arterial vascularization of the maxillary sinus is supplied by the maxillary artery. Within the pterygopalatine fossa, the maxillary artery gives off many branches for the maxillary sinus: the PSAA, with dental and alveolar branches supplying the maxillary sinus; and the ASAA, arising from the IOA with dental and alveolar branches. Venous drainage is ensured by the posterior alveolar vein and the inferior alveolar vein. During the sinus augmentation, several parameters must be considered, particularly the course of the aforementioned arteries and their intraosseous or extraosseous locations and anastomoses.

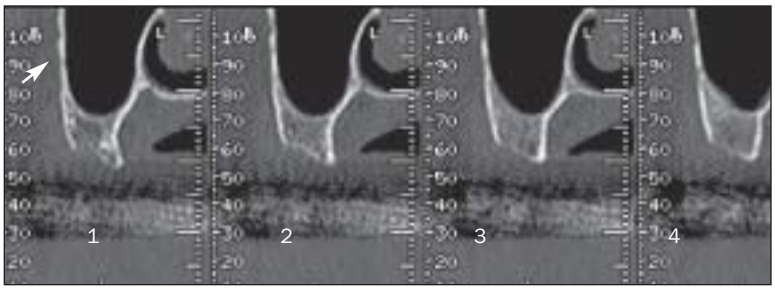

Fig 4a Transversal view of the CT scan of a left sinus: in the inferior third of the sinus cavity, the artery is divided into 2 parts. On these views, the arteries are inside the bone. PSAA *(arrow)*.

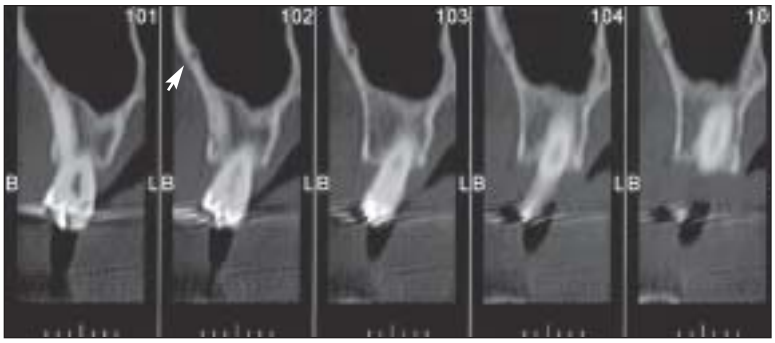

Fig 4b Transversal view of the CT scan of a left sinus in the middle third of the sinus cavity. On all views, the artery is inside the external wall. PSAA *(arrow)*.

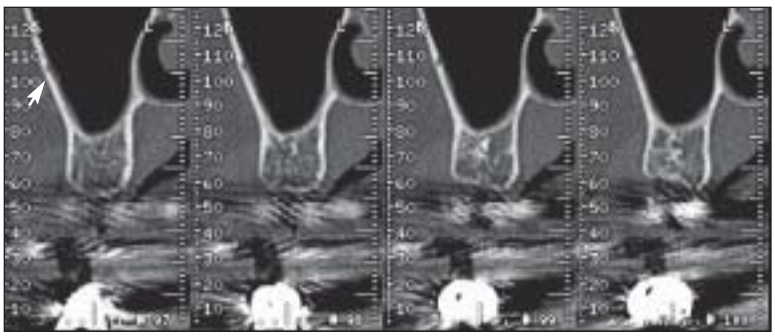

Fig 4c Transversal view of the CT scan of a left sinus: In the middle third of the sinus cavity on all views, the artery stays below the schneiderian membrane.

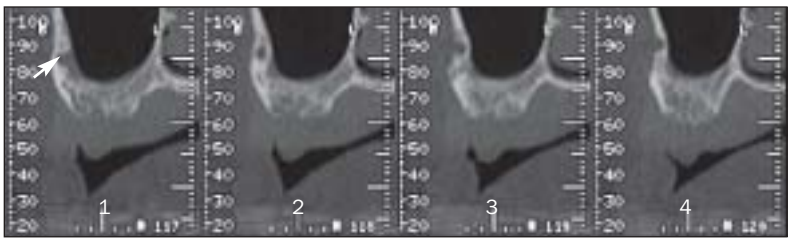

Fig 5 Transversal view of a left sinus on a CT scan: variations of the artery's position in the external wall of the sinus. *(1)* The artery is not seen from the schneiderian membrane. *(2)* The artery is intraosseous. *(3 and 4)* The artery has a subperiosteal position.

Indeed, in the lower two thirds of the antero-lateral wall the arteries may occur in 3 positions on the sinus wall (Fig 5). This part, which is the most widely used, bears the risk of injuring the arterial pedicle, either when the practitioner burs the bone or lifts the membrane.

For this reason, it is necessary to insist on the following points before operating :

- Its position (superficial, intraosseous or intrasinus). In the intraosseous and intrasinus location, the artery can be masked by the thickness of the osseous wall. In that case, the practitioner can be surprised by the bleeding caused by removing the bone and unsticking the membrane (Figs 6a to 6f).
- Its termination (free or anastomosed with the infraorbital artery), its precise course (long or short), and if possible, knowing where it originates.

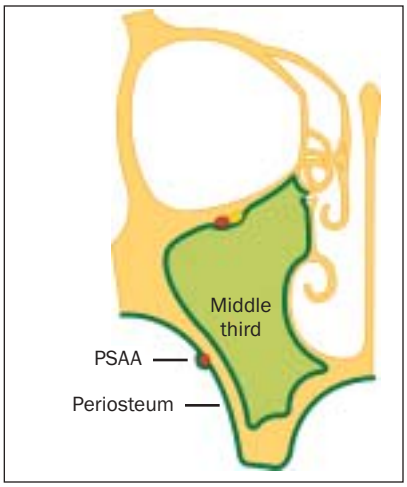

Fig 6a Front cut of a right sinus showing the antral artery partially outside the external bony wall of the sinus in the middle third of the sinus cavity.

