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Maxillary Sinus Ostium Observation with Cone-beam Computed Tomography Using Jugal Point as Reference

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Imaging ranges of cone beam computed tomography (CBCT) is limited and there have been no reports on reference points on the face surface for effective capture of maxillary sinus ostium.

Using 49 cadavers, we performed CBCT imaging of maxillary sinus ostium in order to determine whether the jugal point could be used as a reference point.

The present findings indicated that the jugal point might be a useful surface landmark for CBCT imaging of the maxillary sinus ostium.

Key words：maxillary sinus, maxillary sinus ostium, CBCT, jugal point

Background

It is important to understand the shape of the ostium of the maxillary sinus in patients suspected to have maxillary sinusitis[1)]. The maxillary sinus ostium is located in the middle meatus, on the lateral nasal wall between the middle and inferior concha, while the ethmoid bulla and uncinate process of the ethmoid bone are located around it[2,3)]. The maxillary sinus and nasal cavity are wrapped with ciliated epithelium cells, by which ciliate action sweeps away secretions to the narrow opening of the maxillary sinus and into the nasal cavity. Moreover, the ostium of the maxillary sinus is present in the superior region of the sinus[4)]. In some cases, elevation of the maxillary sinus floor is performed for oral implant placement[5,6)], though secretions often increase due to of inflammation occurring following that surgical procedure[7)]. Therefore, it is important to understand the shape of the maxillary sinus ostium prior to the diagnosis of maxillary sinusitis that occurs postoperatively with dental implant surgery.

For preoperative diagnosis, observation of the cone-beam computed tomography (CBCT) imaging of both the floor and ostium of the maxillary sinus is useful. However, the lateral wall of the nasal cavity is quite complex[4)], thus it is difficult to decide which region to scan for lateral transmission imaging of the cranium. While no known study has reported regarding positioning landmark on the body surface of the CBCT device to obtain the ostium of the maxillary sinus. In this report, the jugal point, the point where the upper margin of the zygomatic arch

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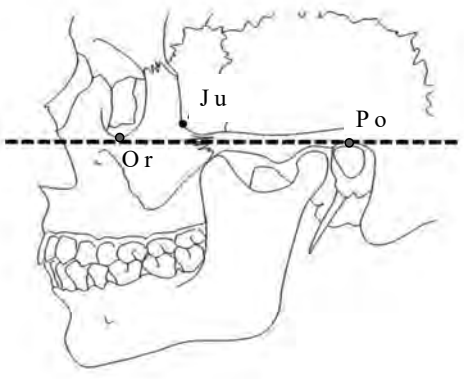

Fig. 1 Indicators for CBCT imaging
Ju : The jugal point, the point where the upper margin of the zygomatic arch bends sharply upwards at the anterior end.
Or-Po : The Frankfurt horizontal plane

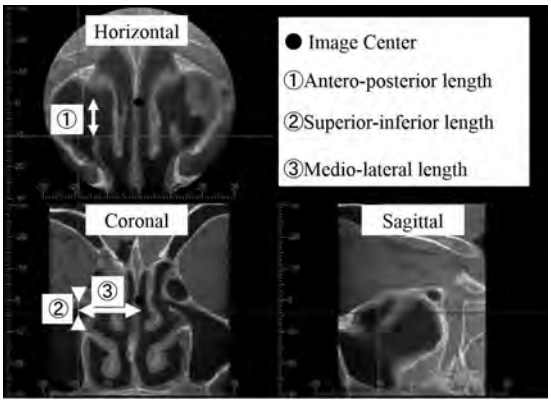

Fig. 2 Measurement items
Antero-posterior length was measured using horizontal CBCT images, while superior-inferior and medio-lateral lengths were measured using coronal CBCT images.

bends sharply upwards at the anterior end[8], was used as the reference.In the present study we set the jugal point as the reference landmark to obtain CBCT images of the maxillary sinus ostium. Thereafter, its position was determined on CBCT slice images. We found that use of the jugal point as a landmark allowed for obtaining useful CBCT images of the ostium.

