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Angulation between Long Axis of Anterior Teeth and Alveolar Process, and Thickness of Alveolar Bone

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Abstract : The main aim of dental implant placement on the anterior region is to recover the function and esthetics. Therefore, this study examined the angulation between the long axis of the anterior teeth and the alveolar process, and thickness of the alveolar bone on the anterior region.

Twenty-five cadaver heads (18 maxillae and 23 mandibles) were examined (16 male and 9 female, mean: 56.7 years). The angulation between the long axis of the anterior teeth and the alveolar process was measured, and the alveolar bone thickness was measured in the three levels (crest; C, middle; M, apex; A) on the labial and lingual sides. All data was analyzed statistically using one-way ANOVA.

The maxillary anterior teeth showed two to three times more lingual inclination than the mandibular teeth. The difference in maxillary alveolar bone thickness on the labial and lingual sides was significant in all levels, particularly in the apex. The mandibular alveolar bone thickness on the labial and lingual side was significantly different only in the apex.

In conclusion, the alveolar bone thickness on the anterior region was too thin, and the long axis of the maxillary anterior teeth showed more lingual inclination than the alveolar process. Therefore, clinicians need to be a detailed assessment of the labial alveolar bone for dental implant placement.

Keywords : Dental implant placement, Anterior region, Long axis of anterior teeth, Long axis of alveolar process, Alveolar bone thickness

Introduction

Anterior tooth loss is caused mainly by trauma, periodontal disease and failure of endodontic treatment. Therefore, the single tooth rehabilitation is preferred the immediate implant placement after the tooth extraction. At the bone loss region of a peri-implant, it takes 6 months to fully recover from immediate implantation after an extraction of the anterior teeth. In addition, immediate implantation is preserved more of the alveolar bone than delayed implantation (Covani et al. 2004, 2007). At this time, for successful dental implant placement on the anterior region, it is very important to recover the function and esthetics (Cardaropoli et al. 2003, Schropp et al. 2003). Particularly in people increasing a interest in aesthetics, the angled abutment is used frequently due to the labial inclination of anterior alveolar process. Accordingly, it is important to analyze the angle of the alveolar process and the long axis of tooth accurately (Clelland et al. 1995). In addition, the thickness of alveolar bone in the labial and lingual sides at the long axis of the tooth is so important that the width of the anterior alveolar process is narrower than the posterior one (Bernard et al. 2004).

Dental implant placement on the edentulous region requires placement along by the long axis of the natural teeth. However, the anterior alveolar process of the maxilla and

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mandible inclines towards the labial side, whereas the long axis of the anterior tooth inclines slightly towards the lingual side (Masumoto et al. 2001, van Loenen et al. 2005, Kao et al. 2008). Despite the increasing thickness of the alveolar bone from the alveolar crest to the apex, the maxillary anterior teeth showed greatly a labioversion and the mandibular anterior teeth have a thin labial bone compared with he maxillary anterior teeth. Thus, the anterior teeth in the maxilla and mandible could lead to aesthetic and support problems after placing a dental implant. Like this, the thickness of the labial alveolar bone is particularly significant in that the anterior alveolar process thickness is thin and the long axis of the tooth has a lingual inclination compared to that of the alveolar process.

Flanagan (2008) compared the thickness of the labial and lingual cortical bone on the edentulism, and Swasty et al. (2009) measured the thickness of the alveolar bone in various age groups. Therefore, Computed Tomography (CT) is generally used to measure the alveolar bone on account of the capacity of a large range of ages and numbers (Tsunori et al. 1998). Recently, the reconstructed 3D images using micro-CT are used more often, because they have higher resolution compared to the conventional CT images and could acquire a full 3D image (Kim et al. 2011). On the other hand, the data of the CT is quite inaccurate compared to the manual measurement of the cadaver. For this reason, the manual measurements of a cadaveric sample, though limited by the number and the age range of the samples, could provide accurate data (Schwartz-Dabney and Dechow 2003, Park et al. 2004, Katranji et al. 2007). However, there is a paucity of reports that measured the angulation between the alveolar process and the tooth axis as well as the thickness of the labial and lingual alveolar bone by manual measurements of cadavers.

Therefore, the purpose of this study was to examine the angulation between the long axis of the anterior teeth and the alveolar process, and thickness of the alveolar bone on the anterior region in Koreans to provide an anatomic knowledge for dental implant placement.

