

Cone beam computed tomography for Maxillary sinus vascular anatomy

Avani Dixit

Associate Professor, Dept. of Oral Medicine & Radiology, Swami Devi Dayal Dental College, Panchkula, Haryana

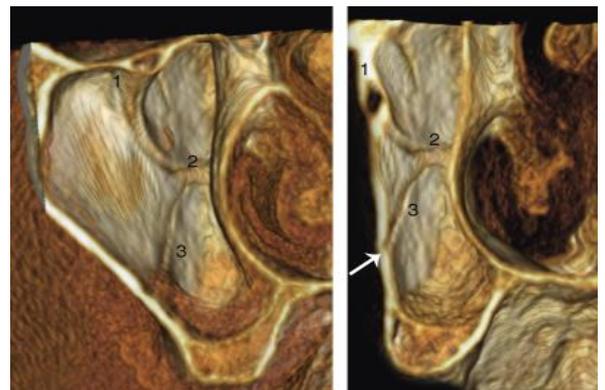
Email: dxtavani@yahoo.co.in

Introduction

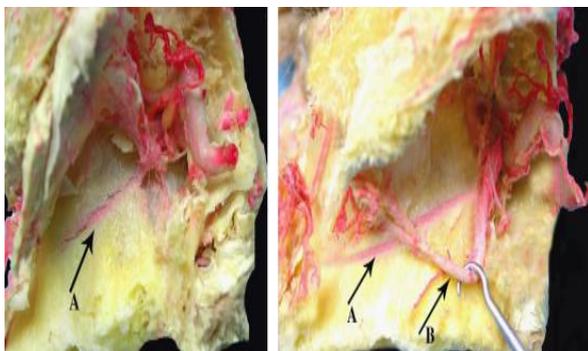
As well described by all anatomists, the vessels of nose region, maxilla and sinus walls constitute a rich network of arteries and veins. Branches of the ophthalmic, maxillary and facial arteries supply the nose. They form anastomosis plexuses within the nasal mucosa. The anterior and posterior ethmoidal branches of the ophthalmic artery supply the frontal and ethmoidal sinuses and the roof of the nose. The sphenopalatine branch of the maxillary artery supplies conchae, meatus and postero-inferior part of the nasal septum being the principal vessel supplying the nasal mucosa. The greater palatine branch of the maxillary artery supplies the inferior meatus. Its terminal part ascends through the incisive canal to anastomosis on the septum with branches of the sphenopalatine and anterior ethmoidal arteries and with the septal branch of the superior labial artery. The pharyngeal branch of the maxillary artery supplies the sphenoidal sinus. The infraorbital artery and the superior, anterior, and posterior alveolar branches of the maxillary artery supply the mucosa of the maxillary sinus. In particular, the maxillary artery passes through the pterygomaxillary fissure from the infratemporal fossa into the pterygopalatine fossa, where it terminates as the third part of the maxillary artery. This part of the artery gives branches running together with those of the maxillary nerve. The posterior superior alveolar artery arises from the maxillary artery and goes through the pterygo-maxillary fissure into the maxillary tuberosity. It gives off several branches: some of them penetrate the bone to supply the maxillary posterior teeth and the maxillary air sinus, and the other branches supply the buccal mucosa. The infraorbital artery emerges into the face at the infraorbital foramen to supply the lower eyelid, part of the cheek, the side of the external nose, and the upper lip. During its route within the infraorbital canal it gives off the anterior superior alveolar artery directed downwards to supply the anterior teeth and the anterior part of the maxillary sinus.⁽¹⁻⁶⁻⁹⁻¹⁹⁾ Solar, together with his group, in 1999 was the first one to state and find out that those vessels were poorly described in classical textbooks of dental and human anatomy.⁽¹⁸⁻²⁰⁾ In his paper, he showed by a scheme, the course of the anastomosis between the posterior superior antral artery and the infraorbital anatomy. Then Elian in 2005, in his radiological study, observed how the computed tomography is not so sensitive comparing the data to the Solar and Traxler studies that were on human cadavers. However, he