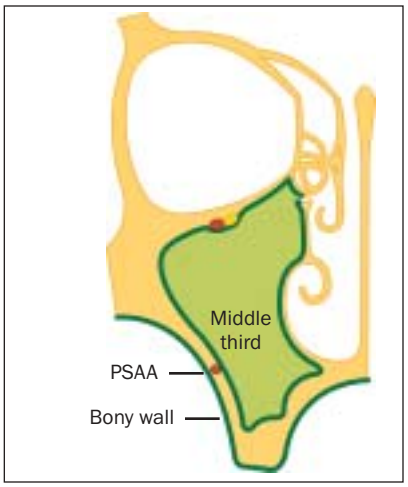

Fig 6b Front cut of a right sinus showing the antral artery partially inside the external bony wall of the sinus, in the middle third of the sinus cavity.

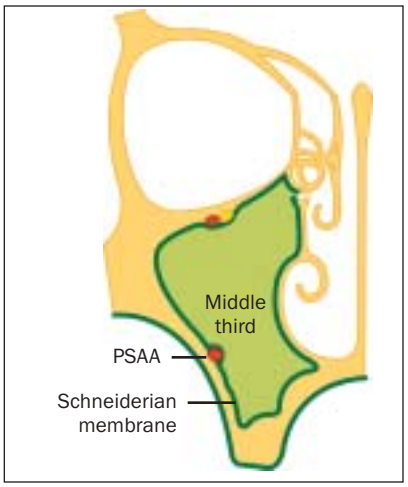

Fig 6c Front cut of a right sinus showing the antral artery under the Schneiderian membrane against the external bony wall of the sinus in the middle third of the sinus cavity.

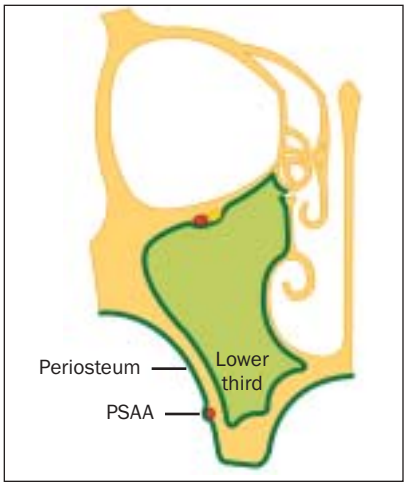

Fig 6d Front cut of a right sinus showing the antral artery under the periosteum of the external wall of the sinus in the inferior third of the sinus cavity.

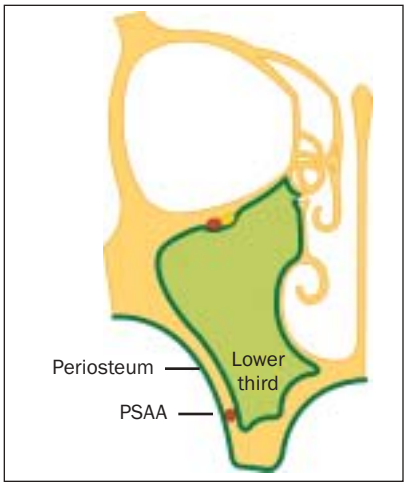

Fig 6e Front cut of a right sinus showing the antral artery inside the external bony wall of the sinus in the inferior third of the sinus cavity.

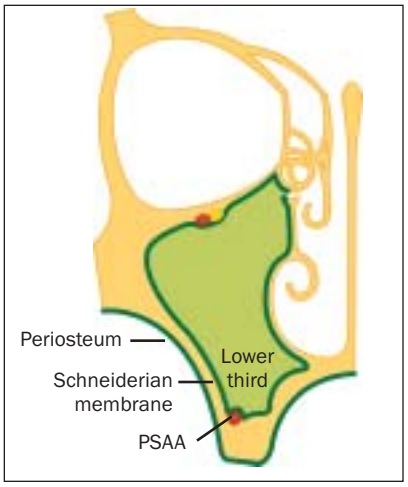

Fig 6f Front cut of a right sinus showing the antral artery underneath the Schneiderian membrane in the inferior third of the sinus cavity.

- Its diameter (large or residual) because sometimes these arteries have very large diameters (up to 2.5 mm) with intrawall or intraosseous location. The sinus approach can therefore be more difficult under local anesthesia. When the diameter was greater than 0.5 mm, in more than 70% of cases, the distribution of the vessels was bilateral.

When a maxillary sinus membrane elevation is needed, the practitioner has to know that:

- In more than 10% of cases, there is a risk of bleeding because of an artery with a diameter of more than 0.5 mm.
- In a patient with an artery with a diameter of more than 0.5 mm (1 to 2 mm diameter), the probability of a high risk of hemorrhage is about 57%.
- In a patient with an artery with a diameter of more than 0.5 mm, the probability of there being bilateral distribution of the vessels is more than 70%.

CONCLUSION

These data may help surgeons to estimate the bleeding risk for a sinus augmentation using crestal or lateral approach under local or general anesthesia. Knowledge of the arterial supply is essential for surgical treatment in the sinus area. A CT scan is recommended and the radiologist must be advised to search for intraosseous or extraosseous vessels in the lower two thirds of the maxillary sinus. Without such data, the therapeutic decision cannot be made correctly.

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