Materials and Methods

Twenty-five cadaver heads (18 maxillae and 23 mandibles) were examined (16 male and 9 female). The age at death of the cadaver heads ranged from 40 to 90 years (mean: 56.7 years). The 18 maxillae and 23 mandibles which had a little bone resorption were chosen among those because the range of age at death was a large. In addition, samples with all anterior teeth including the canine were chosen to measure the angulation between the long axis of the anterior teeth and the alveolar process, and the thickness of alveolar bone.

All specimens were decalcified in a decalcification solution (8 N formic acid+1 N sodium formate) for 1 month. The specimens were neutralized in distilled water for 12 hours. They were cut at the midline of each anterior tooth from the labial side to the lingual side using a microtome blade (Feather Co., Osaka, Japan). Each sectioned specimen was scanned using a scanner (HP Scanjet G4050, Hewlett Packard Co., Houston, Tex, USA), and the scanned image was measured using Adobe Photoshop CS3 ver 10 (Adobe, CA, USA) to a 0.01 mm level (Park et al. 2004).

On each scanned image, the long axis of the anterior teeth was connected to the incisor edge and root apex. The long axis of the alveolar process was set to connect the center point of the cementoenamel junction (CEJ) and the center point of line passing through the root apex parallel to the CEJ. The angulation of the inter-long axis was then measured (Fig. 1).

The alveolar bone thickness was measured at the long axis of the anterior teeth in three levels (crest, middle and apex) on the labial and lingual sides. 2 mm under CEJ was chosen for first level (crest; C) because the absorption level of the alveolar process shows individual difference and periodontal disease is a common phenomenon in the elderly. The second level (middle; M) was set 8 mm under the CEJ. The third level (apex; A) was set at 14 mm under the CEJ considering the mean root length of the anterior teeth. On the three levels, the alveolar bone thickness was counted by adding the root thickness and trabecular and cortical bone thickness at the long axis of the anterior teeth (Fig. 2). All measurements were carried out by four investigators. The inter-observer agreement was high, therefore, the average of the 4 measurements was used as the final measurement.

The inter-observer difference was analyzed by one-way ANOVA. All measurements were reported as the mean±SD. The difference between the right and left sides was analyzed using one-way ANOVA. There was no significant difference so each side measurement was counted as the same group. The alveolar bone thickness in the labial and

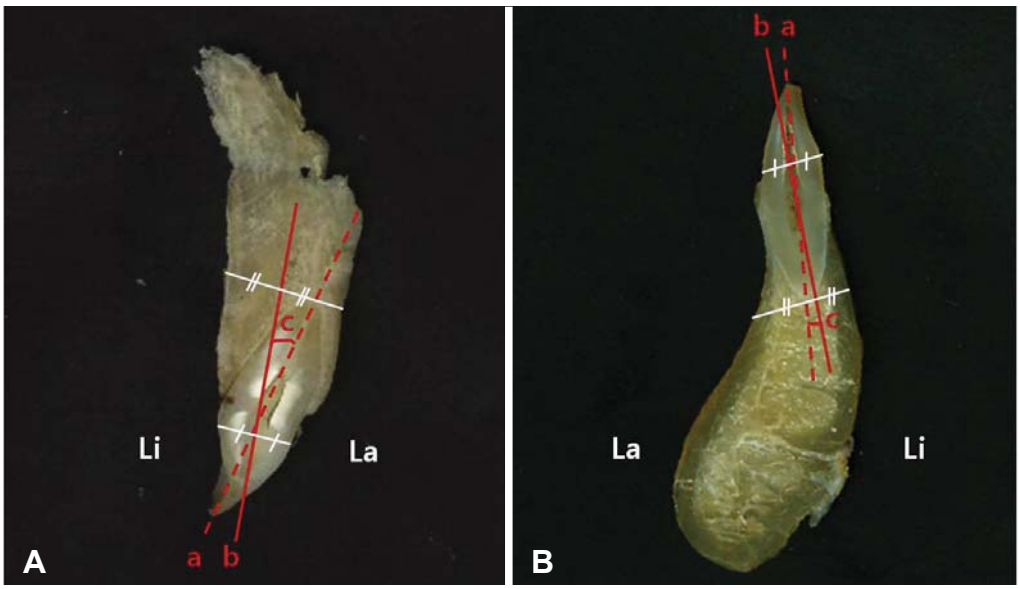

Fig. 1. Scanned image of the midline of the tooth. A; Maxilla, B; Mandible. La; labial side. Li; lingual side. a was the long axis of the anterior tooth that was connected to the incisor edge and root apex. b was the long axis of the alveolar process was set to connect the center point of the cementoenamel junction (CEJ) and the center point of line passing through the root apex parallel to the CEJ. c was showed the angulation between the long axis of anterior tooth and alveolar process. /, // indicates that it has a same distance from the long axis of the alveolar process to the cortical bone of labial and lingual sides between the identical character.

