การเปรียบเทียบความชุกและตำแหน่งของเส้นเลือดอัลวีโอลาร์แอนทรัลระหว่างขากรรไกรบนที่มีฟันและไม่มีฟันในกลุ่มผู้ป่วยชาวไทยโดยใช้ภาพถ่ายรังสีคอมพิวเตอร์ชนิดโคนบีม

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ปีการศึกษา 2558

COMPARISON OF THE PREVALENCE AND POSITION OF ALVEOLAR ANTRAL ARTERY BETWEEN EDENTULOUS AND NON-EDENTULOUS MAXILLAE IN A GROUP OF THAI POPULATION BY CONE BEAM COMPUTED TOMOGRAPHY

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A Thesis Submitted in Partial Fulfillment of the Requirements
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วัตถุประสงค์ เพื่อเปรียบเทียบความชุก ตำแหน่งและขนาดเส้นผ่านศูนย์กลางของเส้นเลือดอัลวีโอล่าแอนทรัลที่ตำแหน่งฟันหลังบนทั้งสี่ซี่ระหว่างขากรรไกรบนที่มีฟันและขากรรไกรบนที่ไม่มีฟัน

วัสดุและวิธีการศึกษา ภาพรังสีโคนบีมคอมพิวเตอร์ขากรราไกรบนจำนวน 184 ภาพ (ตำแหน่งฟันหลังบน 671 ซี่) นำมาใช้ในการศึกษา โดยศึกษาความชุก ตำแหน่ง (วัดระยะจากเส้นเลือดอัลวีโอล่าแอนทรัลไปยังสันกระดูกและระยะจากเส้นเลือดอัลวีโอล่าแอนทรัลไปยังพื้นไซนัสขากรรไกรบน) และศึกษาขนาดเส้นผ่านศูนย์กลางของเส้นเลือดอัลวีโอล่าแอนทรัลจากภาพรังสีตัดขวางบริเวณทั้งสี่ตำแหน่งซี่ฟันหลังบน

ผลการศึกษา ความชุกของเส้นเลือดอัลวีโอล่าแอนทรัลที่ตำแหน่งฟันกรามน้อยซี่แรก ฟันกรามน้อยซี่สอง ฟันกรามซี่แรก และฟันกรามซี่ที่สอง เท่ากับร้อยละ 17.7, 33.3, 30.2 และ 39.0 ตามลำดับ เมื่อเปรียบเทียบความชุกของเส้นเลือดอัลวีโอล่าแอนทรัลระหว่างขากรรไกรบนที่มีฟัน (ร้อยละ 59.3) และขากรรไกรบนที่ไม่มีฟัน (ร้อยละ 59.3) พบว่าไม่มีความแตกต่างทางสถิติ (P=0.213, เพียร์สันไคสแควร์) ระยะเฉลี่ยจากเส้นเลือดอัลวีโอล่าแอนทรัลไปยังสันกระดูกที่ตำแหน่งฟันกรามน้อยซี่แรก ฟันกรามน้อยซี่สอง ฟันกรามซี่แรก และฟันกรามซี่ที่สอง เท่ากับ 24.62 ± 3.55 มม, 20.35 ± 4.74 มม, 15.82 ± 4.09 มม and 15.93 ± 3.57 มม. เมื่อเปรียบเทียบระยะเฉลี่ยจากเส้นเลือดอัลวีโอล่าแอนทรัลไปยังสันกระดูกระหว่างขากรรไกรบนที่มีฟัน (18.32 ± 5.06 มม) และขากรรไกรบนที่ไม่มีฟัน (17.25 ± 4.94 มม) พบว่าไม่มีความแตกต่างทางสถิติ (P=0.236, อินดิเพ็นเด้นท์ทีเทส) ระยะเฉลี่ยจากเส้นเลือดอัลวีโอล่าแอนทรัลไปยังพื้นไซนัสขากรรไกรบนที่ตำแหน่งฟันกรามน้อยซี่แรก ฟันกรามน้อยซี่สอง ฟันกรามซี่แรก และฟันกรามซี่ที่สอง เท่ากับ 11.08 ± 4.49 mm, 8.01 ± 4.01 mm, 8.22 ± 4.43 mm, 7.39 ± 3.42 mm มม. เมื่อเปรียบเทียบระยะเฉลี่ยจากเส้นเลือดอัลวีโอล่าแอนทรัลไปยังสันกระดูกระหว่างขากรรไกรบนที่มีฟัน (8.00 ± 4.05มม) และขากรรไกรบนที่ไม่มีฟัน (9.02 ± 4.32 มม) พบว่าไม่มีความแตกต่างทางสถิติ (P=0.163, อินดิเพ็นเด้นท์ทีเทส) ค่าเฉลี่ยของเส้นผ่านศูนย์กลางของเส้นเลือดอัลวีโอล่าแอนทรัลที่ตำแหน่งฟันกรามน้อยซี่แรก ฟันกรามน้อยซี่สอง ฟันกรามซี่แรก และฟันกรามซี่ที่สอง เท่ากับ 1.15 ± 0.51 มม, 1.07 ± 0.36 มม, 1.27 ± 0.41 มม และ 1.11 ± 0.40 มม ตามลำดับ เมื่อเปรียบเทียบค่าเฉลี่ยของเส้นผ่านศูนย์กลางของเส้นเลือดอัลวีโอล่าแอนทรัลของกระดูกระหว่างขากรรไกรบนที่มีฟัน (1.14 ± 0.42 มม) และขากรรไกรบนที่ไม่มีฟัน (1.15 ± 0.37 มม) พบว่าไม่มีความแตกต่างทางสถิติ (P=0.969, อินดิเพ็นเด้นท์ทีเทส)

สรุป การศึกษานี้ไม่พบความแตกต่างอย่างมีนัยสำคัญทั้งความชุก ตำแหน่ง (วัดระยะจากเส้นเลือดอัลวีโอล่าแอนทรัลไปยังสันกระดูกและระยะจากเส้นเลือดอัลวีโอล่าแอนทรัลไปยังพื้นไซนัสขากรรไกรบน) และศึกษาขนาดเส้นผ่านศูนย์กลางของเส้นเลือดอัลวีโอล่าแอนทรัลทั้งสี่ตำแหน่งซี่ฟันหลังบนระหว่างขากรรไกรบนที่มีฟันและขากรรไกรบนที่ไม่มีฟัน

ภาควิชา ศัลยศาสตร์	ลายมือชื่อนิสิต ....
สาขาวิชา ศัลยศาสตร์ช่องปากและแม็กซิลโลเฟเชียล	ลายมือชื่อ อ.ที่ปรึกษาหลัก ....
ปีการศึกษา 2558	ลายมือชื่อ อ.ที่ปรึกษาร่วม ....

5675833832 : MAJOR ORAL AND MAXILLOFACIAL SURGERY
KEYWORDS: ALVEOLAR ANTRAL ARTERY / DENTATE MAXILLA / EDENTULOUS MAXILLA / MAXILLARY SINUS / CONE BEAM COMPUTED TOMOGRAPHY

C. MUNG SAN AUNG: COMPARISON OF THE PREVALENCE AND POSITION OF ALVEOLAR ANTRAL ARTERY BETWEEN EDENTULOUS AND NON-EDENTULOUS MAXILLAE IN A GROUP OF THAI POPULATION BY CONE BEAM COMPUTED TOMOGRAPHY. ADVISOR: ASSOC. PROF. ATIPHAN PIMKHAOKHAM, D.D.S., Ph.D., CO-ADVISOR: ASSOC. PROF. SOONTRA PANMEKIATE, D.D.S., M.D.Sc., Odont.Dr., 104 pp.

Objectives: Comparison of the prevalence, location and diameter of alveolar antral artery of four posterior maxillary teeth areas between dentate and edentulous maxilla.

Materials and methods: 184 maxillary sinuses (671 posterior maxillary teeth areas) cone beam computed tomographic images were retrospectively selected. The prevalence, location (artery to alveolar crest and artery to maxillary sinus floor) and diameter of alveolar antral artery were investigated in coronal view at four posterior maxillary teeth areas.

Results: Prevalence of alveolar antral artery canal at first premolar, second premolar, first molar and second molar areas was 17.7%, 33.3%, 30.2% and 39.0% respectively. Comparison of the prevalence of alveolar antral artery between dentate (59.3%) and edentulous (61.3%) was not statistically significant difference.(P=0.213, Pearson chi-square test) Mean distance of alveolar antral artery from alveolar crest was 24.62 ± 3.55 mm, 20.35 ± 4.74 mm, 15.82 ± 4.09 mm and 15.93 ± 3.57 mm at first premolar, second premolar, first molar and second molar appropriately. Comparison of distance of alveolar antral artery from alveolar crest between dentate (18.32 ± 5.06 mm) and edentulous (17.25 ± 4.94 mm) is not significant difference. (P=0.236, Independent t test) Mean distance of alveolar antral artery from maxillary sinus floor was 11.08 ± 4.49 mm, 8.01 ± 4.01 mm, 8.22 ± 4.43 mm, 7.39 ± 3.42 mm at first premolar, second premolar, first molar and second molar appropriately. Comparison of distance of alveolar antral artery from maxillary sinus floor between dentate (8.00 ± 4.05 mm) and edentulous (9.02 ± 4.32 mm) is not significant difference. (P=0.163, Independent t test) Mean diameter of alveolar antral artery canal was 1.15 ± 0.51 mm, 1.07 ± 0.36 mm, 1.27 ± 0.41 mm and 1.11 ± 0.40 mm at first premolar, second premolar, first molar and second molar respectively. Comparison of diameter of alveolar antral artery between dentate (1.14 ± 0.42 mm) and edentulous (1.15 ± 0.37 mm) is not significant difference. (P=0.969, Independent t test)

Conclusion: There was no significant difference of the prevalence, location (artery to alveolar crest and artery to maxillary sinus floor) and diameter of alveolar antral artery of four posterior maxillary teeth areas between dentate and edentulous maxilla.

Department:	Oral and Maxillofacial Surgery	Student's Signature	....
Field of Study:	Oral and Maxillofacial Surgery	Advisor's Signature	....
Academic Year:	2015	Co-Advisor's Signature	....

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1. INTRODUCTION

1.1 Background and rationale

Placing dental implants comes to be a viable treatment option when the remaining bone is sufficiently in good quality and quantity. However, placement of dental implant could fail and endanger the implantation process without bone augmentation in deficient alveolar ridge especially in posterior maxilla (1, 2).

In order to do reconstruction on insufficient remaining bone at posterior maxilla, short implant can been used under the strict clinical protocol, but it is likely to fail due to the poor quality of the bone (3). Even though implant-supported distal cantilever can also be utilized, it can have a higher failure rate with longer distal extension area (4). The placement of implant in maxillary tuberosity can also be an alternative approach, but it can damage the maxillary artery. Although zygomatic implant placement can be considered, this approach is not ready for every case because of complexity of the surgical procedure needing surgical skill of surgeon, special instruments and sometimes-general anesthesia prior to do surgical procedure (5).

Placing implant combined with maxillary sinus floor elevation and bone graft is a predictable method with high rate of success, and it is also effective and useful to overcome the limitation of restoring the insufficient posterior maxillary alveolar bone (1). Therefore, maxillary sinus floor elevation with bone graft became popular and the choice of technique for augmentation of remaining insufficient alveolar bone prior to placing implant (2, 6).

Maxillary sinus floor elevation can be done by two techniques; lateral window approach and transalveolar approach (7, 8). Transalveolar approach by osteotomes has been increasingly applied with the development of equipment, but it is difficult to secure a clear view, and the survival rate is low if the amount of residual bone is insufficient (9). Therefore, the lateral approach has been widely considered as a stable and predictable maxillary sinus bone graft.

While bone grafting via maxillary sinus floor elevation, detailed knowledge of anatomy of the maxillary sinus is mandatory. Maxillary sinus is a pyramidal shaped air spaced cavity that has an internal base and an apex extending to the zygomatic process of maxilla. Sometime septa may divide the sinus into two or more cavities. The Schneiderian membrane is attached to the bordering bone of the maxillary sinus. There are several vessels that supply the maxillary sinus, such as the posterior superior alveolar artery, the anterior superior alveolar artery, and the infraorbital artery. Posterior superior alveolar artery enters the posterior superior alveolar foramen on the maxillary tuberosity and gives off extraosseous and intraosseous branches anastomosing with infraorbital artery.

Anatomy and variation of the maxillary sinus that can interfere with maxillary sinus bone graft using lateral window approach include maxillary sinus septum, maxillary sinus diseases, and artery embedded in the lateral wall of the maxillary sinus (10). Maxillary sinus lesions and maxillary septa may cause Sheneiderian membrane perforation during surgery. The intraosseous branch of posterior superior alveolar antral artery (alveolar antral artery) running along the lateral wall of the maxillary sinus and anastomosing with the infraorbital artery can be damaged while removing the lateral bone of maxillary sinus. These vessels have to be taken into consideration during a sinus augmentation because of the potential risk of bleeding during the procedure (11).

Although bleeding is not life threatening, it could impair visualization and complicate augmentation procedure including elevation of the maxillary sinus membrane (10). Moreover, postoperative bleeding and hematoma formation may be occurred (12). Therefore, understanding of the prevalence, location and diameter of this artery is an important factor for increasing the success rate of maxillary sinus bone graft via lateral window approach.

In previous researches, the alveolar antral artery was studied with cadaver or computed tomography (CT) scan. Although the prevalence of artery was 100% in cadaver study (13, 14), 47 to 89% of artery were investigated in CT study (15, 16). Most of the former studies revealed the prevalence of the alveolar antral artery of the maxillary sinus, the diameter of alveolar antral artery and the location of alveolar antral artery calibrated from the alveolar crest and maxillary sinus floor at selected posterior maxillary teeth areas. There was no foregoing paper about comparison of the prevalence, location and diameter of alveolar antral artery of four posterior maxillary teeth areas between dentate and edentulous maxillae. Meanwhile, studying this artery on Thai people has not been found yet. Before performing sinus floor elevation via lateral window approach, concerning the prevalence, location and diameter of alveolar antral artery of every posterior maxillary teeth area is compulsory. Once the prevalence, location and diameter of alveolar antral artery is realized, the osteotomy can be accurately designed to prevent the vessel damage (12, 17).

Therefore, our objectives of this study were to perceive the prevalence, location and diameter of alveolar antral artery at four posterior maxillary teeth areas and compare those between dentate and edentulous maxillae by using cone beam computed tomography (CBCT).

1.2 Research Questions

1. Is the distance of alveolar antral artery from alveolar crest shorter in edentulous posterior maxilla than in dentate posterior maxilla?
2. Is the distance of alveolar antral artery from maxillary sinus floor longer in edentulous posterior maxilla than in dentate posterior maxilla?
3. Is the prevalence of alveolar antral artery more investigated in dentate posterior maxilla than in edentulous posterior maxilla?

1.3 Research Objectives

Compare the prevalence, location and diameter of alveolar antral artery between dentate and edentulous maxilla.

1.4 Research Hypothesis

1. The distance of alveolar antral atery from alveolar crest is shorter in edentulous posterior maxilla than in dentate posterior maxilla.
2. The distance of alveolar antral atery from maxillary sinus floor is longer in edentulous posterior maxilla than in dentate posterior maxilla.
3. The prevalence of alveolar antral artery is more investigated in dentate posterior maxilla than in edentulous posterior maxilla.

