Distribution of the maxillary artery related to sinus graft surgery for implantation

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Ⅰ. Introduction

From the pterygomaxillary junction to the pterygopalatine fossa region, the maxillary artery was usually branched into 5 arteries in the following order : posterior superior alveolar artery (PSAA), infraorbital artery (IOA), artery of the pterygoid canal, descending palatine artery, and sphenopalatine artery[1]. The lateral maxilla is supplied by branches of the PSAA and the IOA that form an anastomosis in the bony lateral antral wall, which also supplies the Schneiderian membrane[2].

The maxillary blood supply is essential for preserving the vitality of the affected maxillary region, intergration of the grafting material, and wound healing such as following sinus floor elevation. Although it is well established that edentulous maxillae demonstrate a decreasing vascularity as bone resorption progresses, the vascular conditions relevant to sinus floor elevation procedures have not been investigated yet[2].

Internal augmentation of the antral floor for the creation of an adequate implant host site is very well documented from the clinical point of view. However, one aspect that has been barely investigated so far is the local arterial supply, on which the vitality of local bone, vascularization of the grafting material, and the healing behavior of the oral mucous membranes depend[2].

When performing an osteotomy in the lateral wall of the sinus, it is possible to violate the integrity of the vascular supply in the lateral bony wall, resulting in intraoperative bleeding that may be mild to severe in nature[3]. Although bleeding is rare due to the absence of a major artery at the surgical area when performing the window opening by a lateral approach during the maxillary sinus graft[4], severe bleeding due to damage to the intraosseous branch of PSAA during the window opening has occasionally been reported by clinicians[3]. This has led to many modified surgical techniques being suggested for minimizing damage to the main artery branches during surgical procedures involving the maxilla and the maxillary sinus graft.

The literature concerning the course of the vessels supplying this region is limited to anatomical textbooks[3]. The purpose of this study was to investigate the anatomic courses and distribution of the endosseous branches of the maxillary artery in the area of the proposed lateral window.

Ⅱ. Materials & Methods

Fifty cone beam computed tomographic (CBCT : i-CAT™, ISI, USA) scans undergoing sinus graft surgery at the LivingWell Dental Hospital were chosen at random for evaluation. The scans were subjected to computerized analysis (Simplant™, Materialise, Belgium) for shape of intrabony indentation formed by the maxillary artery branch. The shape of intrabony indentation was classified into 5 types : Type I (not identified), Type II (as an arc smaller than a half circle), Type III (as an arc larger than a half circle), Type IV (as a circular intrabony canal), and Type V (as a tunnel on the lateral wall of maxillary sinus) (Fig. 1). In those cases where the maxillary artery could be identified, measurements were taken to determine the distance from the alveolar crest and the occlusal plane(Fig. 2). The mean values and standard deviations of the measuring results were calculated.

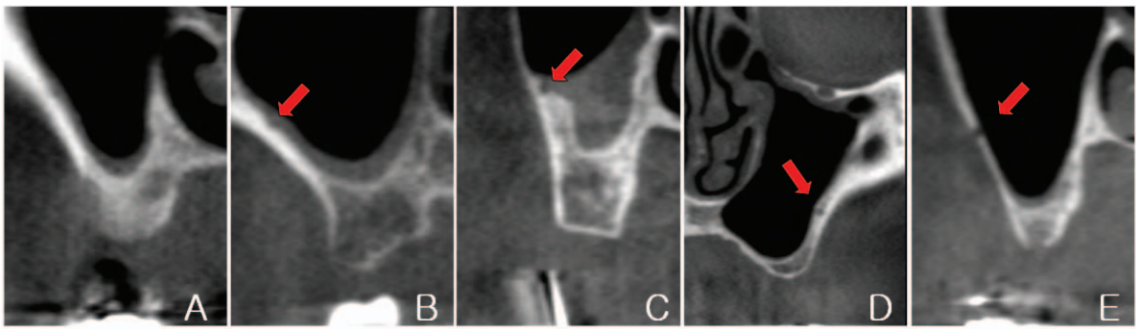

Fig. 1. The shape of intrabony indentation of PSAA. A: Type I (not identified) B: Type II (as an arc smaller than a half circle) C: Type III (as an arc larger than a half circle) D: Type IV (as a circular intrabony canal) E: Type V (as a tunnel on the lateral wall of maxillary sinus).

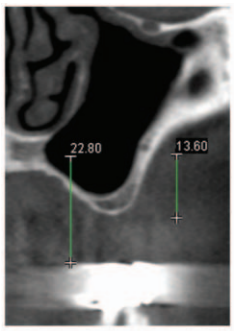

Fig. 2. The measurement of the distance from the alveolar crest or the occlusal plane to the intrabony indentation of PSAA.