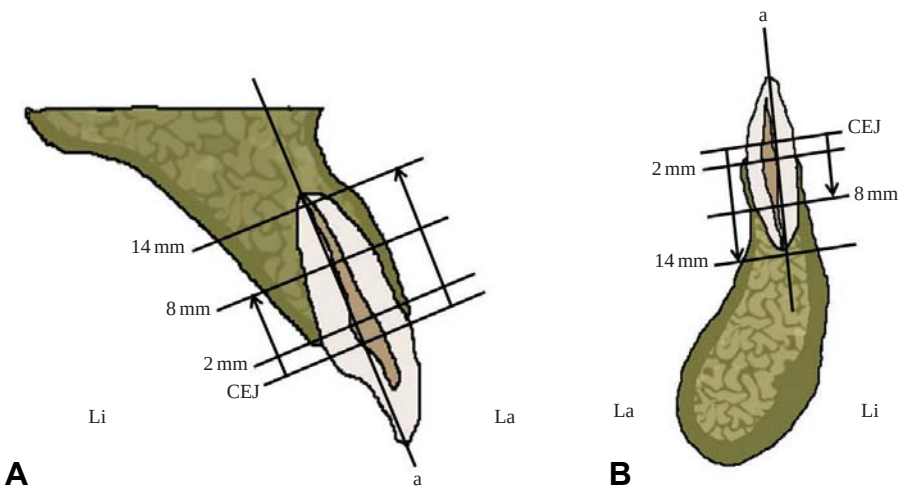

Fig. 2. Diagram showing the thickness of alveolar bone in three levels of the tooth. A; Maxilla, B; Mandible. a; long axis of anterior tooth. CEJ; cementoenamel junction.

lingual side was compared with a post-hoc comparison on Scheffe. As a result, the canine showed a significant difference from the other teeth. Therefore, the analysis of the alveolar bone thickness of the whole anterior teeth included only the central incisor and lateral incisor on the maxilla and mandible. All statistical analyses were performed using SPSS 12.0 (Chicago, IL, USA). A P value < 0.05 was considered significant.

Results

The maxillary anterior teeth showed similar angulation among those, and showed two to three times more lingual

inclination than the mandibular teeth in terms of the angulation between the long axis of the anterior teeth and the alveolar process. On the mandible, the difference in the inter-long axis angulation was a small, and increased from central incisor to canine (Table 1).

On the maxilla, the labial alveolar bone thickness was thickest at the middle but decreased toward the apex in all teeth. The lingual alveolar bone thickness increased toward the apex in all teeth. In addition, the lingual alveolar bone thickness was thicker than the labial side in all levels of each tooth. At lateral incisor, the thickness of labial and lingual alveolar bone was the thinnest in all levels (Table 2).

In mandible, similar to the maxilla, the labial alveolar bone thickness was thickest at the middle but decreased toward the apex in all teeth. The lingual alveolar bone thickness increased toward the apex in all teeth. In addition, the labial and lingual side thickness at the central and lateral incisors was similar at crest and middle regions. The alveolar bone thickness in the canine was larger than that of the central and lateral incisors (Table 3).

The alveolar bone thickness on the labial and the lingual side in the maxilla and the mandible was compared. In the maxilla, the labial alveolar bone thickness was 2.44±0.36 mm (C), 2.83±0.56 mm (M), and 1.95±0.62 mm (A). The lingual alveolar bone thickness was 2.75±0.63 mm (C), 3.94±1.14 mm (M), and 5.69±1.71 mm (A). The alveolar bone thickness on the labial and the lingual side was significantly different, particularly in the apex (Fig. 3).