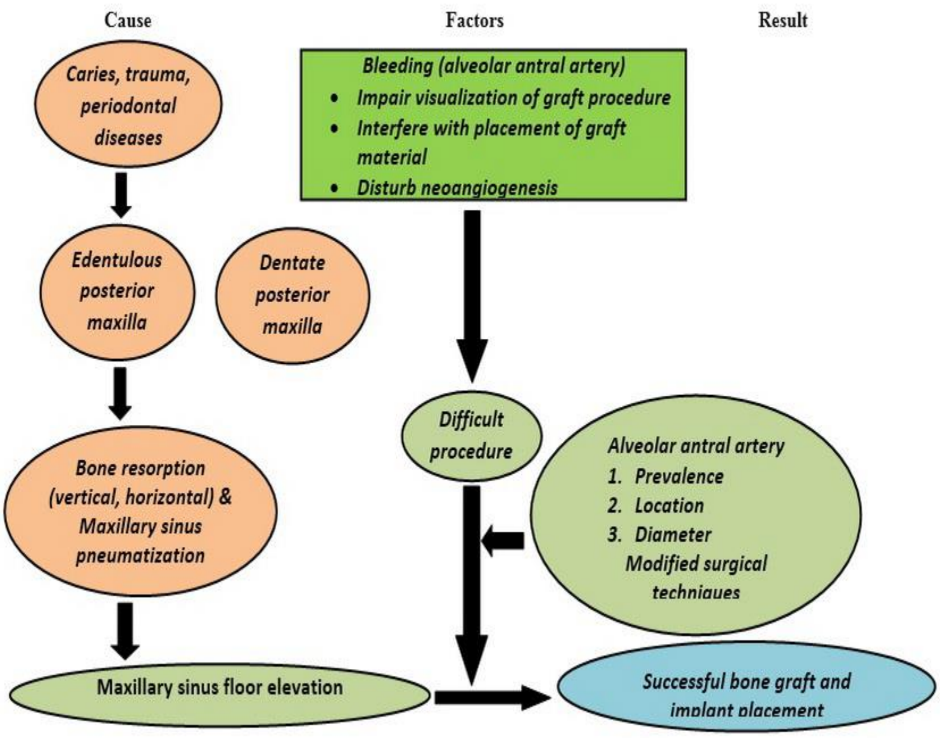
1.5 Benefits of our study

This is the first study of alveolar antral artery that is related to lateral approach of maxillary sinus floor elevation by using CBCT especially in a group of Thai population. Our average results will provide predicting the diameter, distance from alveolar crest and distance from sinus floor of alveolar antral artery that may help in preoperative planning of lateral approach of sinus lift surgery in order to reduce bleeding complication.

1.6 Limitation of our study

1. We did not know not only when and why the tooth was lost but also previous maxillary sinus problem that affected on bone loss.
2. Limitation of time due to data loss (before 2013, January) caused by server error.

1.7 Conceptual framework



2. LITERATURE REVIEWS

2.1 General anatomy of maxillary sinus

The maxillary sinus is the largest, the most constant of the paranasal sinuses and the first sinus to develop in utero. After birth, it grows rapidly in two periods, between birth and 3 years of life and between ages 7 and 18 years.

The maxillary sinus has a pyramidal shape with an anterior wall representing the facial surface of the maxilla. Its posterior bony wall separates it from the pterygomaxillary fossa medially and from the infratemporal fossa laterally. Its medial wall separates it from the nasal cavity. It does not contain any bone and it is formed by the middle meatus mucosa, a layer of connective tissue and the sinus mucosa.

The floor of the maxillary sinus is formed by the alveolar process of the maxillary bone and the hard palate. In children, it is situated at the nasal floor level and 5 to 10 mm below the nasal floor in mature age (18). The roof of the maxillary sinus corresponds to the floor of the orbit, and frequently shows a posteroanterior bony canal for the distal part of the second branch of the trigeminal nerve.

The Schneiderian (mucous) membrane is situated the inner walls of the sinus and in turn is covered by pseudo-stratified columnar ciliated epithelium. Serum-mucosa glands are located in the lamina directly underneath, especially next to the ostium opening. The thickness of the membrane ranges from 0.13mm to 0.5mm in general (19). However, inflammation or allergic phenomena may thicken it generally or locally.

Sometimes maxillary septum (Underwood septum) divide maxillary sinus into two or more cavities and separate maxillary sinus either totally or partially (20). Abnormally thin or thick sinus membrane and presenting maxillary septum can provide membrane perforation while performing sinus lift surgery (10).

2.2 Artery related to maxillary floor elevation

Three branches of maxillary artery; infraorbital artery, posterior lateral nasal artery, and posterior superior alveolar artery supply nutrient to the maxillary sinus (11).

Posterior superior alveolar artery anastomoses intraosseously with infraorbital artery. The intraosseous artery may be investigated at distance of 19mm from the sinus floor on computed tomography (19). Vascularization of the grafting material placed in sinus floor elevation procedure occurs via three routes *(Figure 1).*

Extraosseous anastomosis (EA): terminal branch of posterior superior alveolar artery anastomosis with infraorbital artery (IOA) extraosseously. It can be found at a mean height of 23 to 26 mm from the alveolar crest. This branch may provide hemorrhage while performing mucoperiosteal incisions (21).

Introsseeous anastomosis (IA) or alveolar antral artery: a second branch of posterior superior alveolar artery anastomose with infraorbital artery intraosseously. This branch can be probed at a distance of 18.9 to 19.6 mm from the alveolar margin.

Accidently cutting this artery can be faced during drilling the maxillary sinus lateral bone (21).

The middle portion of the maxillary sinus membrane is supplied by the sphenopalatine artery, the terminal branch of maxillary artery.

The presence of this anastomosis must be investigated to avoid hemorrhage during operation, which may occur if extra osseous artery is cut during flap preparation and periosteum releasing incision and if intraosseous artery is perforated drilling the lateral maxillary sinus bone.

During the sinus elevation procedure, surgeon who has little knowledge about anatomy of maxillary sinus blood supply can do injure these vessels accidently (10). Though bleeding caused by damaged artery is not life-threatening because only small blood vessel is involved, it may interfere with the elevation of the maxillary sinus membrane and fixation of bone graft material by obstructing the visual field during surgery. Although many papers reveal that only small vessel can be seen during lateral window approach, Testori et al, 2010 (12) reported that nearly 3 mm in diameter intraosseous artery was seen at that time of their operation and that vessel was ligated and cut for prevention of visual impairment of surgical field. The distance of the alveolar artery from the alveolar crest is closely related to the alveolar bone resorption and sinus pneumatization. The more the bone resorption and sinus pneumatization, the closer the artery to the alveolar crest. So, this closer distance of artery can cause vessel laceration during drilling the maxillary sinus lateral bone. The higher the distance of alveolar antral artery from the alveolar crest, the safer the procedure avoiding from vessel cut (22). Therefore, understanding of the artery's course and position is important prior to do the maxillary sinus floor elevation procedure for increasing the success rate of maxillary sinus bone graft (10).

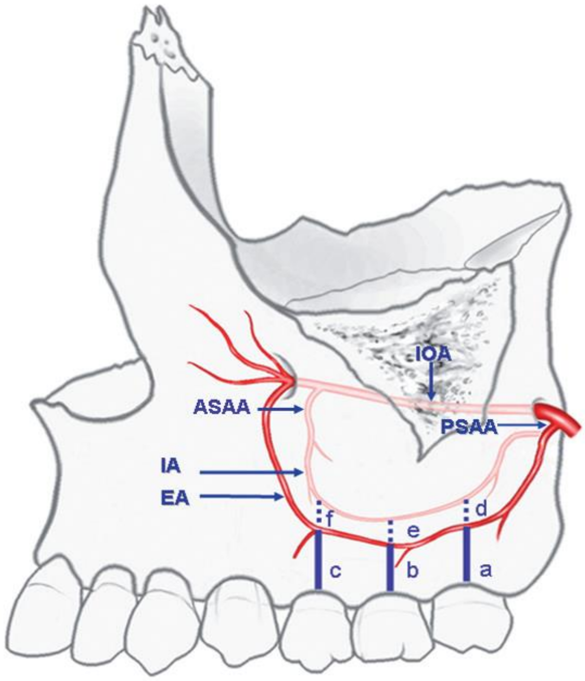


Figure 1. *Blood supply of the lateral wall of maxillary sinus*

IOA: infraorbital artery

ASAA: anterior superior alveolar artery

PSSA: posterior superior alveolar artery

IA: intraosseous anastomosis

EA: extraosseous anastomosis

2.3 Cone beam computed tomography (CBCT) and maxillary sinus floor elevation

The maxillary sinus is the paranasal sinus that impacts most on work of the oral and maxillofacial surgeons when treatment requires bone grafting in this area. Posterior maxillary bone augmentation via sinus lift is considered a conventional procedure for placing dental implant (1, 23). Cone beam computerized tomography (CBCT) is a gold standard for diagnosis and planning of sinus surgery (24). Understanding of the anatomic and functional relationships between the maxillary sinus and maxillary posterior teeth is important when dealing with maxillary sinus surgery planning. A significant difference in the bone height of the sinus floor exists between dentulous and edentulous individuals. Maxillary sinus expansion occurs with alveolar bone atrophy after the tooth loss (25).

The placement of the dental implants in patients with the above condition requires preprosthetic surgical procedures such as alveolar bone grafting and sinus floor elevation. Providing sinus lift with bone grafting to patients who have lost maxillary posterior teeth and surrounding bone requires radiological assessment. The opening of the maxillary sinus osteomeatal complex (OMC) is located high in the medial sinus wall. Compromised maxillary sinus drainage system is associated with a higher risk of postoperative sinusitis, and is a significant area in examining patient with sinus complaints, there may be a justification to extend the field of view (FOV) to include the whole of the maxillary sinus including the OMC. This information permits assessing the risk of surgical planning (26). Infection and edema due to allergy, trauma, and tumor can obstruct maxillary sinus (27). Reaction of dental surgery, sinus lift procedure and periodontal problem may thicken the mucosa in the maxillary sinus floor (28). Perforation of the sinus membrane during sinus floor elevation is the most common complication, with the incidence rate of approximately 30% (29). Maxillary sinus diseases and septum may cause membrane perforation during surgery (10). The intraosseous branch of posterior superior alveolar antral artery (alveolar antral artery) running along the lateral wall of the maxillary sinus and anastomosing with the infraorbital artery can be damaged while removing the lateral bone of maxillary sinus (5). Therefore anatomy and variations of the sinus; artery, septa and mucosal thickening can increase the risk of the sinus membrane perforation during implant surgery (30).

To obtain the above information and make a surgical planning prior to do sinus lift surgery, CBCT is mandatory.

Compared with medical CT scanners, CBCT devices offer a multimodal modality, giving comparable images of bone at sub millimeter resolution with inferior cost, both in financial and a substantially reduced footprint (31). Unlike CT, CBCT software is specific for maxillofacial applications. For many clinical dental situations, CBCT images are preferable to those from CBCT, particularly those requiring highly detailed sectional images of the osseous structures and teeth with generally low radiation dose burden.

Therefore, CBCT images also provide the information of the location of anatomic structures, bone dimensions and morphology (32). CBCT can accurately capture, display and provide 3-dimensional visualization of maxillofacial anatomy and pathology. In maxillary sinus floor elevation procedure, it is important to be acquainted with different anatomic and pathologic findings in sinus, to minimize the risk of postoperative complications.

Regarding the above, anatomic variations and lesions of the maxillary sinus are common findings in CBCT of the maxillofacial region in dental patients referred to pre-implant and sinus lift surgery. From the perspective of a dentist and maxillofacial surgeon, the evaluation of the maxillary sinus in CBCT appears to be relevant, additionally proprietary software has become available that will allow clinicians to manipulate digital images on a personal computer. Prospective investigations would further minimize risks and identify treatment requirements as part of interdisciplinary collaboration for the well-being of the patients. Today CBCT is an integrated diagnostic method to properly assess the risk and prognosis of treatment. It is advisable to develop clinical guidelines for a complete maxillary sinus examination so that nothing is overlooked and to provide successful oral rehabilitation and improving quality of life in dental patients.

2.4 Quality and quantity of the bone in edentulous posterior maxilla

After the tooth loss, alveolar bone resorption is occurred due to the periodontal diseases, caries and trauma, and this process makes difficult in implant placement (1). Frequently, molar teeth furcation leads to alveolar bone resorption because of inaccessibility to clean that area. It is also convenient to remove calculus because of narrow space. As a consequence, periodontal diseases and loss of bone height leads to loss of tooth.

Generally, posterior maxilla consists of a thin facial plate and the underlying trabecular bone has a low mineral content. Loss of posterior maxillary teeth can make reduced bone not only horizontally but also vertically at the expense of the labial plate. Because of this problem, the horizontal bone loss can be found more rapidly in posterior maxilla than other regions of the jaw (33).

This process of resorption is promoted by very low vascularization of the alveolar and trabecular bones. Even if it reduces by 60%, however, the remaining ridge is wide enough in the posterior maxilla for placing implant fixtures. Continuous bone resorption moves the crest of alveolar bone towards the palate at the expense of the bone width (34). Then, posterior maxilla leads to become atrophy until the overall alveolus is ablated to basal bone.

While the teeth are in function, maxillary sinus keeps its size but after the posterior teeth loss, it widens and this process leads to maxillary sinus pneumatization (33). The maxillary antrum expansion can be seen both posteriorly and anteriorly, probably occupying the canine region. After the teeth loss, the posterior maxillary bone amount is notably decreased, maxillary sinus expansion and pneumatization can be found. This occurrence is probably the consequence of atrophy due to decreased bone strain from the function of occlusion.

The osseointegrated implant success rate in posterior maxillary region is notably lower comparing with the implant success rate in the mandible (35). The causes of higher implant failure rates in the maxilla are due to poor bone quality and quantity (36). Bone density of maxilla is more inferior than that of mandibular and this cause unfavorable in osseointegration process (35). Moreover, the morphology and configuration of edentulous maxilla has revealed poor survival rates in conventional implant placement (37).

Maxillary bone consists of cortical (outer) and cancellous (inner) bone layers. Cortical bone has a higher modulus of elasticity and better osseointegration process to occur in a higher bone density comparing with cancellous bone (38). This is probably due to increased bone implant contact that creates a better strength of anchorage promoting implant stability (39). Regarding Leckholm and Zarb, the quality of jaw bones can be categorized into four groups (38) *(Figure 2)*.

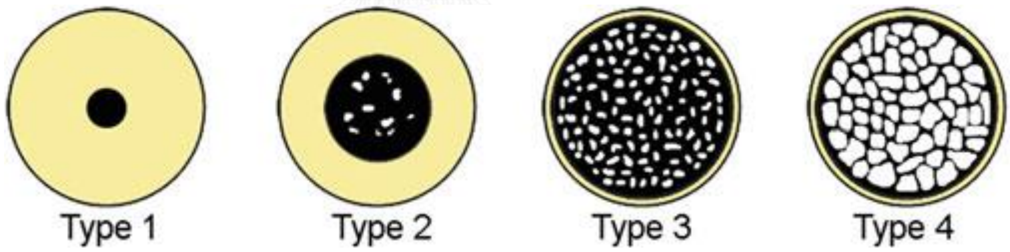


Figure 2*. Lekholm's classification of bone quality*

Type 1 bone consists of homogenous compact bone. Type 2 bone contains a dense cancellous bone core surrounded by cortical bone in 2 mm thickness. Type 3 bone has a core of dense cancellous bone surrounded by a thin layer of cortical bone and Type 4 bone consists of a thin layer of cortical bone surrounding a core of low density cancellous bone of poor strength. Normally, the anterior maxillary region can be classified as Type 3 whilst the posterior region or specifically the molar region is classified as Type 4. Mandible is basically more densely corticated than maxillae. It is noted that there is a high correlation between poor bone density and implant failure.