provided more data regarding the distribution and the position of the vascular anastomosis, and stated the factors of clinical significance: (i) the pre-surgical evaluation performed by CT scans were useful to spot the intraosseous vessel with a great diameter; (ii) the position of the osteotomy, indicating the safe distance as 15 mm from the alveolar bridge.⁽⁷⁾ Mardinger in 2007, using the radiographic method, reported results slightly different from the former authors and how the vessels with a <1 mm diameter do not represent a great risk or bleeding threat or obstacle during the surgical procedures.⁽¹³⁾ Rysz in 2009 studied the anastomosis on fetus cadavers, and clearly the results of the prevalence and distributions were different from the ones reported in the previous studies.⁽¹⁷⁾ Rosano in 2009-2010 in his cadaveric study, confirmed the data reported by Solar and Traxler in 1999.⁽¹⁴⁻¹⁵⁾ Ilguy in 2013 reported measures, septa presence, and that the non-detection of the anastomosis on CBCT is probably caused by the small diameter.⁽¹¹⁾ The more recent study was by Rysz in 2014, which focused this time on adult CBCT scans.⁽¹⁶⁾ All of these authors reported different data and different methods, but all of them agree on two points:

1. The anastomosis supplies the lower part of the sinus, playing an important role in the graft integration and vascularization;
2. Though its accidental sectioning is not life-threatening, the bleeding can make difficult the visibility and the management of the Sneider's membrane.



3D view of the lateral wall of the maxillary sinus which shows the point of emergence of the infraorbital artery (IOA) (1), the point of anastomosis between the IOA and the alveolar antral artery (AAA) (2) as well as the route of the AAA (3) forming a small concavity (white arrow)



Internal view of the maxillary sinus: the arrow A shows the alveolar antral artery, the endosseous branch of the posterior superior alveolar artery (PSAA), partially encased in the lateral sinus wall, while the arrow B shows the infraorbital artery deriving from the maxillary artery and forming a vascular arcade with the PSAA

Discussion

The height and the thickness of crestal bone change relatively to the presence of the tooth and to the injuries can occur during a normal human life, such as endodontic and periodontal infections. In both of arches, it means that the restorative treatment by implants depends on the quantity and quality of residual bone, because of the presence of two noble anatomical structures: alveolar canal in the inferior jaw and the maxillary sinus in the upper jaw. The principal surgical technique to gain a height augmentation is the sinus floor lift procedure, with a lateral approach.⁽⁴⁻¹²⁾ In this procedure, the knowledge of the vascular supply of this region is mandatory, to avoid unwanted hemorrhagic complications and to guarantee a good vascularization of the grafted material.⁽²⁻³⁻⁵⁾ Generally, during the surgical and grafting procedures in this region, the vessels involved are from the arterial anastomosis between the Infraorbital artery and the Posterior Superior Alveolar Artery. Since Solar P.'s group in 1999 provided a scheme and a more extensive anatomical point of view, many authors studied maxillary sinus anatomy and its vascularization.

Indeed the CBCT provides accurate and reliable linear measurement for imaging of dental and maxillofacial surgery. In 2014 Rysz, found the anastomosis in 50% of his sample, using CBCT scans. Furthermore, the group focused on all type of patients than the edentulous, such as the formers. All of these authors affirm that the anastomosis forms a concave arch, with the lowest point located in the first molar area. In addition, they focused their results on the distance of the vessel from the alveolar ridge or the tooth, in many position for the whole length of the maxilla, reporting different data. In the study by Solar et al., the intraosseous anastomosis was located 18.9–19.6 mm from the edge of the alveolar process. Ella et al. reported the anastomosis to be located 3–13 mm

from the edge of the lower alveolar.⁽⁸⁾ In a paper published by Hur et al., the mean distance between the intraosseous anastomosis and the cervical line was 26.9 mm at the level of the first premolar, 24.1 mm for the second premolar, 21.1 mm for the first molar, 22.4 mm for the second molar, and 23.3 mm from the maxillary tuberosity.⁽¹⁰⁾ In the Rysz study, the distance between the anastomosis and the cervical line of the first molar was 15–19 mm.

According to the other authors, the reported data confirm the needs of a deep knowledge of the anatomy of this region and the prescription of a CT before the intervention is fundamental both for a surgical procedure free of nasty complications, and for a better integration of the grafting material and the implant.

When carrying out sinus lift surgery, the bony Window height should be almost 13mm from the ridge if the purpose is to place 11–13mm 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 less than 3mm high.

As a matter of fact, if the damage of a bony vessel 0.2mm can be barely relevant under a clinical point of view, the transection of an AAA with a diameter over 2mm 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 hemorrhage 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 hematomas of the cheek area causing discomfort to patients and creating an ideal “pabulum” for bacteria growth and consequent infection.

In fact, if the maxillary sinus is, even partly, filled up by mucosal edema, hematoma 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.