In the mandible, the labial alveolar bone thickness was 2.48±0.46 mm (C), 2.67±0.57 mm (M), and 2.21±0.85 mm (A). The lingual alveolar bone thickness was 2.36±0.51 mm (C), 2.61±0.47 mm (M), and 3.02±0.99 mm (A).

Table 1. Angulation between the long axis of the anterior teeth and the alveolar process on the maxilla and mandible (mean±SD, unit; °)

	CI	LI	C
Maxilla	19.04±5.20	19.50±7.65	19.01±5.80
Mandible	5.19±4.18	7.35±5.60	8.78±5.95

Abbreviations; CI, central incisor; LI, lateral incisor; C, canine.

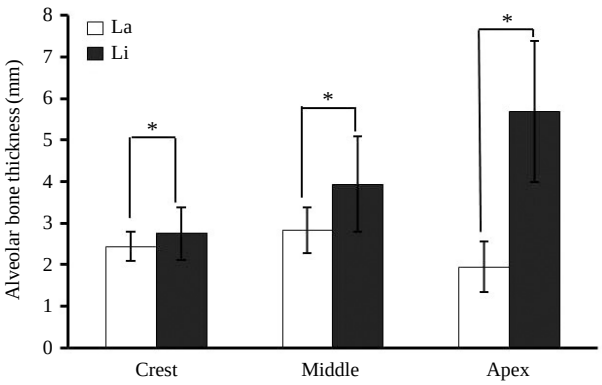

Fig. 3. Diagram showing the comparison of the alveolar bone thickness in the labial and lingual side on the maxilla. * indicates statistical significance with a $P<0.05$.

Table 2. Thickness of the alveolar bone in the three levels of the tooth on the maxilla (mean±SD, unit; mm)

	CI		LI		C	
	La	Li	La	Li	La	Li
Crest	2.57±0.36	2.98±0.63	2.33±0.33	2.56±0.57	3.03±0.45	3.06±0.48
Middle	2.93±0.51	4.44±1.13	2.73±0.60	3.48±0.96	3.22±0.37	4.93±1.05
Apex	2.01±0.55	6.61±1.46	1.89±0.69	4.88±1.52	1.83±0.60	8.06±2.92
Mean±SD	2.50±0.61	4.68±1.87	2.32±0.65	3.64±1.44	2.69±0.78	5.35±2.74

Abbreviations; CI, central incisor; LI, lateral incisor; C, canine; La, labial alveolar bone; Li, lingual alveolar bone.

Table 3. Thickness of the alveolar bone in the three levels of the tooth on the mandible (mean±SD, unit; mm)

	CI		LI		C	
	La	Li	La	Li	La	Li
Crest	2.36±0.48	2.30±0.65	2.58±0.43	2.41±0.36	3.21±0.43	3.38±0.58
Middle	2.53±0.63	2.41±0.49	2.78±0.50	2.78±0.39	3.20±0.50	4.00±1.00
Apex	2.12±0.90	2.73±0.82	2.28±0.82	3.24±1.06	2.73±0.93	4.86±1.59
Mean±SD	2.34±0.70	2.48±0.68	2.54±0.64	2.81±0.76	3.05±0.69	4.08±1.28

Abbreviations; CI, central incisor; LI, lateral incisor; C, canine; La, labial alveolar bone; Li, lingual alveolar bone.

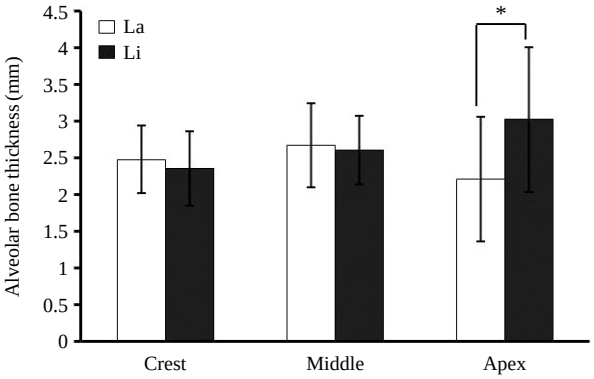

Fig. 4. Diagram showing the comparison of the alveolar bone thickness in the labial and lingual side on the mandible. * indicates statistical significance with a $P < 0.05$.

The alveolar bone thickness on the labial and lingual side was significantly different only in the apex (Fig. 4).