In dentistry, treatment plan depends on edentulous jaw type classification. Atrophic jaw bone involves vertical and horizontal alveolar bone loss as well as bone remodelling process that affects the external shape and the internal structure (40). This can be seen as chronic and irreversible fashion because of tooth extraction, trauma, infection, maxillary sinus pneumatization and ablative tumor surgery (41). The type of alveolar bone atrophy in maxilla and mandible is different that maxilla shows centripetal resorption but mandible reveals centrifugal resorption (42). Higher tendency of bone resorption is seen at the edge of alveolar bone rather than at the bottom part of the socket after the removal of tooth from the socket. According to Tallgren's classic study, more than 2 mm vertical bone loss was investigated in the anterior jawbone between the first year after teeth extraction and insertion of complete dentures.

Anyhow, the resorption rate of alveolar edge reduced to 0.05 mm/year in maxilla and 0.20 mm/year in mandible after the tooth loss (43).

The maxillary bone resorption will move the remaining alveolar bone superiorly and medially. In posterior maxillary region, critical bone atrophy can cause in Class VI thin bone layer with a characteristics of reduced cortical bone thickness, or in a more severe cases a total loss of bone as illustrated in *(Figure 3)* (35).

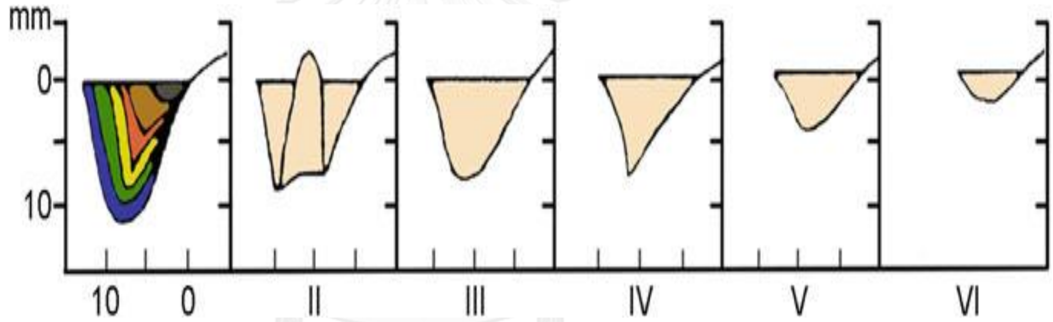


Figure 3. *Classification of jaw atrophy in posterior maxilla*

This is due to critical process of remodelling which happens within the cancellous bone itself after tooth extraction. The thin cortical bone layer reduced the implant anchorage power, causing loss of osseointegration. The insufficient bone quantity can be overcomed via various types of bone augmentation procedures for placing dental implant in the posterior maxillary region.

In order to do reconstruction on insufficient remaining bone at posterior maxilla, short implant can been used under the strict clinical protocol, but it is likely to fail due to the poor quality of the bone (3). Even though implant-supported distal cantilever can also be utilized, it can have a higher failure rate with longer distal extension area (4). The placement of implant in maxillary tuberosity can also be an alternative approach, but it can damage the maxillary artery. Although zygomatic implant placement can be considered, this approach is not ready for every case because of complexity of the surgical procedure needing surgical skill of surgeon, special instruments and sometimes-general anesthesia prior to do surgical procedure (5).

Placing implant combined with maxillary sinus floor elevation and bone graft is a predictable method with high rate of success, and it is also effective and useful to overcome the limitation of restoring the insufficient posterior maxillary alveolar bone (1). Therefore, maxillary sinus floor elevation with bone graft became popular and the choice of technique for augmentation of remaining insufficient alveolar bone prior to placing implant (2, 6).

2.5 Surgical technique of maxillary sinus floor elevation

Originally, maxillary sinus floor elevation was reported by Tatum in 1976 and afterward published by Boyne in 1980 (7, 8). This is the most common augmentation procedure in posterior maxillary area where maxillary sinus pneumatization and/or vertical bone loss has happened.

Recently, two approaches of the maxillary sinus floor elevation can be seen in the literature. The first approach (lateral window approach) is the classic and the more frequently performed technique by Tatum (7). More currently, Summers recommended a second approach (the crestal approach) using osteotomes (8).

In lateral window approach, crestal incision is started on the alveolar ridge. Occasionally, the incision line is made slightly palatal to the alveolar crest to preserve keratinized attached gingiva for solid wound closure and to prevent wound dehiscence. A full-thickness flap is then raised to allow access to the lateral antral wall. Lateral window is accomplished with a round bur to create a trapdoor on the lateral wall, once the flap has been raised. The height of trapdoor should not be beyond the width of the sinus to allow for a final horizontal position of the new floor.

The sinus membrane is then gently lifted from the floor of the sinus with an antral curette. It is necessary to free up the sinus membrane in three directions not only anteriorly and posteriorly but also medially before seeking the medial trapdoor. A space is created after the sinus membrane elevation. This space is grafted with different materials to obtain platform for placing implant. Autogenous bone such as iliac crest, chin, anterior ramus, and tuberosity plays as a gold standard in grafting. Hydroxyapatite alone or mixed with autogenous bone can been utilized alternatively (1). To prevent membrane necrosis, overfilling of grafted bone should be avoided.

Implants can be placed both simultaneously (1-stage approach) and after up to 12 months of grafting to allow graft maturation (2-stage approach). If the thickness of bone is 4 mm or less, simultaneous implant would be jeopardized in stability. So, 2-stage approach should be needed. Although 1-stage procedure is less time-consuming, it is more technically sensitive and its success rate depends on the amount of remaining bone (1) *(Figure 4).*

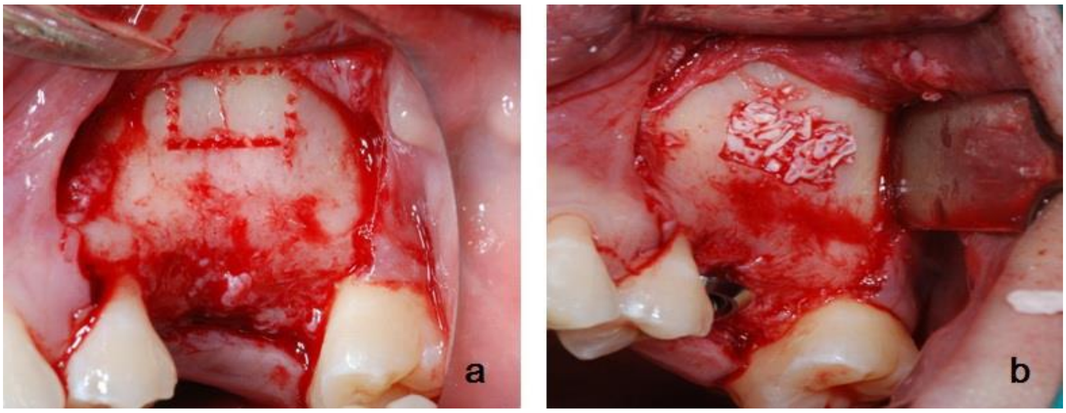


Figure 4. *Lateral window approach sinus floor elevation (a) Lateral window and (b) bone graft*

Crestal approach starts with a crestal incision. A full-thickness flap is then raised to make alveolar ridge exposure. The smallest size of osteotome is tapped by a mallet into the bone. The depth of osteotome extension depends on estimating preoperative bone height underneath the maxillary sinus.

Increased sizes of osteotome are introduced sequentially to provide alveolar bone expansion. After using the largest osteotome, grafted bone is put to the osteotomy hole. Choosing diameter of implant fixture should be a little bit larger than the osteotomy hole. It turns into the final osteotome, tenting the elevated sinus membrane (1).

Crestal approach by osteotomes has been increasingly applied with the development of equipment, but it is difficult to secure a clear view and the survival rate is low if the amount of residual bone is insufficient (9). Therefore, the lateral approach has been widely considered as a stable and predictable maxillary sinus bone graft.

2.6 Similar previous studies

According to Rosano et al. 2011 (22) in Italy, they studied 30 maxillary sinuses in cadaver and 200 maxillary sinuses by CBCT for investigation of the prevalence and position of alveolar antral artery. In cadaver study, they did injecting liquid latex mixed with green India ink through the external carotid artery and artery was investigated in 100% of cases. In CBCT study, artery was seen in only 47% of the cases and the position of artery was 11.25 ± 2.9 mm from the alveolar crest at first molar region.

Regarding Guncu et al. 2011 (44) from Turkey, 242 maxillary sinuses were studied for investigation of the prevalence and location of alveolar antral artery using CBCT. Prevalence was 64% and location was 18 ± 4.9 mm from the alveolar crest.

Kqiku et al, 2013 (14) (Austria) proved that artery was seen in 100% of the subjects and location of the artery was 14.7mm at second premolar, 14.5mm at first molar and 17.7mm at second molar regions from the alveolar crest in their cadaver study.

To regard with our literature review of 10 previous CT studies on 2100 maxillary sinuses, the prevalences of alveolar antral artery of maxillary sinus are the followings.

No.	Papers	Country	No. of sample	Detection rate
1.	Elian et al. 2005 (45)	France	50	52.9%
2.	Mardinger et al. 2007 (46)	Israel	208	55%
3.	Rosano et al. 2011 (22)	Italy	200	47%
4.	Guncu et al. 2011 (44)	Turkey	242	64.5%
5.	Park et al. 2012 (47)	Korea	93	54.8%
6.	Kang et al. 2013 (20)	Korea	150	64.3%
7.	Ilguy et al. 2013 (48)	Turkey	270	89.3%
8.	Kurt et al. 2014 (49)	Turkey	292	78%
9.	Apostolakis et al. 2014 (16)	Greece	312	82%
10.	Yang & Kye. 2014 (50)	Korea	283	32.5%
11.	Average of review		2100	62.03%

According to the Park et al, 2012 (47) (Korea), 93 maxillary sinuses were studied for the prevalence and location of the alveolar antral artery using CBCT. The results were the followings.

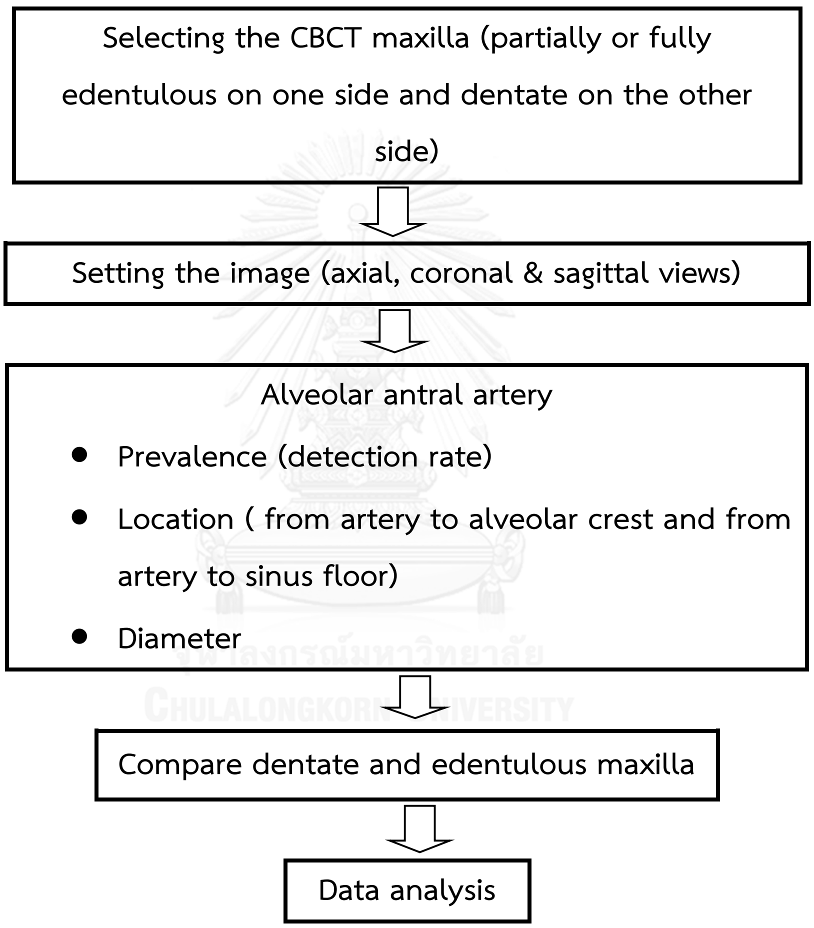
Distance of artery from alveolar crest		
Tooth area	Dentate	Edentulous
Premolar	20.62 ± 3.05 mm	18.83 ± 2.79 mm
Molar	17.50 ± 2.84 mm	15.50 ± 1.64 mm
Distance of artery from sinus floor		
Tooth area	Dentate	Edentulous
Premolar	8.21 ± 2.79 mm	7.75 ± 3.31 mm
Molar	7.53 ± 2.15 mm	7.97 ± 2.31 mm
Total prevalence of artery - 66.7 % (51/93)		

In this cases, the distance of alveolar antral from the alveolar crest was longer in dentate group than in edentulous group. The distance of the artery from maxillary sinus floor at molar area in dentate group was shorter than in edentulous group, but the distance of the artery from maxillary sinus floor at premolar area in dentate group was longer than in edentulous group and the measurement result was reverse. The prevalence was 66.7%.

Regarding the above papers, detection rate and location of the artery are different from country to country and some results are reverse. Today, the study of this artery in Thai people has not been seen in the literature yet. Therefore, we would like to know and investigate the prevalence, location (alveolar antral artery to alveolar crest and maxillary sinus floor) and diameter of alveolar antral artery in a group of Thai population between dentate and edentulous maxillae using CBCT.

3. MATERIAL AND METHODS

3.1 Research methodology framework



3.2 Study Design

This is retrospective study using the CBCT images of maxillary sinus.

3.3 Ethical Consideration

Our research was approved by Human Ethical Committee of Faculty of Dentistry, Chulalongkorn University on July 8, 2014. (Letter No. 050/2014)

3.4 Materials

3.4(a) Subjects

Maxillary CBCT images from patients undergoing CBCT imaging for implant therapy at the Department of radiology, Faculty of Dentistry, Chulalongkorn University, Bangkok, Thailand from 2013, January to 2015, May were retrospectively selected.

3.4(b) Inclusion Criteria

1. Image of CBCT maxilla was fully or partially edentulous on one side and dentate on the other side.
2. CBCT volumes that cover all maxillary teeth and maxillary sinus were included.

3.4(c) Exclusion Criteria

1. Pathology that could affect the calibration were excluded.
2. Poor quality of CBCT volume such as scattering and inferior level of window exposure were excluded.
3. Teeth with abnormal position in axial view that can provide wrong value of diameter while calibrating the diameter in tooth axis bucco-palatally were excluded for individual measurement of four posterior maxillary areas *(Figure 5).*

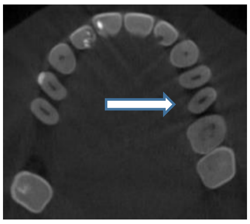


Figure 5. *Abnormal position of left maxillary second premolar in axial view.*

3.4(d) Data sampling method

According to the inclusive and exclusive criteria, records of CBCT maxilla were shortlisted. Sample size was calculated by the following formula (51). Sampling was done by simple random sampling method.

$$n = \frac{Z_{\alpha/2}^{2}\, p\, q}{d^2}$$

Where α = probability of type I error

= 0.05 (2-sided), $Z_{0.05/2} = Z_{0.025}$ = 1.96

p = Expected proportion e.g., prevalence = 0.62

q = 1- p = 0.38

d = allowable error in estimating prevalence = 0.07

(Margin of error)

$$n = \frac{(1.96)^2 (0.62) (0.38)}{(0.07)^2} = 184.71$$

3.5 Methods

3.5(a) Calibration

Calibration was done by a master student who is doing recent thesis under the close supervision of an experienced oral and maxillofacial radiologist and surgeon. Intra examiner variance was measured during the study on CBCT scans by reading twice of 20% of total cases by the reviewer. The two readings were separated by at least one month and the CBCT scans were selected randomly.