Materials and Methods

Forty-nine cadavers (22 males with 44 sides; 27 females with 54 sides; average age 80.7 years) were used in this study. The Frankfurt horizontal plane of the cranium was set parallel to the floor. To decide the region to perform CBCT scanning, the reference guide for the coronal plane were set on the median line. The reference guide of the sagittal plane was set on the left jugal point (Fig. 1), where the upper margin of the zygomatic arch bends sharply upwards at the anterior end. CBCT images were obtained using a 3DX Multi Image Micro CT FPD (Morita, Kyoto, Japan), with scanning performed for 18 seconds at 80 kV and 5 mA. The distance from the center of each horizontal reconstructed CBCT image to the ostium of the maxilla was measured with used as antero-posterior length, while the vertical and horizontal distances from the center of the coronal plane to the ostium of the maxilla were measured with used as the superior-inferior and medio-lateral lengths respectively (Fig. 2). All measurements were performed using a Morita One Volume viewer (Morita, Kyoto, Japan). The study protocol was approved by the ethics committee of Ohu University (No.185).

A Kolmogorov-Smirnov normality test and an F-test were used for comparisons. Gender differences were compared using an unpaired t-test, with a P value less than 0.05 considered to indicate a significant difference.

Results

The antero-posterior length from the center to the ostium of the maxillary sinus on the CBCT images was 13.98±5.29 mm and 11.11±4.95 mm forward in males and females, respectively, while the average of all results was 12.55±5.28 mm forward. There was a significant difference between the genders. As for the superior-inferior length, that was 0.38±5.09 mm supra in males and 0.94±3.84 mm supra in females,

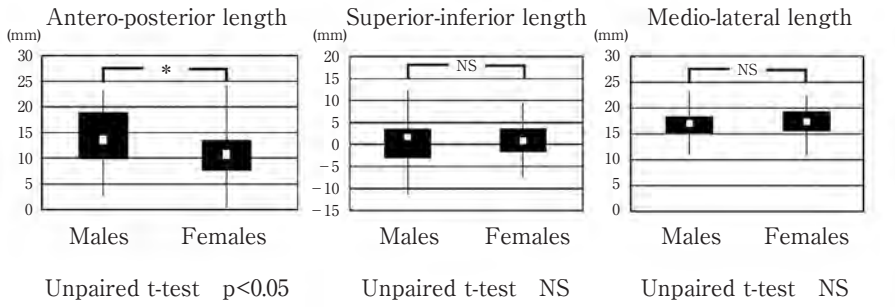

Fig. 3 Measurement results

with the average of all results 0.69±4.42 mm supra. There was no significant difference between the male and female subjects. Finally, the medio-lateral length was 16.97±2.79mm lateral in males and 17.29±2.61 mm lateral in females, and the average of all results was 17.13±2.68 mm lateral, with no significant difference between the genders (Fig. 3, Table. 1, 2).

Table. 1 Measurement results

Taotal		
	Mean(mm)	S.D.
Antero-posterior length	12.55 (forward)	5.28
Superior-inferior length	0.69 (supra)	4.42
Medio-lateral length	17.13 (lateral)	2.68

Table. 2 Measurement results of male and female subjects

Males		
	Mean(mm)	S.D.
Antero-posterior length	13.98 (forward)	5.29
Superior-inferior length	0.38 (supra)	5.09
Medio-lateral length	16.97 (lateral)	2.79
Females		
	Mean(mm)	S.D.
Antero-posterior length	11.11 (forward)	4.95
Superior-inferior length	0.94 (supra)	3.84
Medio-lateral length	17.29 (lateral)	2.61

Discussion

Generally, oral implants are used in the maxilla and mandible, though a notable anatomical feature is that the alveolar process of the maxilla is weaker than that of the mandible in most areas[9]. Moreover, the maxillary sinus, which is the largest paranasal sinus, is contained within the maxillary body. It shows age-related growth, with diameter and volume reaching their maximum size at 16 years of age[10]. The alveolar process shows atrophy after tooth loss[11], while the dimensions of the maxillary sinus are influenced by both aging and tooth loss[12]. Thus, the acceptable regions of oral implant placement are affected according to those limitations, with related surgical procedures, i.e., sinus floor elevation, related to the floor of the maxillary sinus occasionally performed prior to oral implant placement[5, 6, 13].