Ⅲ. Result

The shape of intrabony indentation was variable and the prevelence according to the type was showed in the Tab. 1. The intraosseous branch of the maxillary artery was not radiographically discernible in 17.3% of scans (Type I). And Type II case (24.7%) was difficult to identify with a single scan image only and it was identified by comparing serial cross-sectional images. Type V case (tunnel shape) was noted mostly on the 2nd molar area.

The average distance from the alveolar crest to the lower border of the artery was 15.9 mm (26.5 mm from the occlusal plane). There was no significant difference of that average distance according to sex. And the factor of age was not influence on the distance. The average distance

Table 1. The Shape of the intrabony indentation of PSAA

Type I	17.3%	not found
Type II	24.7%	difficult to identify with a single image
Type III	23.5%	easy to identify with a single image
Type IV	22.2%	"
Type V	12.3%	"

Table 2. The distance of the intrabony indentation

Group	from the alveolar crest	from the occlusal plane
Overall	15.9±4.6 mm	26.5±4.5 mm
Male	15.5±5.3 mm	26.1±4.5 mm
Female	16.4±3.7 mm	27.1±4.5 mm
Age<60	15.9±3.5 mm	27.5±4.0 mm
Age≥60	15.6±5.6 mm	25.8±4.9 mm
Right Side	15.9±4.6 mm	26.7±4.5 mm
Left Side	15.8±4.8 mm	26.4±4.7 mm

Table 3. The distance of the intrabony indentation

Tooth Area	from the alveolar crest	from the occlusal plane
1st premolar	20.6±5.8 mm	31.5±5.7 mm
2nd premolar	17.1±4.9 mm	27.8±4.3 mm
1st molar	13.5±3.9 mm	24.5±3.9 mm
2nd molar	16.0±3.5 mm	26.1±3.1 mm

was very similar on both sides (Tab. 2).

The distance measure according to each posterior teeth area was shown on the Tab. 3. The artery was closest to the alveolar crest on first molar area and the average distance was 13.5 mm and the deviation of measurement was about 4.0mm.

In the cases that exhibited a slight U-shaped curve in the course of the artery, the change in direction occurred at the region on the first molar. In a panoramic view reformatted from CBCT scan data, was shown the course of the artery as an U-shaped curve (Fig. 3). And A 3 dimensional reconstructed image was revealed the course of the artery which runs inside the lateral wall of the maxillary sinus as an U-shape curve (Fig. 4).

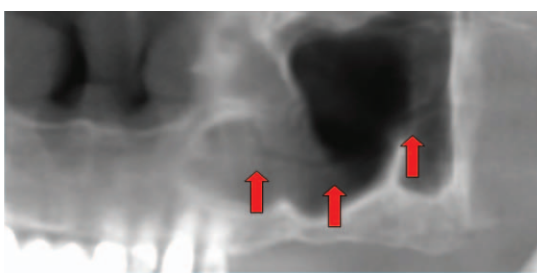

Fig. 3. The course of artery in a reformatted panoramic view.

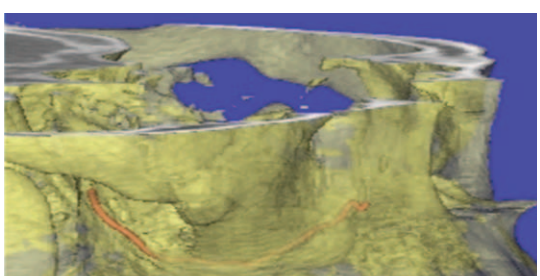

Fig. 4. The course of artery in a 3D image reconstructed from CBCT scan data.

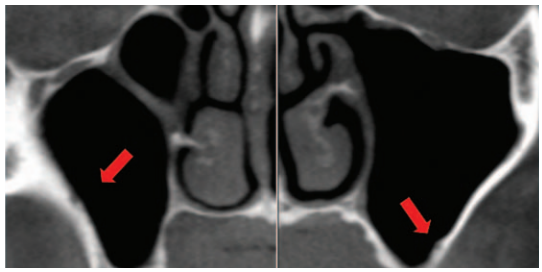

Fig. 5. In this case, the height of artery level was noted with marked variance on both first molar area in same patient.

In some case, the distance from alveolar creat to the indentation of the artery was marked different compared with average distance. Although in same patient and in corresponding tooth area of both sides, the distance was shown a significant difference according to the side (Fig. 5).

Ⅳ. Discussion

Elian and associates[3] reported that the intraosseous branch of the artery was radio graphically discernible in 52.9% of cases. In this study, 58.0% of cases was easy to identify the indentation of the artery. But it was difficult to identify the intrabony indentation in Type II case (24.7%) with a single cross-sectional image only.