3.5(b) Image setting before measurement

All CBCT images were performed using 3D Accuitomo 170 (J Morita MFG. CORP., Kyoto, Japan) with 90 kVp, 5 mA, 17.5 seconds exposure time and field of view in 10 x 10cm. Images were reconstructed with 0.25 mm voxel size.

All the reconstructions and measurements were accomplished with the use of One Volume Viewer software (J Morita MFG. CORP., Kyoto, Japan). Appropriate background lighting and a Samsung computer (Intel(R) Core(TM) i3-3120M CPU @ 2.50GHz) (Samsung Electronics Co. Ltd, Korea) screen were applied for the analysis of the images.

3.5(c) Measurement of alveolar antral artery

The measurement reference points was the center of the first premolar, second premolars, first molar and second molar mesiodistally and bucolingually according to the tooth axis in axial view and at the level of bucal alveolar crest in coronal view *(Figure 6).*

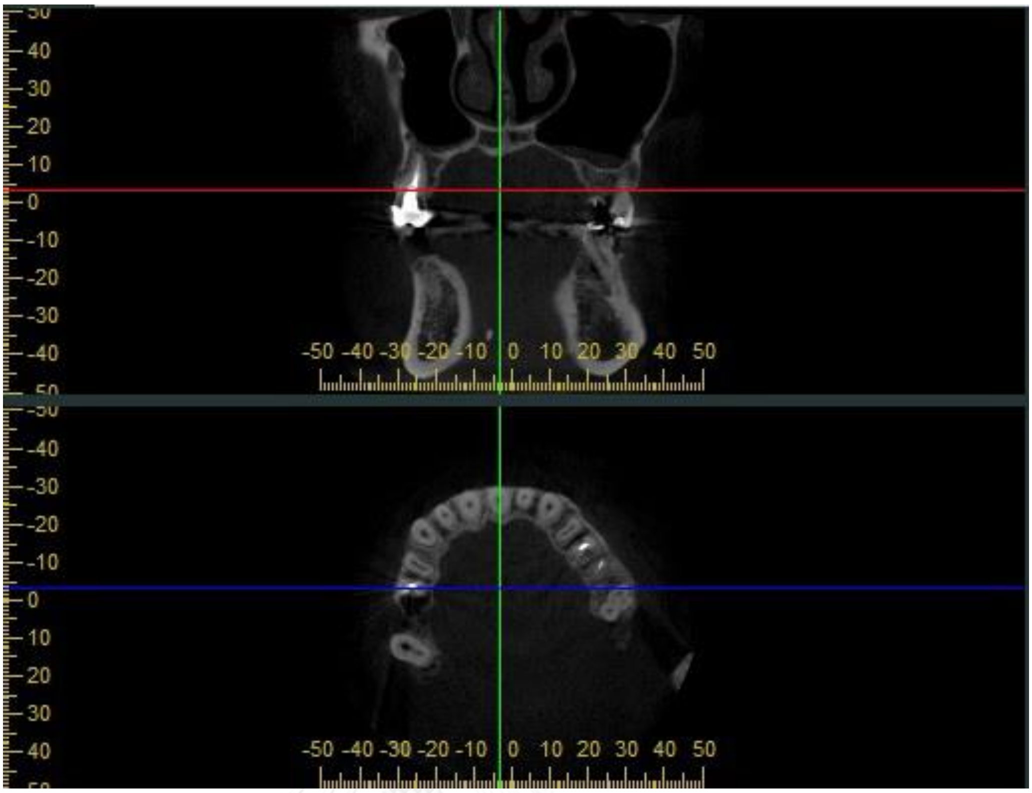


Figure 6. *Reference point of right maxillary second premolar*
(center of the tooth mesiodistally and bucolingually according to the tooth axis in axial view and at the level of buccal alveolar crest in coronal view)

To locate the measurement standard point in edentulous maxilla, equal distance from the adjacent tooth of dentate side was applied (47). To make the reference point at edentulous maxillary left second molar area, the measurement from the center of maxillary right first molar to the center of maxillary right second molar was done *(Figure 7-a).* Horizontal 180 degree plane was drawn from the center of maxillary right second molar and the line regarding the buccopalatal tooth axis of maxillary right second molar was also drawn. Then the angle between horizontal 180 degree plane and the line regarding tooth axis was measured *(Figure 7-b).* These two measurements were applied to make reference point in edentulous area. The measurement was done from the center of maxillary left first molar to obtain the value from the right dentate side and the tip of the measurement have to be the center of alveolar crest buccopalatally *(Figure 7-c).* The horizontal 180 degree plane was drawn from the tip of that measurement line and angulation was measured from that horizontal line until getting the same value from right dentate side. Then the line was drawn regarding to that angle and this line will be the reference line of edentulous maxillary second molar *(Figure 7-d).* All the reference points for edentulous areas were set like this.

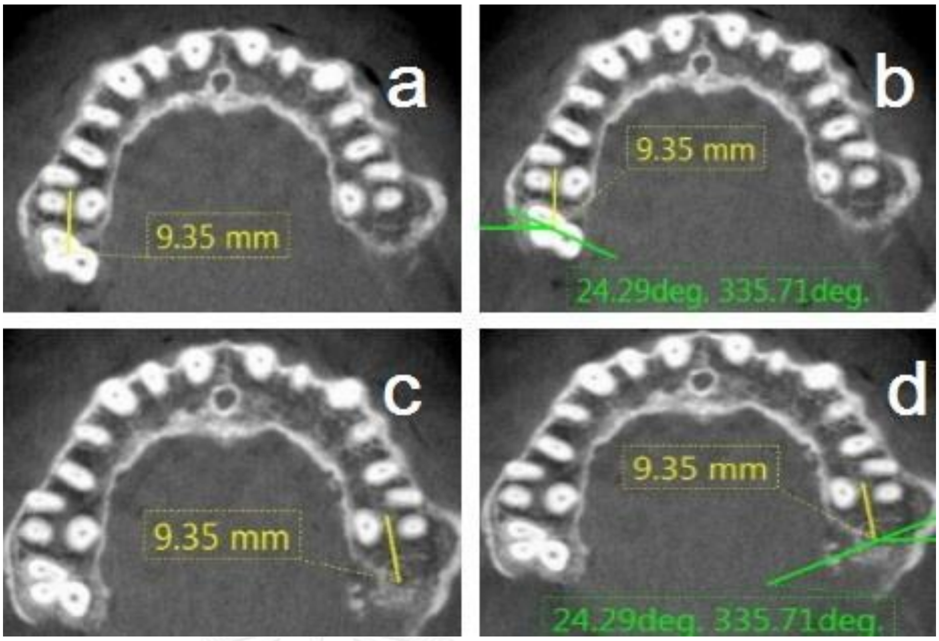


Figure 7. *Setting the reference point in edentulous area*

Then, in coronal view, the radiolucent structure artery canal that runs by being fully or partially embedded in the lateral wall of maxillary sinus at four areas of posterior maxilla (first premolar, second premolar, first molar and second molar) in both dentate and edentulous maxilla was examined. To distinguish the real artery canal and artificial defect generated while reconstructing CT images, axial, sagittal and coronal images will be contrasted to reconfirm that the regions contain artery *(Figure 8).*

Figure 8. *Real artery canal (a) axial view, (b) coronal view and (c) sagittal view*

If there is an artery, the diameter of artery was recorded as the greatest distance between the inner sides of the cortical bone in coronal view (16) *(Figure 9).* The distance from lower border of artery to the lowest point of the buccal alveolar ridges at the center of first, second premolars and first, second molars was measured vertically (44) *(Figure 9).* The distance from lower border of the artery to the lowest point of the maxillary sinus floor was also measured vertically (44) *(Figure 9).*

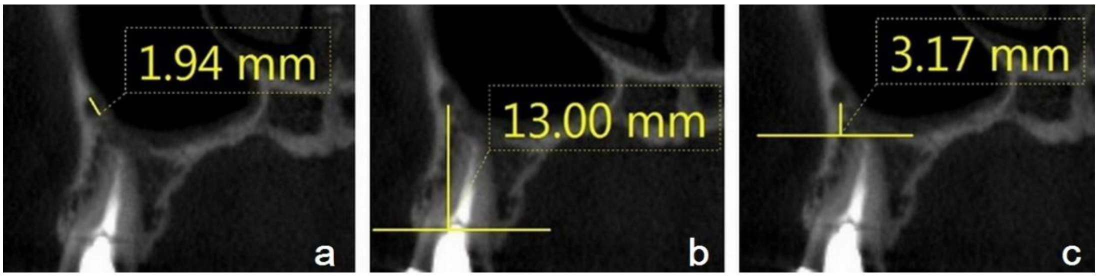


Figure 9. *Measurement of alveolar antral artery*
(a) Diameter (b) Distance of artery from alveolar crest (c) Distance of artery from maxillary sinus floor

Then the following parameters were evaluated.

(a) Prevalence of alveolar antral artery of maxillary sinus

According to Apostolakis & Bissoon. 2014 (16), artery canal investigated at least one of four posterior maxillary teeth areas represents the prevalence of artery canal of maxillary sinus.

(b) Prevalence of alveolar antral artery of four posterior maxillary teeth areas

(c) The distance of alveolar antral artery from alveolar crest of four posterior maxillary teeth areas

(d) The distance of alveolar antral artery from maxillary sinus floor of four posterior maxillary teeth areas

(e) Diameter of alveolar antral artery of four posterior maxillary teeth areas of four posterior maxillary teeth areas

(f) Classification of alveolar antral artery according to the position

Position of alveolar antral artery canal was divided into three types modified from Guncu et al. 2011 (44): (a) intraosseous - tunnel shape (b) intraosseous - circular shape (c) below the maxillary sinus membrane *(Figure 10)*.

(g) Classification of alveolar antral artery according to diameter

Diameter of the artery canal was classified into three groups according to Mardinger et al. 2007 (46): (a) diameter < 1 mm, (b) diameter 1 - 2 mm, and (c) diameter > 2 mm.

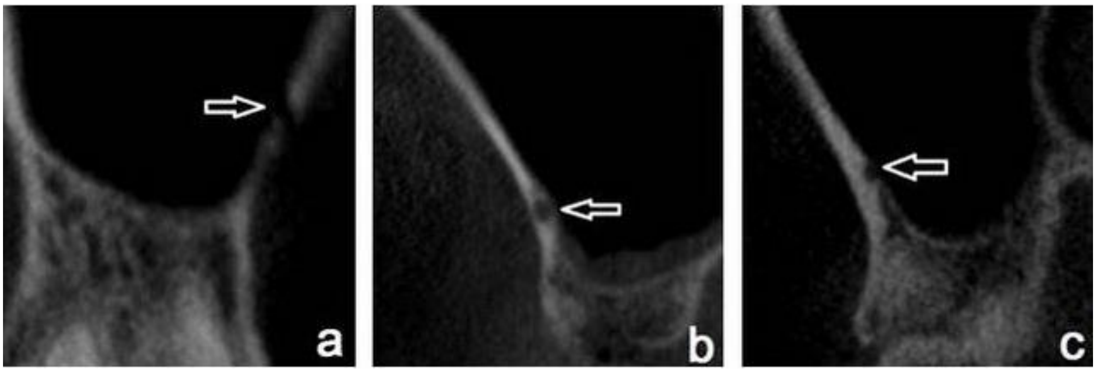


Figure 10. *Classification of alveolar antral artery according to position*

(a) Artery canal is situated intraosseously as a tunnel shape in the lateral wall of maxillary sinus in coronal view of CBCT image. (intraosseous - tunnel shape) (b) Artery canal is situated intraosseously as a circular shape in the lateral wall of maxillary sinus in coronal view of CBCT image. (intraosseous - circular shape) (c) Artery canal is situated below the membrane of maxillary sinus in coronal view of CBCT image. (below the maxillary sinus membrane)

3.6 Statistical analysis

All data were analyzed using the statistical software SPSS 22.0 (IBM, NY, USA). The prevalence of alveolar antral artery canal of maxillary sinus and four posterior maxillary teeth areas was compared according to gender and type of jaw using Pearson chi-square test. A significant correlation among the mean value and standard deviation of the distance of artery to alveolar crest, the distance of artery to sinus floor and diameter of artery of four posterior maxillary teeth areas were tested by ANOVA. The mean value and standard deviation of the distance of artery to alveolar crest, the distance of artery to sinus floor and diameter of artery canal of four posterior maxillary areas were compared not only between dentate and edentulous but also between male and female via independent t test. Pearson correlation was used to determine intraexaminer variance for 20% of total samples.

4. RESULTS

4.1 Demographic data

4.1(a) Maxillary sinuses

To regard with our selection criteria, 184 maxillary sinuses were satisfied. Ninety-one were dentate and ninety-three were edentulous maxilla *(Table 1).* Fifty-eight were in male and one hundred and twenty-six were in female *(Table 2).* Mean age and standard deviation of age was 51.16 ± 12.15 years and range from 19 to 84 years.

Table 1. *Dentate and edentulous maxillary sinuses*

Dentate	Edentulous	Total
91	93	184

Table 2. *Male and female maxillary sinuses*

Male	Female	Total
58	126	184

4.1(b) Four posterior maxillary teeth areas

Of total 746 posterior maxillary teeth areas, 671 areas were obtained by our selection criteria. Of 671 areas, 563 were dentate and 108 were edentulous maxilla *(Table 3).* In distribution of gender, 203 were male and 468 were female *(Table 4).*

Table 3. *Dentate and edentulous posterior maxillary teeth areas*

Tooth areas	Dentate	Edentulous	Total
1st premolar	122	8	130
2nd premolar	153	24	177
1st molar	131	51	182
2nd molar	157	25	182
All four areas	563	108	671

Table 4. *Male and female posterior maxillary teeth areas*

Tooth areas	Male	Female	Total
1st premolar	37	93	130
2nd premolar	54	123	177
1st molar	56	126	182
2nd molar	56	126	182
All four areas	203	468	671

4.2 Parameters

4.2(a) Prevalence of alveolar antral artery canal of maxillary sinus

The alveolar antral artery canal was detected in 111 of total 184 sinuses (60.3%). Comparison of the prevalence of artery canal of maxillary sinus between dentate side (54 of 91, 59.3%) and edentulous side (57 of 93, 61.3%) and between male (38 of 58, 65.5%) and female (73 of 126, 57.9%) was no statistically significant difference *(Table 5 & 6).*

Table 5. Prevalence of alveolar antral artery between dentate and edentulous maxilla

	Dentate (N=91)	**Edentulous** (N=93)	**Total** (N=184)
No. of detection (%)	54 (59.3)	57 (61.3)	111 (60.3)

P=0.880, Pearson chi-square test

Table 6. Prevalence of alveolar antral artery between male and female

	Male (N=58)	**Female** (N=126)	**Total** (N=184)
No. of detection (%)	38 (65.5)	73 (57.9)	111 (60.3)

P=0.418, Pearson chi-square test

4.2(b) Prevalence of alveolar antral artery canal of four posterior maxillary teeth areas

Of total 671 posterior maxillary teeth areas, artery canal was investigated at 208 areas (31.0%). Prevalence of alveolar antral artery canal at first premolar, second premolar, first molar and second molar areas was 17.7%, 33.3%, 30.2% and 39.0% respectively and statistically significant difference was discovered among them ($P < 0.001$, Pearson chi-square) *(Table 7)*.