Discussion

For dental implant placement, the direction of the long axis of the teeth toward the alveolar bone is very important, and the appropriate placement angle and thick cortical plates are the primary way of achieving primary implant stability (Katranji et al. 2007). The initial stability at the time of implant installation is affected more by the cortical bone thickness than by the implant fixture length. In particular, in the anterior region of the maxilla, it is difficult to recover the support and aesthetics with thin labial alveolar bone and a protruding root shape (Buser et al. 2004, Miyamoto et al. 2005).

Flanagan (2008) said using CT that the cortical thickness of the lingual side is always thicker than that of the labial side under the condition that the absorption of the bone occurs, and the cortical bone of the lingual side should have a greater influence to have support or stabilization. Swasty et al. (2009), who using CT on the mandible, reported that the cortical bone thickness was thinnest in the first decade of life, and thickest in the fifth decade with a decrease in thickness thereafter. Park et al. (2004), who performed measurements on cadavers, showed that the labial cortical bone thickness became thicker going from the alveolar process to the basal bone on the mandible. Schwartz-Dabney and Dechow (2003) reported that in a dentulous mandible on cadavers, the cortical bone thickness varied according to the site and the labial cortical bone thickness was significantly thicker than the lingual side.

Until now, many studies have examined the thickness of the cortical bone, but the thickness of the labial and lingual alveolar bone is particularly significant at the long axis of the anterior teeth. Because the anterior alveolar process width is narrow compared to the posterior process, and the long axis of the tooth has lingual inclination compared to that of the alveolar process. Therefore, this study measured the thickness of the labial and lingual alveolar bone at the long axis of the tooth.

In this study, the alveolar bone thickness in the maxilla was thinnest in the three levels (crest, middle and apex) in both the labial and lingual sides of the lateral incisor, and thickest on the canine. The labial alveolar bone thickness was thickest in the middle and thinnest in the apex in all anterior teeth. The lingual alveolar bone thickness was the thickest in the apex in all anterior teeth.

On the mandible, the alveolar bone thickness was thinnest in the three levels in both labial and lingual sides of the central incisor, and thickest on the canine. The labial alveolar bone thickness was similar to the maxilla; thickest in the middle and thinnest in the apex in all anterior teeth. The lingual alveolar bone thickness was also thickest in the apex in all anterior teeth. In addition, the alveolar bone thickness was similar in the labial and lingual sides in the crest and middle of the central and lateral incisors, and in the canine, where the lingual side was thicker than the labial side.

The root thickness of maxillary central and lateral incisors becomes sharply thinner from the 6 mm under CEJ toward apex, and the contour of labial alveolar bone is a concave shape toward root apex (Kim et al. 2011). That is, the thickness of labial alveolar bone becomes thicker from crest to apex. However, in this study, the labial alveolar bone thickness was thickest in the middle and thinnest in the apex. This difference could occur for the root thickness, because in this study the alveolar bone thickness was measured by adding the root thickness and trabecular and cortical bone thickness at the long axis of the anterior teeth. Therefore, to understand the alveolar bone thickness correctly, it was thought that additional studies, which measure only sheer alveolar bone thickness without a dental root, should be conducted in the future.

On the anterior maxilla, the labial alveolar bone thickness is thin, and particularly in exposed area as remodeling of alveolar bone, the degree of vertical bone loss is affect-

ed by the thickness of remaining labial bone (Cardaropoli et al. 2006). Therefore, the labial alveolar bone thickness needs to be analyzed accurately to improve the stability and aesthetics of dental implants. Consequently, immediate impant placement after extraction was recommended (Wagenberg and Ginsburg 2001, Cardaropoli et al. 2003, Araujo and Lindhe 2005, Juodzbalys and Wang 2007). Yoo et al. (2006) reported that a change in the alveolar crest level could be recommended in most implants for an immediate implant after extraction, and the mandible showed more alveolar crest absorption than the maxilla during immediate implant placement. Nevins et al. (2006) recommended that bone graft materials should be used to minimize bone absorption because the thin labial cortical bone of the anterior maxilla could be absorbed easily after extraction. In present study, the labial and lingual alveolar bone thickness was the thinnest in the maxillary lateral incisor and mandibular central incisor, therefore, that region needs to be more care among the anterior teeth.