Solar and associates[2] investigated the blood supply to the lateral wall of the sinus. Their anatomic study of cadavers showed the presence of the endosseous branch of the posterior superior alveolar artery in the lateral wall in 100% of their specimens. Formed by an anastomosis of the infraorbital artery and the posterior superior alveolar artery, this vessel was located an average distance of 18.9 mm (±2.82 mm) from the alveolar crest[2]. As far as the type of osteotomy lines to be used in sinus floor elevation surgery is

concerned, the findings of their study indicate that the bony window, through which the grafting material will be placed, should be as small as possible so that the vascular stumps of the endoessous anastomosis extend as close to the center of the graft as possible.

Elian et al.[3] reported that in their study, according to the CT scan data, 80% of the arteries were located more than 15mm from the crest (average 16.4±3.5 mm), and recommeded that the superior osteotomy cut will be made approximately 15 mm from the alveolar crest for placement of 13 to 15 mm implant in length. This indicates that approximately 20% fo the cases present a potential surgical complication.

The average distance of the artery from the alveolar crest was 15.9±4.6 mm in the presented study which was similar to the value of 16.4±3.5 mm reported by Elian et al[3]. In the Elian's study, it is recommended that the superior osteotomy cut will be made approximately 15 mm from the alveolar crest. But in our study, the average distance between the artery and the alveolar crest on the first molar area was measured 13.5±3.9 mm. So we recommend that the superior osteotomy cut will be made less than 13 mm from the alveolar crest.

Damage to the periosteum leads to bone necrosis as a result of ischemia and to partial regeneration of the underlying bone[10]. The range of variability of the threshold for a decrease in vascular supply to the maxilla that will result in aseptic necrosis is unknown[5]. So far no studies are available describing the fate of local maxillary bone after periosteal denudation, vascularization of the graft, and revascularization of local tissue after sinus graft surgery.

Since the diameter of the intraosseous branch fo the PSAA is less than those of the descending palatine artery[6], the posterior lateral nasal artery[7], and the maxillary artery[8], bleeding due to damage inflicted during the window opening procedure has not been considered to be a serious problem. But Kim et al.[9] reported that the maxium external diameter of the intraosseous branch of the PSAA was approximately 2 mm at the posterior superior alveolar foramen and 1.6 mm at the infrazygomatic crest. These measurements – indicating the moderate diameter of this arterial branch – suggest that severe bleeding could occur when the artery is damaged.

Elian et al.[3] recommended that there is consideration of importance in determining the potential for intraoperative complications related to compromise of this vessel in the lateral wall. That is that in cases where the alveolar ridge has been severely resorbed, there is the likehood that the vessel will be closer to the crest than the reported average value. Considering the variance of that distance, CT scan may be used very usefully.

Ⅴ. Conclusion

From the findings of this study, the following conclusions can be drawn :

1. The intrabony indentation of the maxillary artery could not be found in CBCT scans in 17.3% of cases.
2. The average distance from the alveolar crest to the lower border of the artery was 15.9 mm.
3. There was no significant difference of that average distance according to sex, age and side.

4. The artery was closer to the crest on first molar area and the average distance was 13.5 mm.

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Abstract

임프란트 식립시 상악동 점막거상술과 관련된 상악동맥 분지의 분포

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본 연구의 목적은 CBCT (Cone Beam Computed Tomography) 영상을 이용하여 상악동 점막거상술을 위한 lateral window 를 형성하는 부위의 상악동맥 골내 분지의 해부학적 분포와 주행에 관하여 연구함에 있다.

리빙웰 치과병원에 내원하여 임프란트 식립을 위한 상악동 점막거상술을 시행하였던 증례의 CBCT (i-CAT ™, ISI, USA) 영상 중 50 증례를 임의로 선택하였고, 촬영된 영상은 영상 재구성 프로그램 (Simplant ™, Materialise, Belgium) 을 통하여 상악동맥의 골내 흔적의 형태와 함께 치조정 혹은 교합면으로 부터의 거리를 측정하였다. 본 연구의 조사결과를 통하여 다음과 같은 결론을 얻을 수 있었다.

1. 상악동맥의 골내 흔적은 17.3% 증례에서 CBCT 영상에서 관찰되지 않았다.
2. 치조골 정상에서 상악동맥의 골내 흔적 하연까지 평균 거리는 15.9 mm 로 나타났다.
3. 평균 거리는 성별, 나이, 좌우측에 관련되어 의미있는 차이를 나타내지 않았다.
4. 상악동맥의 분지는 상악 제1대구치 부위에서 치조정에 가장 가깝게 주행하였고, 평균거리는 13.5mm 로 나타났다.

key words : maxillary artery, sinus graft, posterior superior alveolar artery, Cone Beam Computed Tomography