Table 7. Prevalence of alveolar antral canal at four posterior maxillary teeth areas

Tooth area	No. of detection (%)
1st premolar (N=130)	23 (17.7)
2nd premolar (N=177)	59 (33.3)
1st molar (N=182)	55 (30.2)
2nd molar (N=182)	71 (39.0)
Total 4 areas (N=671)	208 (31.0)

P value = 0.001, Pearson chi-square test

Although, artery canal was more detected in dentate than edentulous at second premolar and second molar areas, more detection of artery canal was investigated in edentulous than dentate at first premolar area, first molar area and in total 4 areas. But, there was no statistically different significance between them *(Table 8).*

Table 8. Prevalence of alveolar antral artery between dentate and edentulous maxilla

Tooth area	The prevalence of artery canal n/ total (%)		P value*
	Dentate	Edentulous	
1st premolar	20/ 122 (16.4)	3/ 8 (37.5)	0.149
2nd premolar	52/ 153 (34.0)	7/ 24 (29.2)	0.816
1st molar	35/ 131 (26.7)	20/ 51 (39.2)	0.109
2nd molar	62/ 157 (39.5)	9/ 25 (36.0)	0.827
Total 4 areas	169/ 563 (30.0)	39/ 108 (36.1)	0.213

*Pearson chi-square test

Artery canal was significantly more detected in male than female at all teeth areas except second molar region. The prevalence of total four posterior maxillary teeth areas between male (42.9%) and female (25.9%) was also statistically different (P < 0.001, independent t test) *(Table 9).*

Table 9. Prevalence of alveolar antral artery between male and female

Tooth area	**The prevalence of artery canal** n/ total (%)		**P value***
	Male	**Female**	
1st premolar	11/ 37 (29.7)	12/93 (12.9)	0.039
2nd premolar	26/ 54 (48.2)	33/ 123 (26.8)	0.009
1st molar	26/ 56 (46.4)	29/ 126 (23.0)	0.003
2nd molar	24/ 56 (42.9)	47/ 126 (37.3)	0.513
Total 4 areas	87/ 203 (42.9)	121/ 468 (25.9)	<0.001

*Pearson chi-square test

4.2(c) The distance of alveolar antral artery canal from alveolar crest of four posterior maxillary teeth areas

Mean value of the measurement from artery to alveolar crest was 24.62 ± 3.55 mm, 20.35 ± 4.74 mm, 15.82 ± 4.09 mm and 15.93 ± 3.57 mm at first premolar, second premolar, first molar and second molar appropriately and there was statistically significant difference was seen among them (P value <0.001, ANOVA). Total four areas' mean value of the measurement from artery to alveolar crest was 18.12 ± 5.05 mm (range from 5.44 ± 37.08) *(Table 10).*

Table 10. Distance of alveolar antral artery from alveolar crest at four posterior maxillary teeth areas

Tooth area	Measurement (Mean ± SD) mm
1st premolar	24.62 ± 3.55
2nd premolar	20.35 ± 4.74
1st molar	15.82 ± 4.09
2nd molar	15.93 ± 3.57
Total 4 areas	18.12 ± 5.05

P value < 0.001, ANOVA

Mean value of the measurement from artery canal to alveolar crest was greater in dentate than edentulous at all posterior maxillary teeth areas and in total 4 areas except second premolar area. But comparison of that between dentate (18.32 ± 5.06 mm) and edentulous (17.25 ± 4.94 mm) was not statistically significant. (P - 0.236) *(Table 11).*

Table 11. Distance of alveolar antral artery from alveolar crest between dentate and edentulous maxilla

Tooth area	Measurement from artery to alveolar crest (Mean ± SD) mm		P value*
	Dentate	Edentulous	
1st premolar	24.73 ± 3.51	23.87 ± 4.49	0.706
2nd premolar	20.18 ± 4.91	21.62 ± 3.10	0.454
1st molar	15.98 ± 4.16	15.53 ± 4.08	0.697
2nd molar	16.00 ± 3.45	15.47 ± 4.48	0.679
Total 4 areas	18.32 ± 5.06	17.25 ± 4.94	0.236

*Independent t-test

4.2(d) The distance of alveolar antral artery canal from maxillary sinus floor of four maxillary teeth areas

Mean value of the measurement from artery to maxillary sinus floor was 11.08 ± 4.49 mm, 8.01 ± 4.01 mm, 8.22 ± 4.43 mm, 7.39 ± 3.42 mm at first premolar, second premolar, first molar and second molar appropriately and there was statistically significant difference was seen among them (P value = 0.002, ANOVA). Mean value of the measurement from artery to alveolar crest of total 4 areas was 8.19 ± 4.11 mm (range from 0.72 ± 19.56 mm) *(Table 12).*

Table 12. Distance of artery from maxillary sinus floor at four maxillary teeth areas

Tooth area	**Measurement** (Mean ± SD) mm
1st premolar	11.08 ± 4.49
2nd premolar	8.01 ± 4.01
1st molar	8.22 ± 4.43
2nd molar	7.39 ± 3.42
Total 4 areas	8.19 ± 4.11

P value = 0.002, ANOVA

Mean value of the measurement from artery canal to maxillary sinus floor was greater in edentulous than dentate at all posterior maxillary teeth areas and in total 4 areas except first premolar area. But comparison of that between dentate (8.00 ± 4.05 mm) and edentulous (9.02 ± 4.32 mm) was not statistically significant (P = 0.163) *(Table 13)*.

Table 13. Distance of artery from maxillary sinus floor between dentate and edentulous

Tooth area	Measurement from artery to sinus floor (Mean ± SD) mm		P value*
	Dentate	Edentulous	
1st premolar	11.39 ± 4.69	9.04 ± 2.39	0.411
2nd premolar	7.70 ± 4.10	10.21 ± 2.48	0.122
1st molar	7.68 ± 4.01	9.16 ± 5.05	0.235
2nd molar	7.33 ± 3.30	7.77 ± 4.36	0.722
Total 4 areas	8.00 ± 4.05	9.02 ± 4.32	0.163

*Independent t-test

4.2(e) Diameter of alveolar antral artery canal of four posterior maxillary teeth areas

Mean diameter of alveolar antral artery canal was 1.15 ± 0.51 mm, 1.07 ± 0.36 mm, 1.27 ± 0.41 mm and 1.11 ± 0.40 mm at first premolar, second premolar, first molar and second molar respectively and statistically significant difference was seen among them (P = 0.045, ANOVA). The mean diameter of total 4 areas was investigated to be 1.14 ± 0.41 mm (range from 0.50 to 2.70 mm) *(Table 14).*

Table 14. Diameter of alveolar antral artery at four posterior maxillary teeth areas

Tooth area	Diameter of artery (Mean ± SD)mm
1^{st} premolar	1.15 ± 0.51
2^{nd} premolar	1.07 ± 0.36
1^{st} molar	1.27 ± 0.41
2^{nd} molar	1.11 ± 0.40
Total 4 areas	1.14 ± 0.41

P value = 0.045, ANOVA

Even though mean diameter of artery canal was larger in dentate than edentulous at first premolar and second premolar areas, larger mean diameter artery canals was seen in edentulous at first molar, second molar areas and in total 4 areas. But comparison of that between dentate and edentulous at four posterior maxillary areas and in total 4 areas was not statistically significant *(Table 15).*

Table 15. Diameter of alveolar antral artery between dentate and edentulous maxilla

Tooth area	Diameter of artery canal (Mean ± SD) mm		P value*
	Dentate	Edentulous	
1st premolar	1.20 ± 0.52	0.81 ± 0.27	0.222
2nd premolar	1.09 ± 0.37	0.91 ± 0.37	0.215
1st molar	1.27 ± 0.40	1.28 ± 0.42	0.920
2nd molar	1.10 ± 0.42	1.15 ± 0.27	0.746
Total 4 areas	1.14 ± 0.42	1.15 ± 0.37	0.969

*Independent t-test

Diameter of artery canal was significantly larger in male than female at all teeth areas and in total 4 posterior maxillary teeth areas except first premolar region *(Table 16).*

Table 16. Diameter of alveolar antral artery between male and female

Tooth area	Diameter of artery canal (Mean ± SD) mm		P value*
	Male	Female	
1st premolar	1.21 ± 0.62	1.10 ± 0.39	0.595
2nd premolar	1.15 ± 0.36	1.00 ± 0.34	0.112
1st molar	1.44 ± 0.41	1.12 ± 0.34	0.003
2nd molar	1.34 ± 0.37	0.99 ± 0.36	<0.001
Total 4 areas	1.38 ± 0.46	1.02 ± 0.35	<0.001

*Independent t-test

4.2(f) Classification of alveolar antral artery canal according to the position

Artery canal is situated below the maxillary sinus membrane (58.7%), intraosseously as a tunnel shape (26.9%) and intraosseously as a circular shape (14.4%) *(Table 17).*

Table 17. Classification of artery according to position

Tooth area	Type 1 (n/ %)	Type 2 (n/ %)	Type 3 (n/ %)	Total N
1st premolar	3/ 13.0	11/ 47.8	9/ 39.1	23
2nd premolar	13/ 22.0	27/ 45.8	19/ 32.2	59
1st molar	8/ 14.5	43/ 78.2	4/ 7.3	55
2nd molar	6/ 8.5	41/ 57.7	24/ 33.8	71
Total 4 areas	30/ 14.4	122/ 58.7	56/ 26.9	208

Type 1 = intraosseous - circular shape, type 2 = below the maxillary sinus membrane, type 3 = intraosseous - tunnel shape.

4.2(g) Classification of alveolar antral artery canal according to the diameter

One to two mm diameter of artery canal was detected in 61.1% and < 1 mm diameter was in 37.0% while only 1.9% of > 2mm diameter was seen in total 4 areas. Like the result in total, 1 to 2 mm diameter artery canal was highly detected while < 1 mm diameter were in second and > 2 mm diameter arteries were in the lowest in all posterior maxillary teeth areas *(Table 18)*.

Table 18. Classification of artery canal according the diameter

Tooth area	< 1mm (n/ %)	1 to 2 mm (n/ %)	> 2mm (n/ %)	Total N
1st premolar	10/ 43.5	12/ 52.2	1/ 4.3	23
2nd premolar	23/ 39.0	35/ 59.3	1/ 1.7	59
1st molar	13/ 23.6	41/ 74.5	1/ 1.8	55
2nd molar	31/ 43.7	39/ 55.0	1/ 1.4	71
Total 4 areas	77/ 37.0	127/ 61.1	4/ 1.9	208

Pearson correlation test for intraexaminer variance was 0.987.

5. DISSCUSSION AND CONCLUSSION

5.1 Discussion

5.1 (a) Prevalence of alveolar antral artery canal of maxillary sinus

When the prevalence of artery canal ranges from 47 to 89.3% (16, 20, 22, 44-47), alveolar antral artery canal was evaluated in 111 of total 184 maxillary sinuses (60.3%) in our study. Although our result investigated on Thai people was relatively lower than the previous three reports (16, 48, 49) that revealed higher detection rate of artery canal, 89.3%, 78% and 82% respectively conducted on Turkish and Greece people, the result of our study was very similar to the value from the studies on (Asian) Korean population that revealed 52.9%, 54.8% and 64.3% (20, 47, 52). With regard to these values, artery canal was investigated less high via CBCT in Asian than European and Turkish. The possible another reasons of less detection rate of artery of our study than those three studies are due to different CBCT machines and resolution of CBCT that depends not only on voxel dimension but also on hardware, contrast resolution, artifacts and noises (53). When voxel size (0.25 mm) was applied in recent study, 0.2 mm was used in those three studies (16, 48, 49) that proved high detection rate, 89.3%, 78% and 82%. Therefore 0.2 mm and 0.4 mm diameter arteries were detected in the studies of Apostolakis et al. 2014 (16) and Ilguy et al. 2013 (48) studies respectively. However, less than 0.5 mm diameter artery could not be identified in our study. Anyhow, our result is still the same with the average prevalence (62.03%) of our literature review of 10 previous CT studies on 2100 maxillary sinuses.

To compare the prevalence of artery canal of maxillary sinus between male and female, our results showed no significant difference and this is the same with the Park et al. 2012 (47) and Ilguy et al. 2013 (48). However, Kim et al. 2011 (52) conducted higher detection was seen in male than female.

While higher prevalence was noticed in dentate than edentulous maxilla (48), there was no significant difference between them in our study. This is limitation of our research that we did not know when the tooth was lost. The longer duration of tooth loss can provide more of the bone resorption on that area (33). That can affect on the prevalence of artery canal at edentulous area (48).

5.1 (b) Prevalence of alveolar antral artery canal of four posterior maxillary teeth areas

At four posterior maxillary teeth areas, the artery canal was much more observed at second molar region (39.0%) than second premolar region (33.3%), first molar region (30.2%) and first premolar region (17.7%).

While higher prevalence was significantly noticed in dentate than edentulous maxilla in the study of Ilguy et al. 2013 (48), there was no significantly difference between them in our study. This is limitation of our research that we did not know when the tooth was lost. The longer duration of tooth loss can provide more of the bone resorption on that area (33). That can affect on the prevalence of artery at edentulous area (48). Although the previous result based on the prevalence of artery canal of maxillary sinus, our result came from the prevalence of artery canal of four posterior maxillary teeth areas.

Artery canal was significantly more detected in male than female while investigating at four posterior maxillary teeth areas except second molar region. The summarization of detection rate of total four posterior maxillary teeth areas was also statistically higher in male than female ($p < 0.001$). In the prevalence of artery canal of maxillary sinus, when there was no significant difference between male and female in our study according to Apostolakis & Bissoon. 2014 (16), Kim et al. 2011 (52) revealed higher detection rate was found in male. Definition of the prevalence of artery canal of maxillary sinus is that only artery investigated at least one of four posterior maxillary teeth areas represents the prevalence of artery canal of maxillary sinus (16). Interestingly, to confirm that detection of artery canal is higher in male than female, the value from the prevalence of artery of four areas of posterior maxillary teeth is clearly more realistic than that of the artery canal of maxillary sinus from previous studies' technique. With regard to our study at four posterior maxillary areas, we could conclude that greater detection of artery is observed in male than female.

5.1 (c) The distance of alveolar antral artery canal from alveolar crest of four posterior maxillary teeth areas

Artery canal is situated 24.62 ± 3.55 mm, 20.35 ± 4.74 mm, 15.82 ± 4.09 mm and 15.93 ± 3.57 mm from the alveolar crest at first premolar, second premolar, first molar and second molar appropriately in our study. The course of artery canal is curved with the most inferior site at first molar area and the most superior site at first premolar area. Location of artery canal at first premolar area is the safest for doing lateral osteotomy of sinus lift because of the highest distance from the alveolar crest among four posterior maxillary teeth areas. The nearest location of artery canal from alveolar crest is first molar area in our study and this is the same with Yang & Kye. 2014 (50) and Kurt et al. 1014 (49); 15.6 ± 4.06 mm and 24.6 ±7.9 mm from alveolar crest respectively. To compare with the result from Turkish people from Kurt et al. 2014 (49), artery canal is probed closer to the alveolar crest at first molar area in Asian than Turkish via our study based on Thai people and Yang & Kye 2014 (50) conducted on Korean. To avoid the accidental damage of alveolar antral artery, superior border of lateral window have to be up to 15 mm from the alveolar crest regarding Mardinger et al. 2007 (46) and Kang et al. 2013 (20) and they concluded that all of their cases were safe to perform surgery by their mean value from selected posterior maxillary areas. Although all posterior maxillary areas are safe for surgery with regard to mean value of our study, we investigated 55 cases of artery canal of total 208 (26%) located less than 15 mm from alveolar crest at molar areas. Therefore, to obtain good surgical outcome and reduce complications due to perforation of artery, CBCT is still necessary prior to perform surgery to locate the artery canal in every case.