Conclusions

The arterial connection between the infraorbital artery and the posterior superior alveolar artery in the

lateral wall of the sinus is not a variance but a rule. Knowing and spotting it before the surgical intervention of sinus floor lift augmentation is important in order to choose the best incision position, to avoid hemorrhagic incident and for a better graft integration.

References

1. Anastasi G., Castano P., Castorina S., Cremona O., De Caro R., Gaudio E., Macchiarelli G., Rende M., Ribatti D., Sforza C., Tacchetti C., (2014) *Anatomia Umana – Atlante*, voll 1-3 Milano edi Ermes.
2. Bell WH, Levy BM. (1971) Revascularization and bone healing after posterior maxillary osteotomy. *J Oral Surg* 29:313–320.
3. Bell WH, You ZH, Finn RA, Fields RTh. (1995) Wound healing after multi-segmental Le Fort I osteotomy and transection of the descending palatine vessels. *J Oral Maxillofac Surg* 53:1425–1433.
4. Bernardi S., Mummolo S., Li Vigni M., Ciavarelli Macozzi L., Zeka K., Giuseppe Marzo G., Continenza M. A. (2014) The Antral Artery Anastomosis: An In Vivo Investigation, *Italian Journal of Anatomy and Embriology*, vol. 119, n. 1 (supplement) pag. 16.
5. Boyne PJ, James RA. (1980). Grafting of the maxillary sinus floor with autogenous marrow and bone. *J Oral Surg* 38:613–616.
6. Brand RW, Isselhard DE. 1990. *Anatomy of orofacial structures*, 4th Ed. St. Louis: C.V. Mosby. p 171–177.
7. Elian N, Wallaces S, Cho SC, Jalbout ZN, Froum S. (2005) Distribution of the maxillary artery as it related to sinus floor augmentation. *Int J Oral Maxillofac Implants*: 20: 784–787.
8. Ella, B., Se'darat, C., Da Costa Noble, R., Normand, E., Lauerjat, Y., Siberchicot, F., Caix, P. & Zwetyenga, N. (2008) Vascular connections of the lateral wall of the sinus: surgical effect in sinus augmentation. *The International Journal of Oral & Maxillofacial Implants* 23: 1047–1052.
9. Fonzi L. (2000), *Anatomia funzionale e clinica dello splancnocranio*, Milano Edi Ermes.
10. Hur MS, Kim JK, Hu KS, Bae HE, Park HS, Kim HJ. (2009) Clinical implications of the topography and distribution of the posterior superior alveolar artery. *J Craniofac Surg*;20:551–4.
11. Ilguy D, Ilguy M, Dolekoglu S, Fisekcioglu E, (2013) Evaluation of the posterior superior alveolar artery and the maxillary sinus with CBCT. *Braz Oral Res.*, (Sao Paulo) Sep-Oct;27(5):431-7.
12. Marchetti E., Lopez M.A. Confalone L., Mummolo S. Marzo G. (2010), Maxillary sinus augmentation by crestal approach and ultrasound, *Jour Oss*;2(3):79-83.
13. Mardinger O., Abba M., Hirshberg A., Schwartz-Arad D. (2007): Prevalence, diameter and course of the maxillary intraosseous vascular canal with relation to sinus augmentation procedure: a radiographic study. *Int. J. Oral Maxillofac. Surg.*
14. Rosano G, Taschieri S, Gaudy JF, Del Fabbro M. (2009) Maxillary sinus vascularization: a cadaveric study. *J Craniofac Surg*;20:940–3.
15. Rosano G, Taschieri S, Gaudy J-F, Weinstein T, Del Fabbro M. (2011) Maxillary sinus vascular anatomy and its relation to sinus lift surgery. *Clin. Oral Impl. Res.* 22, 711–715. doi: 10.1111/j.1600-0501.2010.02045.x.
16. Rysz M., Ciszek B., Rogowska M., Krajewski R. (2014) Arteries of the anterior wall of the maxilla in sinus lift surgery. *Int. J. Oral Maxillofac. Surg.*;43:1127–1130.
17. Rysz M., Koleśnik A., Lewińska B., Ciszek B., (2009) The study of arterial anastomoses in the region of the alveolar process and the anterior maxilla wall in fetuses. *Folia Morphol.* Vol. 68, No. 2, pp. 65–69.
18. Solar P, Geyerhofer U, Traxler H, Windisch A, Ulm C, Watzek G. (1999) Bloody supply to the maxillary sinus relevant to sinus floor elevation procedure. *Clin Oral Implants Res*:10:34–44.
19. Standring S. (2007) *Gray's Anatomy*, 39th Edition, Ed. Elsevier, Basel.