Covani et al. (2004, 2007) compared an immediate implant with a delayed implant after extraction, which all loss of the peri-implant healed after the second surgery in both methods. The distance between the labial and lingual side of alveolar crest was 8.1 mm in the immediate implant and 5.8 mm in the delayed implant. In addition, when it was evaluated the reformation degree of vertical bone on anterior region in an immediate implant after the extraction, the loss of the peri-implant fully healed after 6 months. In particular, the vertical absorption observed in the labial side was not observed on the esthetic side effects. Whereas, Araujo et al. (2005) reported that the vertical bone absorption in the labial side of the anterior region was more than that in the lingual side. In addition, when an amount of absorption after placement was compared an immediate implant on a dentulous alveolar bone with delayed implant on an edentulous alveolar bone, the immediate implant did not preserve larger volume of the alveolar bone than that of the delayed implant.

In this study, the long axis of the anterior teeth showed more lingual inclination than the alveolar process in both the maxilla and mandible. The angulation between the long axis of the anterior teeth and the alveolar process on the maxilla was 19.04° in the central incisor, 19.50° in the lateral incisor and 19.01° in the canine, which produced similar inclination. On the mandible, it was 5.19°, 7.35° and 8.78°, respectively, which increased from the central incisor to the canine. The maxillary anterior teeth showed two to three times more lingual inclination than the mandibular teeth.

The labial alveolar bone thickness at each level decreased towards the apex in the maxillary anterior teeth. This is due to the long axis of the tooth, which showed approximately 19° more lingual inclination than the alveolar process. On the mandible, there was no difference, even though it also decreased towards the apex because the angulation between the long axis of the anterior teeth and the alveolar process was small. Therefore, it could be recommended that a dental implant is placed slightly toward the lingual side to the natural tooth to compensate for the absorption of labial alveolar bone.

In conclusion, it should be careful during dental implant placement on the labial alveolar bone, because the alveolar bone thickness on the anterior region was too thin and the long axis of the maxillary anterior teeth showed more lingual inclination than the alveolar process. Further studies will be needed to reveal the thickness and ratio of the cortical and trabecular bone in the anterior region. In addition, in present study, the bone loss arose a few at cutting due to the shortage of decalcification. And it did not be cut on the median plane of tooth till the root apex correctly because they were cut through the midline of the each anterior tooth at the central point of incisal edge on dental crown. Therefore, to measure the median plane of tooth with precision, it was thought that studies combined with micro-CT images should be essential in the future.

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앞니장축과 이틀돌기의 각도 및 이틀뼈의 두께

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간추림 : 앞니부위의 임플란트 시술 시 기능과 심미성의 회복은 중요한 요소이다. 본 연구의 목적은 한국인 앞니부위의 치아와 이틀돌기의 장축 사이의 각도 및 이틀뼈의 두께를 계측하여 임플란트 시술 시 유용한 해부학적 자료를 제공하는데 있다.

본 연구에서는 한국인 시신 25구에서(남자 16구, 여자 9구) 얻어진 위턱뼈 18쪽과 아래턱뼈 23쪽을 사용하였다. 치아와 이틀돌기의 장축을 설정하여 두축 사이의 각도를 계측하였고, 입술쪽과 혀쪽의 이틀능선, 뿌리중간, 그리고 뿌리끝 부위에서 이틀뼈의 두께를 Adobe Photoshop을 이용하여 측정하였다.

이틀돌기와 치아장축 사이의 각도는 위턱 앞니들이 아래턱보다 2～3배 정도 더 혀쪽 경사를 보였다. 위턱에서 입술쪽과 혀쪽 이틀뼈의 두께는 유의적 차이를 보였으며, 특히 뿌리끝부위에서 큰 차이를 보였다. 아래턱에서 입술쪽 이틀뼈의 두께와 혀쪽 이틀뼈의 두께를 비교한 결과 뿌리끝부위에서만 유의적 차이가 나타났다.

이를 종합하면, 앞니부위의 이틀돌기의 두께가 얇고 특히 위턱에서 치아의 장축이 이틀돌기에 대하여 상당한 혀쪽 경사를 보이기 때문에, 임상의들은 임플란트 시술 시 입술쪽 이틀뼈에 대한 주의가 요구된다.

찾아보기 낱말 : 임플란트 식립, 앞니부위, 앞니 장축, 이틀돌기의 장축, 이틀뼈의 두께

† 공동 제1저자로 동등한 역할을 수행하였음.

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