To compare the distance of artery canal from alveolar crest between dentate and edentulous, there was significantly higher in dentate than edentulous maxilla in the studies of Rosano et al. 2011 (22), Park et al. 2012 (47) and Ilguy et al. 2013 (48). However there was no statistically significant difference in our study even greater mean value distance was found at all teeth areas and in total four posterior maxillary teeth areas of dentate maxilla except second premolar area that is due to abnormally very high location of one artery canal (37.08 mm from alveolar crest) investigated at second premolar area in edentulous maxilla. The possible reasons of no difference of artery canal location from alveolar crest between dentate and edentulous maxilla is our limitation of study that we did not know when the tooth was lost. The longer duration of tooth loss can provide more of the bone resorption on that area (33). And there was correlation between bone resorption and location of artery canal that is closer to the alveolar crest (48). Another reasons is only the images of the patients scheduled for sinus lift surgery were used as samples in the previous study (22). But we utilized images from the patients who planned for implant placement. Therefore, the situation of quantity of remaining bone may be different between the previous study and our study. The last reason is that although our results come from the measurement at four posterior maxillary teeth areas, selected posterior maxillary teeth areas were used to do calibration in previous study.

5.1 (d) The distance of alveolar antral artery canal from maxillary sinus floor of four posterior maxillary teeth areas

The distance from artery to maxillary sinus floor was 11.08 ± 4.49 mm, 8.01 ± 4.01 mm, 8.22 ± 4.43 mm, 7.39 ± 3.42 mm at first premolar, second premolar, first molar and second molar appropriately. While the shortest distance from artery canal to sinus floor was measured at first premolar area in Hur et al. 2009 (54), Kurt et al. 2014 (49) and our study revealed at second molar area. Although Hur et al. 2009(54) and Kurt et al. 2014 (49) investigated that the longest distance of artery canal from sinus floor was at first molar area, the highest location of artery canal was detected at first premolar area in our study. The mean distance of the artery canal of four posterior maxillary teeth areas from sinus floor was 8.19 ± 4.11 mm in our study and 9.73 mm in Hur et al. 2009(54) that is conducted on Korean people. To compare with the mean value (13.25 mm) of Kurt et al. 2014 (49) studied on Turkish, alveolar antral artery is more close to the maxillary sinus floor in Asian than Turkish.

To compare the distance from artery canal to maxillary sinus floor between dentate and edentulous maxilla, greater mean distance from artery to sinus floor was investigated at all teeth area and in total 4 areas of edentulous maxilla except first premolar area. At first premolar area, greater distance was seen in dentate maxilla. Our result is nearly the same with the report of Park et al. 2012 (47) measured at two areas (between premolars and between first molar and second molar) that greater distance was found at molar area in edentulous maxilla but at premolar area, greater distance was investigated in dentate maxilla oppositely. Both our result and report of Park et al. 2012 (47) were statistically not significant between dentate and edentulous maxilla. When the teeth are in function, size of maxillary sinus is stable, but sinus expends not only posteriorly but also anteriorly after the posterior maxillary teeth are lost (34). However, there was no sinus expansion at first premolar area in edentulous maxilla in our study. We do agree with Jung et al. 2009 (55) that very low pneumatization can be occurred at anterior maxillary sinus after the tooth extraction. Another reason is limitation of our study that we did not know the duration of the tooth loss as we mentioned earlier.

5.1 (e) Diameter of alveolar antral artery canal of four posterior maxillary teeth areas

In our study, diameters of artery canal of four posterior maxillary teeth areas were 1.15 ± 0.51 mm, 1.07 ± 0.36 mm, 1.27 ± 0.41 mm and 1.11 ± 0.40 mm at first premolar, second premolar, first molar and second molar respectively. Although Rahpeyma et al. 2014 (56) stated that the least risk of bleeding tendency be at second molar area due to presenting smallest diameter of artery canal at that area, our result reveal that surgery at second premolar area is the safest (1.07 ± 0.36 mm diameter of artery canal). But we agree with Rahpeyma et al. (56) artery canal does not have a constant diameter even in the same artery.

There was no significant difference of mean diameter of artery canal between dentate and edentulous in our study. Although Pietrokovski. 1975 (33) proposed alveolar bone resoption is occurred not only in width but in height after the tooth loss, Apostolakis & Bissoon. 2014 (16) concluded that maxillary sinus expansion and lateral bone resorption are far lower chance than alveolar bone resorption. The result of Mardinger et al. 2007 (46) revealed there was no correlation of diameter of artery canal between in presence of teeth and absence of teeth areas. Therefore, we can conclude that diameter of artery canal is not different between in dentate and edentulous maxilla.

In the study of diameter of artery canal of four posterior maxillary teeth areas, larger diameter of artery canal was investigated in male than female at all areas. At first molar region, second molar region and in total 4 areas, diameter of artery canal of male was remarkably larger than that of female. Interestingly, all > 2 mm diameter artery canals (4 of 208/ 1.9%) were investigated only in male.

5.1 (f) Classification of alveolar antral artery canal according to the position

In the position of artery canal, while Guncu et al. 2011 (44) and Ilguy et al. 2014 (48) mentioned intreosseous - tunnel shape, below the membrane and outer the cortex of lateral sinus wall, intraosseous - circular shape, intraosseous - tunnel shape and below the membrane were investigated in our research. Instead of outer the cortex artery canal, intraosseous - circular type was discovered in our study. Although intraosseous - tunnel artery canals were the most detected in previous two studies; 68.2% (44) and 71.1% (48), below the membrane type was the highest (58.7%) of all four maxillary teeth areas and in overall in our investigation. Our result based on the measurement at four posterior maxillary teeth areas, but the previous two papers did not mentioned where and how many areas the calibration was performed.

5.1 (g) Classification of alveolar antral artery canal according to the diameter

In classification of diameter of artery canal, 1 to 2 mm in diameter were the highly detected and followed by < 1 mm and > 2 mm at four posterior maxillary teeth areas. In average of four posterior maxillary teeth areas, 1 to 2 mm diameter were highly discovered (61.1%) and the second one was < 1 mm (37%) and the last was > 2 mm (1.9%) This is the same with Guncu et al. 2011 (44); 1 to 2 mm diameter (51.4%), less than 1 mm (36.1%) and > 2 mm (12.3%). Like this study, > 2 mm diameter was the lowest detection in the previous four studies; 6.7% (46), 12.3% (44), 4.35 (22) and 4% (16). To compare with those, > 2mm diameter artery canal was more rarely detected in our research. The smallest diameter that we investigated was 0.5 mm (only 2 numbers). Our result is comparable with Rahpeyma et al. 2014 (56) that less than 0.5mm diameter artery canal were not detected.

5.2 Conclusion

We retrospectively examined 671 posterior maxillary areas (first premolar to second molar) on 184 maxillary sinuses via CBCT images. There were no significant differences of the prevalence of alveolar antral artery canal, the distance of alveolar antral artery canal from alveolar crest, the distance of alveolar antral artery canal from maxillary sinus floor and diameter of alveolar antral artery between dentate and edentulous maxilla

5.3 Further study

The measurement of alveolar antral artery to alveolar crest along the lateral border of alveolar bone *(Figure 11)* is clinically more useful than our measurement technique. Comparison of alveolar antral artery between fully edentulous on one side and fully dentate on the other will be more effective to obtain information between dentate and edentulous maxilla. The combined study of all maxillary sinus anatomy that can cause immediate complication in sinus lift surgery such as maxillary sinus septum, maxillary sinus membrane and alveolar antral artery will provide more useful information in sinus lift surgery than separate maxillary sinus anatomical study.

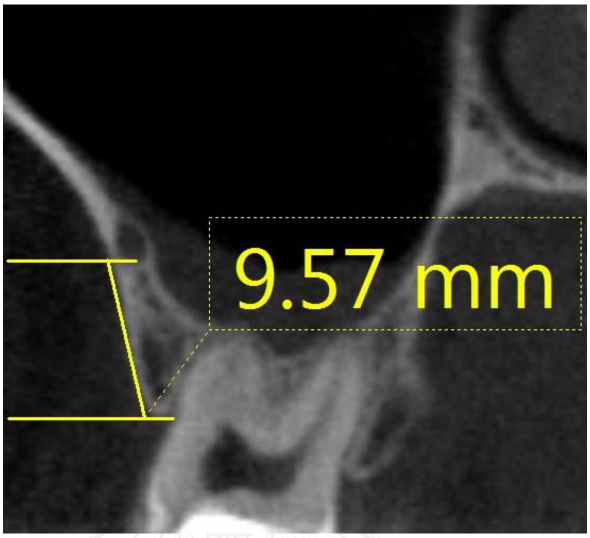


Figure 11. Distance of alveolar antral artery to alveolar crest along the lateral border of alveolar bone.

REFERENCES

1. Woo I, Le BT. Maxillary sinus floor elevation: review of anatomy and two techniques. Implant dentistry. 2004 Mar;13(1):28-32. PubMed PMID: 15017301.

2. Pjetursson BE, Tan WC, Zwahlen M, Lang NP. A systematic review of the success of sinus floor elevation and survival of implants inserted in combination with sinus floor elevation. J Clin Periodontol. 2008;35(s8):216-40.

3. Anitua E, Orive G, aguirre JJ, Andia I. Five-year clinical evaluation of short dental implants placed in posterior areas: A retrospective study. J Periodontol. 2008;79 Number 1:42-7.

4. Jaffin RA, Berman CL. The Excessive Loss of Branemark Fixtures in Type IV Bone: A 5-Year Analysis. J Periodontol. 1991;62(1):1-4.

5. Maló P, Nobre MdA, Lopes A, Ferro A, Moss S. Extramaxillary Surgical Technique: Clinical Outcome of 352 Patients Rehabilitated with 747 Zygomatic Implants with a Follow-Up between 6 Months and 7 Years. Clinical implant dentistry and related research. 2015; 17, Supplement 1:153-62.

6. Smiler DG, Johnson PW, Lodaza JL, Mish C, Rosenlicht JL, Tatum OH. Sinus lift grafts and endosseous implant: Treatment of the atrophic maxilla. Dent Clin North Am. 1992;36:151-86.

7. Tatum HJ. Maxillary and sinus implant reconstructions. Dent Clin North Am. 1986;30:207-29.

8. Summers RB. A new concept in maxillary implant surgery: the osteotome technique. Compendium. 1994;15:152-6.

9. Rosen PS, Summers R, Mellado JR, Salkin LM, Shanaman RH, Marks MH. The Bone-Added Osteotome Sinus Floor Elevation Technique: Multicenter Retrospective Report of Consecutively Treated Patients. The International journal of oral & maxillofacial implants. 1999;14:853-8.

10. Zijderveld SA, van den Bergh JP, Schulten EA, ten Bruggenkate CM. Anatomical and surgical findings and complications in 100 consecutive maxillary sinus floor elevation procedures. Journal of oral and maxillofacial surgery : official journal

of the American Association of Oral and Maxillofacial Surgeons. 2008 Jul;66(7):1426-38. PubMed PMID: 18571027.

11. Ella B, Sedarat C, Noble Rda C, Normand E, Lauverjat Y, Siberchicot F, et al. Vascular connections of the lateral wall of the sinus: surgical effect in sinus augmentation. The International journal of oral & maxillofacial implants. 2008 Nov-Dec;23(6):1047-52. PubMed PMID: 19216273.

12. Testori T, Rosano G, Taschieri S, Del Fabbro M. Ligation of an unusually large vessel during maxillary sinus floor augmentation. A case report. European journal of oral implantology. 2010 Autumn;3(3):255-8. PubMed PMID: 20847995.

13. Rosano G, Taschieri S, Gaudy JF, Del Fabbro M. Maxillary sinus vascularization: a cadaveric study. The Journal of craniofacial surgery. 2009 May;20(3):940-3. PubMed PMID: 19461336.

14. Kqiku L, Biblekaj R, Weiglein AH, Kqiku X, Stadtler P. Arterial blood architecture of the maxillary sinus in dentate specimens. Croatian medical journal. 2013 Apr;54(2):180-4. PubMed PMID: 23630145. Pubmed Central PMCID: 3641875.

15. Elian N, S W, SC C, ZN J. Distribution of the maxillary artery s it relates to sinus floor augmentation. J Oral Maxillofac Implants. 2005;20(5):784-7.

16. Apostolakis D, Bissoon AK. Radiographic evaluation of the superior alveolar canal: measurements of its diameter and of its position in relation to the maxillary sinus floor: a cone beam computerized tomography study. Clinical oral implants research. 2014 May;25(5):553-9. PubMed PMID: 23413918.

17. Maridati P, Stoffella E, Speroni S, Cicciu M, Maiorana C. Alveolar antral artery isolation during sinus lift procedure with the double window technique. The open dentistry journal. 2014;8:95-103. PubMed PMID: 24949106. Pubmed Central PMCID: 4062959.

18. Cauwenberge PV, Sys L, Belder TD. Anatomy and physiology of the nose and paranasal sinuses. Immunol Allgery Cli North Am 2004;24 (1):1-17.

19. Fabbro MD, Testori T. Anatomy of maxillary sinus. Textbook of maxillary sinus surgery and alternatives in treatment. 2009;Chapter-2(8-21).

20. Kang SJ, Shin SI, Herr Y, Kwon YH, Kim GT, Chung JH. Anatomical structures in the maxillary sinus related to lateral sinus elevation: a cone beam computed

tomographic analysis. Clinical oral implants research. 2013 Aug;24 Suppl A100:75-81. PubMed PMID: 22150785.

21. Solar P, Geyerhofer U, Traxier H, Windisch A, Ulm C, Watzek G. Blood supply to the maxillary sinus relavent to sinus floor elevation procedures. clinical Oral Implant Research. 1999;10:34-44.

22. Rosano G, Taschieri S, Gaudy JF, Weinstein T, Del Fabbro M. Maxillary sinus vascular anatomy and its relation to sinus lift surgery. Clinical oral implants research. 2011 Jul;22(7):711-5. PubMed PMID: 21143535.

23. Nkenke E, Stelzle F. Clinical outcomes of sinus floor augmentation for implant placement using autogenous bone or bone substitutes: a systematic review. . Clinical oral implants research. 2009;4:124–33.

24. Cagici CA, Yilmazer C, Hurcan C, Ozer C, Ozer F. Appropriate interslice gap for screening coronal paranasal sinus tomography for mucosal thickening. Eur Arch Otorhinolaryngol.266:519–25.

25. Chan HL, Wang HL. Sinus pathology and anatomy in relation to complications in lateral window sinus augmentation. Implant dentistry.20:1– 7.

26. Pignataro L, Mantovano M, Torretta S, Felisati G, Sambataro G. ENT assessment in the integrated management of candidate for (maxillary) sinus lift. Acta Otorhinolaryngol Ital. 2008;28:110– 9.