A maxillary hiatus is located on the nasal surface of the maxilla. In the cranial bone, along with the ethmoid bone, the inferior nasal concha and palatal bone exist on the lateral nasal wall, while the maxillary hiatus is narrowed and forms the hiatus semilunaris between the ethmoid bulla and uncinate process of the ethmoid bone. The hiatus semilunaris is covered by mucosa. The maxillary sinus opens to the nasal cavity through the ostium of the maxillary sinus in the hiatus semilunaris. The lateral wall of the

nasal cavity is quite complex[2,3]. The maxillary sinus functions as part of the respiratory system. Mucosa epithelium is composed of ciliated cells that function to drain secretions to the nasal cavity through the opening of the maxillary sinus in the superior region of the sinus[4]. The risk of development of sinusitis is largely dependent on the shape of the ostium of the maxillary sinus that opens through the nasal cavity.

Several reports have shown that the septa on the floor of the maxillary sinus has effects on membrane perforation during maxillary sinus floor elevation performed prior to oral implant placement in the maxillary molar region[14~17]. On the other hand, few studies have noted that the position of the ostium of the maxillary sinus can affect occurrence of postoperative complications following sinus floor elevation.

In the field of otorhinolaryngology, morphological studies regarding the relationship of the lateral nasal wall to endoscopic paranasal sinus surgery have been performed, including measurements from the nasal sill to lateral nasal wall landmarks[18]. However, those measurements were performed using the lateral nasal wall of embalmed half cadaver heads. The maxillary line is a surgical landmark defined as the curvilinear eminence on the lateral nasal wall from the anterior attachment of the middle turbinate to the root of the inferior turbinate[19,20]. On the other hand, there is no anatomical landmark for the ostium of the maxillary sinus on the lateral surface of the cranial bone.

CBCT imaging of the maxillary sinus in the field of dentistry is usually performed when planning maxillary sinus elevation and prior to diagnosis related to oral implant placement[21]. To obtain adequate images including the ostium of the maxillary sinus, it is important to understand its position, thus scout images are acquired with CBCT lateral transmission imaging of the cranium. The jugal point is a palpate landmark on the lateral cranium, the point where the upper margin of the zygomatic arch bends sharply upwards at the anterior end[8]. This point can be easily detected by palpation on the body surface. Therefore this point is considered suitable for use as a landmark for the ostium of the maxillary sinus. In the present study, we performed CBCT imaging using the jugal point landmark to show the location of the ostium of the maxillary sinus in the examined cadavers.

In all forty-nine cases, we were able to visualize the bilateral ostium of the maxillary sinus within a known range. We measured the distance from the midpoint of the CBCT image to the opening of the maxillary sinus ostium, which showed an antero-posterior length of 12.55±5.28 mm, superior-inferior length of 0.69±4.42 mm, and medio-lateral length of 17.13±2.68 mm. Using the jugal point and median line as landmarks, the bilateral ostium of the maxillary sinuses was included in the CBCT image region. The actual measurements in all of the present cadavers were less than 1 cm different from our image measurements. Furthermore, there were no significant differences found between males and females, except for antero-posterior length from the center to the ostium of the maxillary sinus.

Conclusion

The present findings suggest that the jugal point is useful as a palpate landmark to simultaneously visualize the bilateral ostium of the maxillary sinus by CBCT within the limited range of the obtained image. Increased imaging accuracy reduces total radiation dose for the patient. For measuring from the ostium of the maxillary sinus to the center of a CBCT image obtained using the jugal point landmark, our findings showed an antero-posterior length

of 12.55±5.28 mm forward, superior-inferior length of 0.69±4.42 mm supra, and medio-lateral length of 17.13±2.68 mm lateral. An accurate understanding of the position of the maxillary sinus ostium on images obtained with the jugal point as a landmark can ensure efficient diagnosis of maxillary sinus conditions.