27. Brook I. Sinusitis of odontogenic origin. Otolaryngol Head Neck Surg. 2006;35:349–55.

28. Shanbhag S, Karnik P. Association between periapical lesions and mucosal thickening: a retrospective Cone-beam computed study. Journal of endodontics. 2013;39:853–7.

29. Cakur B, Sumbullu MA, Durna D. Relationship among Sneiderian membrane, Underwood´s septa, and the maxillary sinus inferior border. Clinical implant dentistry and related research. 2011;6:1– 4.

30. Neugebauer J, Ritter L, Mischkowski RA, Dreiseidler T, Schherer P, Ketterle M. Evaluation of maxillary sinus anatomy by cone - beam CT prior to sinus floor elevation. The International journal of oral & maxillofacial implants. 2010;5:258–5.

31. Angelopoulos C, Scarfe WC, farman AG. A Comparison of Maxillofacial CBCT and Medical CT. Atlas Oral Maxillofacial Surg N Am. 2012;20:1-17.

32. Beaumont C, ropoulos GZ, Rohmann K, Tatakis DN. Prevalence of maxillary sinus disease and abnormalities in patients scheduled for sinus lift procedures. J Periodontol. 2005;76:461–7.

33. Pietrokovski J. The bony residual ridge in man. J Prosthet Dent. 1975;34:456-62.

34. Misch CE. Divisions of available bone in implant dentistry. The International journal of oral & maxillofacial implants. 1990;7:9-17.

35. Li T, Kong L, Wang Y, Hu K, Song L, Liu B, et al. Selection of dental implant diameter and lengthin type IV bone: a three-dimensional finite element analysis International journal of oral and maxillofacial surgery. 2009;38 (10):1077-83.

36. Meyer U, Vollmer D, Runte C, Bourauel C, Joos U. Bone loading pattern around implants in average and atrophic edentulous maxillae: a finite-element analysis. The Journal of craniofacial surgery. 2001;29 (2):100-5.

37. Delvin H, Horner K, Ledgerton D. A comparison of maxillary and madibular bone mineral densities. J Prosthet Dent. 1998;79 (3):323-7.

38. Lekholm U, Zarb GA. Tissue-integrated prostheses. In: Branemark PI, Zarb GA, Albrektsson T. Tissue-integrated prosthese Quintessence, Chicago. 1985.

39. Danza M, Zollino I, Paracchini L, Riccardo G, Fanali S, Carinci F. 3D finite element analysis to detect stress distribution: spiral family implants. Journal of oral and maxillofacial surgery : official journal of the American Association of Oral and Maxillofacial Surgeons. 2009;8 (4):334-9.

40. Cawood JI, Stoelinga PJW, Blackburn TK. The evolution of preimplant surgery from preprosthetic surgery. International journal of oral and maxillofacial surgery. 2007;36 (5):377–85.

41. Nkenke E, Hahn M, Lell M, Wiltfang J, Mosgau SS, StechB B. Anatomic site evaluation of the zygomatic bone for dental implant placement. Clin Oral Impl Res. 2003;14:72–9.

42. Eufinger H, Gellrich NC, Sandmann D, Dieckmann J. Descriptive and metric classification of jaw atrophy: An evaluation of 104 mandibles and 96 maxillae of dried skulls. International journal of oral and maxillofacial surgery. 1997;26 (1):23–8.
43. Bryant SR, Zarb GA. Outcomes of implant prosthodontic treatment in older adults. J Can Dent Assoc. 2002;68 (2):97–102.
44. Guncu GN, Yildirim YD, Wang HL, Tozum TF. Location of posterior superior alveolar artery and evaluation of maxillary sinus anatomy with computerized tomography: a clinical study. Clinical oral implants research. 2011 Oct;22(10):1164-7. PubMed PMID: 21244499.
45. Elian N, Wallace S, Cho SC, Jalbout ZN, Froum S. Distribution of the maxillary artery as it relates to sinus floor augmentation. The International journal of oral & maxillofacial implants. 2005 Sep-Oct;20(5):784-7. PubMed PMID: 16274154.
46. Mardinger O, Abba M, Hirshberg A, Schwartz-Arad D. Prevalence, diameter and course of the maxillary intraosseous vascular canal with relation to sinus augmentation procedure: a radiographic study. International journal of oral and maxillofacial surgery. 2007 Aug;36(8):735-8. PubMed PMID: 17629462.
47. Park W-H, Choi S-Y, Kim C-S. Study on the position of the posterior superior alveolar artery in relation to the performance of the maxillary sinus bone graft procedure in a Korean population. J Korean Assoc Oral Maxillofac Surg. 2012;38:71-7.
48. Ilguy D, Ilguy M, Dolekoglu S, Fisekcioglu E. Evaluation of the posterior superior alveolar artery and the maxillary sinus with CBCT. Brazilian oral research. 2013 Sep-Oct;27(5):431-7. PubMed PMID: 24036981.
49. Kurt MH, Kurşun EŞ, Alparslan YN, Öztaş B. POSTERIOR SUPERIOR ALVEOLAR ARTERY EVALUATION IN A TURKISH SUBPOPULATION USING CBCT. Clinical Dentistry and Research. 2014;38(2):12-9.
50. Yang SM, Kye SB. Location of maxillary intraosseous vascular anastomosis based on the tooth position and height of the residual alveolar bone: computed tomographic analysis. J Periodontal Implant Sci. 2014;44:50-6.
51. Friedman LM, Furberg CD, Demets DL. Fundamentals of Clinical Trials: Springer; [cited Chapter-8]. Fourth:[133-67].

52. Kim JH, Ryu JS, Kim KD, Hwang SH, Moon HS. A radiographic study of the posterior superior alveolar artery. Implant dentistry. 2011 Aug;20(4):306-10. PubMed PMID: 21778887.

53. Pauwels R, Beinsberger J, Stamatakis H, Tsiklakis K, Walker A, Bosmans H, et al. Comparison of spatial and contrast resolution for cone-beam computed tomography scanners. Oral surgery, oral medicine, oral pathology and oral radiology. 2012 Jul;114(1):127-35. PubMed PMID: 22727102.

54. Hur M-S, Kim J-K, Hu K-S, Bae HEK, Park H-S, Kim H-J. Clinical implications of the topography and distribution of the posterior superior alveolar artery. Journal of Craniofacial Surgery. 2009;20(2):551-4.

55. Jung YH, Nah KS, Cho BH. Maxillary sinus pneumatization after maxillary molar extraction assessed with cone beam computed tomography. Korean Journal of Oral and Maxillofacial Radiology. 2009;39(3):109-13.

56. Rahpeyma A, Khajehahmadi S, Amini P. Alveolar Antral Artery: Does its Diameter Correlate with Maxillary lateral wall Thickness in Dentate Patients? Iranian journal of otorhinolaryngology. 2014 Jul;26(76):163-7. PubMed PMID: 25009806. Pubmed Central PMCID: 4087855.

Record of Measurements

Subject No (   ), Age (   ) yrs., Sex (   ).

1. Prevalence of alveolar antral artery of maxillary sinus

Right maxilla		Left maxilla	
Dentate	Edentulous	Dentate	Edentulous

2(a) Location of alveolar antral artery (from lower border of artery to lowest point of buccal alveolar crest)

	Right maxilla (mm)		Left maxilla (mm)	
	Dentate	Edentulous	Dentate	Edentulous
First premolar				
Second premolar				
First molar				
Second molar				

2(b) Location of alveolar antral artery (from lower border of artery to lowest point of maxillary sinus floor)

	Right maxilla (mm)		**Left maxilla (mm)**	
	Dentate	**Edentulous**	**Dentate**	**Edentulous**
First premolar				
Second premolar				
First molar				
Second molar				

2(c) Diameter of alveolar antral artery artery (greatest distance between the inner sides of the aretey canal)

	Right maxilla (mm)		**Left maxilla (mm)**	
	Dentate	**Edentulous**	**Dentate**	**Edentulous**
First premolar				
Second premolar				
First molar				
Second molar				

Statistic Output

Table 1: Demographic data of Maxillary sinuses according type of jaw

Type of jaw

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	dentate	91	49.5	49.5	49.5
	edentulous	93	50.5	50.5	100.0
	Total	184	100.0	100.0	

Table 2: Demographic data of Maxillary sinuses according to sex

Sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	male	58	31.5	31.5	31.5
	female	126	68.5	68.5	100.0
	Total	184	100.0	100.0	

Table 3: Demographic data of four posterior maxillary teeth areas according to type of jaw

Type of jaw

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	dentate	563	83.9	83.9	83.9
	edentulous	108	16.1	16.1	100.0
	Total	671	100.0	100.0	

Table 4: Demographic data of four posterior maxillary teeth areas according to type of jaw

Sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	ale	203	30.3	30.3	30.3
	female	468	69.7	69.7	100.0
	Total	671	100.0	100.0	

Table 5: Comparison of the prevalence of alveolar antral artery of maxillary sinus between dentate and edentulous maxilla

Type of jaw * prevalence of artery Cross tabulation

Count

		prevalence of artery		Total
		presence	absence	
type of jaw	dentate	54	37	91
	edentulous	57	36	93
Total		111	73	184

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.073[a]	1	.787		
Continuity Correction[b]	.014	1	.905		
Likelihood Ratio	.073	1	.787		
Fisher's Exact Test				.880	.452
Linear-by-Linear Association	.073	1	.788		
N of Valid Cases	184				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 36.10.

b. Computed only for a 2x2 table

Table 6: Comparison of the prevalence of alveolar antral artery of maxillary sinus between male and female

Sex * prevalence of artery Cross tabulation

Count

		prevalence of artery		Total
		presence	absence	
sex	male	38	20	58
	female	73	53	126
Total		111	73	184

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.954[a]	1	.329		
Continuity Correction[b]	.663	1	.415		
Likelihood Ratio	.963	1	.326		
Fisher's Exact Test				.418	.208
Linear-by-Linear Association	.948	1	.330		
N of Valid Cases	184				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 23.01.

b. Computed only for a 2x2 table

Table 7: Comparison of the prevalence of alveolar antral artery of maxillary sinus of four posterior maxillary teeth areas

Prevalence of artery * tooth Cross tabulation

Count

		tooth				Total
		first premolar	second premolar	first molar	second molar	
prevalence of artery	presence	23	59	55	71	208
	absence	107	118	127	111	463
Total		130	177	182	182	671

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	16.726[a]	3	.001
Likelihood Ratio	17.680	3	.001
Linear-by-Linear Association	12.112	1	.001
N of Valid Cases	671		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 40.30.

Table 8: Comparison of the prevalence of alveolar antral artery at first premolar area between dentate and edentulous

Type of jaw * prevalence of artery Cross tabulation

Count

		prevalence of artery		Total
		presence	absence	
type of jaw	dentate	20	102	122
	edentulous	3	5	8
Total		23	107	130

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.297[a]	1	.130		
Continuity Correction[b]	1.076	1	.300		
Likelihood Ratio	1.898	1	.168		
Fisher's Exact Test				.149	.149
Linear-by-Linear Association	2.279	1	.131		
N of Valid Cases	130				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 1.42.

b. Computed only for a 2x2 table

Table 8: Comparison of the prevalence of alveolar antral artery at second premolar area between dentate and edentulous

Type of jaw * prevalence of artery Cross tabulation

Count

		prevalence of artery		
		presence	absence	Total
type of jaw	dentate	52	101	153
	edentulous	7	17	24
Total		59	118	177

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.217[a]	1	.641		
Continuity Correction[b]	.054	1	.816		
Likelihood Ratio	.221	1	.638		
Fisher's Exact Test				.816	.415
Linear-by-Linear Association	.216	1	.642		
N of Valid Cases	177				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.00.

b. Computed only for a 2x2 table

Table 8: Comparison of the prevalence of alveolar antral artery at first molar area between dentate and edentulous

Type of jaw * prevalence of artery Cross tabulation

Count

		prevalence of artery		
		presence	absence	Total
type of jaw	dentate	35	96	131
	edntulous	20	31	51
Total		55	127	182

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.719[a]	1	.099		
Continuity Correction[b]	2.159	1	.142		
Likelihood Ratio	2.646	1	.104		
Fisher's Exact Test				.109	.072
Linear-by-Linear Association	2.704	1	.100		
N of Valid Cases	182				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 15.41.

b. Computed only for a 2x2 table

Table 8: Comparison of the prevalence of alveolar antral artery at second molar area between dentate and edentulous

Type of jaw * prevalence of artery Cross tabulation

Count

		prevalence of artery		Total
		presence	absence	
type of jaw	dentate	62	95	157
	edentulous	9	16	25
Total		71	111	182

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.110[a]	1	.740		
Continuity Correction[b]	.012	1	.911		
Likelihood Ratio	.111	1	.739		
Fisher's Exact Test				.827	.460
Linear-by-Linear Association	.110	1	.740		
N of Valid Cases	182				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.75.

b. Computed only for a 2x2 table

Table 8: Comparison of the prevalence of alveolar antral artery of four posterior maxillary teeth areas between dentate and edentulous

Type of jaw * prevalence of artery Cross tabulation

Count

		prevalence of artery		
		presence	absence	Total
type of jaw	dentate	169	394	563
	edentulous	39	69	108
Total		208	463	671

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.573[a]	1	.210		
Continuity Correction[b]	1.301	1	.254		
Likelihood Ratio	1.539	1	.215		
Fisher's Exact Test				.213	.128
Linear-by-Linear Association	1.571	1	.210		
N of Valid Cases	671				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 33.48.

b. Computed only for a 2x2 table

Table 9: Comparison of the prevalence of alveolar antral artery at first premolar area between male and female

Sex * prevalence of artery Cross tabulation

Count

		prevalence of artery		Total
		presence	absence	
sex	male	11	26	37
	female	12	81	93
Total		23	107	130

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5.146[a]	1	.023		
Continuity Correction[b]	4.056	1	.044		
Likelihood Ratio	4.783	1	.029		
Fisher's Exact Test				.039	.025
Linear-by-Linear Association	5.107	1	.024		
N of Valid Cases	130				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.55.

b. Computed only for a 2x2 table

Table 9: Comparison of the prevalence of alveolar antral artery at second premolar area between male and female

Sex * prevalence of artery Cross tabulation

Count

		prevalence of artery		
		presence	absence	Total
sex	male	26	28	54
	female	33	90	123
Total		59	118	177

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	7.675[a]	1	.006		
Continuity Correction[b]	6.745	1	.009		
Likelihood Ratio	7.478	1	.006		
Fisher's Exact Test				.009	.005
Linear-by-Linear Association	7.631	1	.006		
N of Valid Cases	177				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 18.00.

b. Computed only for a 2x2 table

Table 9: Comparison of the prevalence of alveolar antral artery at first molar area between male and female

Sex * prevalence of artery Cross tabulation

Count

		prevalence of artery		
		presence	absence	Total
sex	male	26	30	56
	female	29	97	126
Total		55	127	182

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	10.078[a]	1	.002		
Continuity Correction[b]	8.998	1	.003		
Likelihood Ratio	9.736	1	.002		
Fisher's Exact Test				.003	.002
Linear-by-Linear Association	10.022	1	.002		
N of Valid Cases	182				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 16.92.

b. Computed only for a 2x2 table

Table 9: Comparison of the prevalence of alveolar antral artery at second molar area between male and female

Sex * prevalence of artery Cross tabulation

Count

		prevalence of artery		Total
		presence	absence	
sex	male	24	32	56
	female	47	79	126
Total		71	111	182