Compliance with ethical standards
Conflicts of interest : None to declare

References

1) Yenigun, A., Fazliogullari, Z., Gun, C., Uysal, II., Nayman, A. and Karabulut, A.K. : The effect of the presence of the accessory maxillary ostium on the maxillary sinus. Eur. Arch. Otorhinolaryngol. **273** ; 4315-4319 2016
2) Isobe, M., Murakami, G. and Katakura, A. : Variations of the uncinated process of the lateral nasal wall with clinical implications. Clin. Anat. **11** ; 295-303 1998.
3) Hopkins, C. : Nose, Nasal cavity and paranasal sinuses. In Gray's anatomy, (Ed., Standring, S.) 41st Ed. ; 556-570 Elsevier, Livingstone Churchill 2016.
4) Paff, G, H. : The internal nose paranasal sinuses. In anatomy of the head and neck 1st Ed. ; 186-203 W.B. Saunders company, Philadelphia 1973.
5) Tatum, H, Jr. : Maxillary and sinus implant reconstructions. Dent. Clin. North. Am. **30** ; 207-229 1986.
6) Boyne, P.J. and James, R.A. : Grafting of the maxillary sinus floor with autogenous marrow and bone. J. Oral Surg. **38** ; 613-616 1980.
7) Lim, H.C., Kim, J.H., Choi, S.H., Yu, J.A. and Lee, D.W. : Conflicts between histologic and clinical/radiologic findings in functional endoscopic sinus surgery for managing maxillary sinusitis following sinus augmentation : A case report. Int. J. Oral Maxillofac. Implants. **34**; 1247-1253 2019
8) Harrison, R. J. : The individual bones of the cranium. In Cunningham's textbook of anatomy (Ed., Romanes, G. J.) 11th Ed. ; 105-132 Oxford University press London 1972.
9) Sicher, H. and DuBrul, E. L. : Structure and relations of the alveolar processes. In oral anatomy 6th Ed. ; 413-430 The C. V. Mosby company, Saint Louis 1975.
10) Lorkiewicz-Muszyñska, D., Kociemba, W., Rewekant, A., Sroka, A., Jończyk-Potoczna, K., Patelska-Banaszewska, M. and Przystańska, A. : Development of the maxillary sinus from birth to age 18. Postnatal growth pattern. Int J. Pediatr. Otorhinolaryngol. **79** ; 1393-1400 2015.
11) Berkovitz, B. K.B. : Oral cavity. In Gray's anatomy (Ed., Standring, S.) 41st Ed. ; 507-533 Elsevier Livingstone Churchill 2016.
12) Velasco-Torres, M., Padial-Molina, M., Avila-Ortiz, G., García-Delgado, R., O'Valle, F., Catena, A. and Galindo-Moreno, P. : Maxillary sinus dimensions decrease as age and tooth loss increase. Implant Dent. **26** ; 288-295 2017.
13) Lazaridis, N., Tilaveridis, I., Venetis, G. and Lazaridou, M. : Maxillary sinus osteoplasty with vascularized pedicled bone flap. Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod. **106** ; 828-832 2008.
14) Shen, E.C., Fu, E., Chiu, T.J., Chang, V., Chiang, C.Y. and Tu, H.P. : Prevalence and location of maxillary sinus septa in the Taiwanese population and relationship to the absence of molars. Clin. Oral Implants Res. **23** ; 741-745 2012.
15) Krennmair, G., Ulm, C.W., Lugmayr, H. and Solar, P. : The incidence, location, and height of maxillary sinus septa in the edentulous and dentate maxilla. J. Oral Maxillofac. Surg. **57** ; 667-671 1999.
16) Kim, M.J., Jung, U.W., Kim, C.S., Kim, K.D., Choi, S.H., Kim, C.K. and Cho, K.S. : Maxillary sinus septa : prevalence, height, location, and morphology. A reformatted computed tomography scan analysis. J. Periodontol. **77** ; 903-908 2006.
17) Van den Bergh, J.P., ten Bruggenkate, C.M., Disch, F.J. and Tuinzing, D.B. : Anatomical aspects of sinus floor elevations. Clin. Oral Implants Res. **11** ; 256-265 2000.
18) Calhoun, K.H., Rotzler, W.H. and Stiernberg, C.M. : Surgical anatomy of the lateral nasal wall. Otolaryngol Head Neck Surg. **102** ; 156-160 1990.
19) Chastain, J.B., Cooper, M.H. and Sindwani, R. : The maxillary line : anatomic characterization and clinical utility of an important surgical landmark. Laryngoscope. **115** ; 990-992 2005.
20) li, M.J., Nayak, J.V., Vaezeafshar, R., Li, G. and Psaltis, A.J. : Anatomic relationship of nasolacrimal duct and major lateral wall landmarks : cadaveric study with surgical implica-

tions. Int. Forum Allergy Rhinol. **4**；684-688 2014.
21) Ata-Ali, J., Diago-Vilalta, J.V., Melo, M., Bagán, L., Soldini, M.C., Di-Nardo, C., Ata-Ali, F. and Mañes-Ferrer, J.F.：What is the frequency of anatomical variations and pathological findings in maxillary sinuses among patients subjected to maxillofacial cone beam computed tomography? A systematic review. Med Oral Patol Oral Cir Bucal. **22**；e400-e409 2017.

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