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.503[a]	1	.478		
Continuity Correction[b]	.297	1	.586		
Likelihood Ratio	.500	1	.479		
Fisher's Exact Test				.513	.292
Linear-by-Linear Association	.500	1	.479		
N of Valid Cases	182				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 21.85.

b. Computed only for a 2x2 table

Table 9: Comparison of the prevalence of alveolar antral artery of four posterior maxillary teeth areas between male and female

Sex * prevalence of artery Cross tabulation

Count

		prevalence of artery		
		presence	absence	Total
sex	male	87	116	203
	female	121	347	468
Total		208	463	671

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	19.136[a]	1	.000		
Continuity Correction[b]	18.349	1	.000		
Likelihood Ratio	18.603	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	19.107	1	.000		
N of Valid Cases	671				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 62.93.

b. Computed only for a 2x2 table

Table 10: Comparison of distance of artery from alveolar crest of four posterior maxillary teeth areas

Descriptives

artery to alveolar crest

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
first premolar	23	24.6187	3.54625	.73944	23.0852	26.1522	17.38	29.39
second premolar	59	20.3519	4.73854	.61691	19.1170	21.5867	9.00	37.08
first molar	55	15.8173	4.09422	.55206	14.7104	16.9241	5.44	24.00
second molar	71	15.9304	3.56528	.42312	15.0865	16.7743	7.12	23.19
Total	208	18.1154	5.04628	.34990	17.4256	18.8052	5.44	37.08

ANOVA

artery to alveolar crest

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1897.280	3	632.427	38.238	.000
Within Groups	3373.959	204	16.539		
Total	5271.239	207			

artery to alveolar crest

Tukey HSD[a,b]

teeth areas	N	Subset for alpha = 0.05		
		1	2	3
first molar	55	15.8173		
second molar	71	15.9304		
second premolar	59		20.3519	
first premolar	23			24.6187
Sig.		.999	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 43.153.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Table 11: Comparison of distance of alveolar antral artery from alveolar crest at first premolar area between dentate and edentulous

Group Statistics

	type of jaw	N	Mean	Std. Deviation	Std. Error Mean
artery to alveolar crest	dentate	20	24.7305	3.51201	.78531
	edentulous	3	23.8733	4.49463	2.59498

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
artery to alveolar crest	Equal variances assumed	.290	.596	.383	21	.706	.85717	2.23949	-3.80012	5.51445
	Equal variances not assumed			.316	2.381	.777	.85717	2.71120	-9.18993	10.90427

Table 11: Comparison of distance of alveolar antral artery from alveolar crest at second premolar area between dentate and edentulous

Group Statistics

	type of jaw	N	Mean	Std. Deviation	Std. Error Mean
artery to alveolar crest	dentate	52	20.1808	4.91446	.68151
	edentulous	7	21.6229	3.10217	1.17251

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
artery to alveolar crest	Equal variances assumed	1.800	.185	-.753	57	.454	-1.44209	1.91490	-5.27661	2.39244
	Equal variances not assumed			-1.063	10.597	.311	-1.44209	1.35619	-4.44095	1.55678

Table 11: Comparison of distance of alveolar antral artery from alveolar crest at first molar area between dentate and edentulous

Group Statistics

	type of jaw	N	Mean	Std. Deviation	Std. Error Mean
artery to alveolar crest	dentate	35	15.9820	4.15515	.70235
	edntulous	20	15.5290	4.07529	.91126

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
artery to alveolar crest	Equal variances assumed	.024	.877	.392	53	.697	.45300	1.15674	-1.86712	2.77312
	Equal variances not assumed			.394	40.326	.696	.45300	1.15052	-1.87170	2.77770

Table 11: Comparison of distance of alveolar antral artery from alveolar crest at second molar area between dentate and edentulous

Group Statistics

	type of jaw	N	Mean	Std. Deviation	Std. Error Mean
artery to alveolar crest	dentate	62	15.9979	3.45288	.43852
	edentulous	9	15.4656	4.47628	1.49209

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
artery to alveolar crest	Equal variances assumed	.215	.644	.416	69	.679	.53235	1.27934	-2.01987	3.08456
	Equal variances not assumed			.342	9.432	.740	.53235	1.55520	-2.96132	4.02601

Table 11: Comparison of distance of alveolar antral artery from alveolar crest of four posterior maxillary teeth areas between dentate and edentulous

Group Statistics

	type of jaw	N	Mean	Std. Deviation	Std. Error Mean
artery to alveolar crest	dentate	169	18.3151	5.06385	.38953
	edentulous	39	17.2500	4.94003	.79104

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
artery to alveolar crest	Equal variances assumed	.012	.911	1.189	206	.236	1.06509	.89556	-.70054	2.83072
	Equal variances not assumed			1.208	57.893	.232	1.06509	.88174	-.69998	2.83016

Table 12: Comparison of distance of alveolar antral artery from maxillary sinus floor of four posterior maxillary teeth areas

Descriptives

artery to sinus floor

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
first premolar	23	11.0839	4.48893	.93601	9.1428	13.0251	2.32	18.25
second premolar	57	8.0061	4.01192	.53139	6.9416	9.0706	.72	19.56
first molar	55	8.2165	4.42776	.59704	7.0196	9.4135	1.50	18.44
second molar	71	7.3899	3.42112	.40601	6.5801	8.1996	1.25	16.94
Total	206	8.1935	4.10987	.28635	7.6290	8.7581	.72	19.56

ANOVA

artery to sinus floor

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	240.038	3	80.013	5.015	.002
Within Groups	3222.620	202	15.954		
Total	3462.658	205			

artery to sinus floor

Tukey HSD[a,b]

teeth_areas	N	Subset for alpha = 0.05 1	2
second molar	71	7.3899	
second premolar	57	8.0061	
first molar	55	8.2165	
first premolar	23		11.0839
Sig.		.773	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 42.878.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Table 13: Comparison of distance of alveolar antral artery from maxillary sinus floor at first premolar area between dentate and edentulous

Group Statistics

	type of jaw	N	Mean	Std. Deviation	Std. Error Mean
artery to sinus floor	dentate	20	11.3900	4.68754	1.04817
	edentulous	3	9.0433	2.39352	1.38190

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
artery to sinus floor	Equal variances assumed	2.242	.149	.839	21	.411	2.34667	2.79821	-3.47253	8.16586
	Equal variances not assumed			1.353	4.796	.236	2.34667	1.73444	-2.16947	6.86280

Table 13: Comparison of distance of alveolar antral artery from maxillary sinus floor at second premolar area between dentate and edentulous

Group Statistics

	type of jaw	N	Mean	Std. Deviation	Std. Error Mean
artery to sinus floor	dentate	50	7.6978	4.10479	.58051
	edentulous	7	10.2086	2.48396	.93885

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
artery to sinus floor	Equal variances assumed	2.146	.149	-1.571	55	.122	-2.51077	1.59822	-5.71367	.69213
	Equal variances not assumed			-2.275	11.263	.043	-2.51077	1.10382	-4.93336	-.08819

Table 13: Comparison of distance of alveolar antral artery from maxillary sinus floor at first molar area between dentate and edentulous

Group Statistics

	type of jaw	N	Mean	Std. Deviation	Std. Error Mean
artery to sius floor	dentate	35	7.6763	4.00866	.67759
	edntulous	20	9.1620	5.04832	1.12884

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
artery to sius floor	Equal variances assumed	2.007	.162	-1.202	53	.235	-1.48571	1.23605	-3.96491	.99349
	Equal variances not assumed			-1.128	32.780	.267	-1.48571	1.31659	-4.16501	1.19358

Table 13: Comparison of distance of alveolar antral artery from maxillary sinus floor at second molar area between dentate and edentulous

Group Statistics

	type of jaw	N	Mean	Std. Deviation	Std. Error Mean
artery to sinus floor	dentate	62	7.3342	3.30411	.41962
	edentulous	9	7.7733	4.35638	1.45213

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
artery to sinus floor	Equal variances assumed	1.109	.296	-.358	69	.722	-.43914	1.22801	-2.88896	2.01068
	Equal variances not assumed			-.291	9.383	.778	-.43914	1.51154	-3.83731	2.95903

Table 13: Comparison of distance of alveolar antral artery from maxillary sinus floor of four posterior maxillary teeth areas between dentate and edentulous

Group Statistics

	type of jaw	N	Mean	Std. Deviation	Std. Error Mean
artery to sinus floor	dentate	167	8.0005	4.04863	.31329
	edentulous	39	9.0203	4.31890	.69158

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
artery to sinus floor	Equal variances assumed	.261	.610	-1.398	204	.163	-1.01978	.72922	-2.45756	.41801
	Equal variances not assumed			-1.343	54.670	.185	-1.01978	.75923	-2.54152	.50196

Table 14: Comparison of diameter of alveolar antral artery from maxillary sinus floor of four posterior maxillary teeth areas

Descriptives

diameter of artery

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
first premolar	23	1.1522	.50671	.10566	.9331	1.3713	.58	2.70
second premolar	59	1.0700	.35526	.04625	.9774	1.1626	.50	2.17
first molar	55	1.2716	.40535	.05466	1.1621	1.3812	.64	2.22
second molar	71	1.1058	.40036	.04751	1.0110	1.2005	.50	2.32
Total	208	1.1446	.40757	.02826	1.0889	1.2003	.50	2.70

ANOVA

diameter of artery

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.324	3	.441	2.724	.045
Within Groups	33.061	204	.162		
Total	34.386	207			

Table 15: Comparison of diameter of alveolar antral artery at first premolar area between dentate and edentulous

Group Statistics

	type of jaw	N	Mean	Std. Deviation	Std. Error Mean
Diameter of artery	dentate	20	1.2030	.51870	.11599
	edentulous	3	.8133	.26502	.15301

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Diameter of artery	Equal variances assumed	1.083	.310	1.258	21	.222	.38967	.30964	-.25427	1.03360
	Equal variances not assumed			2.030	4.792	.101	.38967	.19200	-.11039	.88972

Table 15: Comparison of diameter of alveolar antral artery at second premolar area between dentate and edentulous

Group Statistics

	type of jaw	N	Mean	Std. Deviation	Std. Error Mean
diameter of artery	dentate	52	1.0912	.36899	.05117
	edentulous	7	.9129	.17327	.06549

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
diameter of artery	Equal variances assumed	2.318	.133	1.253	57	.215	.17830	.14233	-.10672	.46331
	Equal variances not assumed			2.145	14.908	.049	.17830	.08311	.00105	.35554

Table 15: Comparison of diameter of alveolar antral artery at first molar area between dentate and edentulous

Group Statistics

	type of jaw	N	Mean	Std. Deviation	Std. Error Mean
diameter of artery	dentate	35	1.2674	.40398	.06829
	edntulous	20	1.2790	.41814	.09350

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
diameter of artery	Equal variances assumed	.021	.885	-.101	53	.920	-.01157	.11468	-.24158	.21844
	Equal variances not assumed			-.100	38.546	.921	-.01157	.11578	-.24585	.22270

Table 15: Comparison of diameter of alveolar antral artery at second molar area between dentate and edentulous

Group Statistics

	type of jaw	N	Mean	Std. Deviation	Std. Error Mean
diameter of artery	dentate	62	1.0998	.41722	.05299
	edentulous	9	1.1467	.27028	.09009

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
diameter of artery	Equal variances assumed	1.460	.231	-.326	69	.746	-.04683	.14373	-.33356	.23991
	Equal variances not assumed			-.448	14.268	.661	-.04683	.10452	-.27061	.17695

Table 15: Comparison of diameter of alveolar antral artery of four posterior maxillary teeth areas between dentate and edentulous

Group Statistics

	type of jaw	N	Mean	Std. Deviation	Std. Error Mean
diameter of artery	dentate	169	1.1441	.41613	.03201
	edentulous	39	1.1469	.37322	.05976

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
diameter of artery	Equal variances assumed	.997	.319	-.039	206	.969	-.00284	.07258	-.14593	.14025
	Equal variances not assumed			-.042	61.781	.967	-.00284	.06780	-.13837	.13269

Table 16: Comparison of diameter of alveolar antral artery at first premolar area between male and female

Group Statistics

	sex	N	Mean	Std. Deviation	Std. Error Mean
Diameter of artery	male	11	1.2127	.62322	.18791
	female	12	1.0967	.39165	.11306

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Diameter of artery	Equal variances assumed	1.039	.320	.540	21	.595	.11606	.21500	-.33106	.56318
	Equal variances not assumed			.529	16.576	.604	.11606	.21930	-.34752	.57964

Table 16: Comparison of diameter of alveolar antral artery at second premolar area between male and female

Group Statistics

	sex	N	Mean	Std. Deviation	Std. Error Mean
diameter of artery	male	26	1.1531	.36454	.07149
	female	33	1.0045	.33899	.05901

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
diameter of artery	Equal variances assumed	.394	.533	1.616	57	.112	.14853	.09189	-.03548	.33254
	Equal variances not assumed			1.602	51.863	.115	.14853	.09270	-.03750	.33456

Table 16: Comparison of diameter of alveolar antral artery at first molar area between male and female

Group Statistics

	sex	N	Mean	Std. Deviation	Std. Error Mean
diameter of artery	male	26	1.4373	.40987	.08038
	female	29	1.1231	.34430	.06394

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
diameter of artery	Equal variances assumed	1.754	.191	3.089	53	.003	.31420	.10173	.11016	.51825
	Equal variances not assumed			3.059	49.094	.004	.31420	.10271	.10781	.52060

Table 16: Comparison of diameter of alveolar antral artery at second molar area between male and female

Group Statistics

	sex	N	Mean	Std. Deviation	Std. Error Mean
diameter of artery	male	24	1.3354	.37348	.07624
	female	47	.9885	.36415	.05312

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
diameter of artery	Equal variances assumed	.001	.971	3.765	69	.000	.34691	.09215	.16308	.53073
	Equal variances not assumed			3.734	45.401	.001	.34691	.09292	.15981	.53400

Table 16: Comparison of diameter of alveolar antral artery of four posterior maxillary teeth areas between male and female

Group Statistics

	sex	N	Mean	Std. Deviation	Std. Error Mean
diameter of artery	male	87	1.2959	.42833	.04592
	female	121	1.0359	.35574	.03234

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
diameter of artery	Equal variances assumed	3.411	.066	4.771	206	.000	.25999	.05450	.15255	.36744
	Equal variances not assumed			4.629	163.617	.000	.25999	.05617	.14909	.37090

Table 17: Classification of alveolar antral artery according to position

Type of artery

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	circular	30	4.5	14.4	14.4
	semicircular	122	18.2	58.7	73.1
	through	56	8.3	26.9	100.0
	Total	208	31.0	100.0	
Missing	System	463	69.0		
Total		671	100.0		

Table 18: Classification of alveolar antral artery according to diameter

Classification of artery

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	less than 1mm	77	11.5	37.0	37.0
	1 - 2 mm	127	18.9	61.1	98.1
	more than 2mm	4	.6	1.9	100.0
	Total	208	31.0	100.0	
Missing	System	463	69.0		
Total		671	100.0		

Pearson correlation of intraexaminer variances

Correlations

		first measurement	second measurement
first measurement	Pearson Correlation	1	.987**
	Sig. (2-tailed)		.000
	N	63	63
second measurement	Pearson Correlation	.987**	1
	Sig. (2-tailed)	.000	
	N	63	63

**. Correlation is significant at the 0.01 level (2-tailed).

APPENDIX

VITA

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Education and Employee

BDS - Institute of Dental Medicine, Mandalay (1999 to 2005)

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