A study on sagittal root position of maxillary anterior teeth in Korean

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Purpose: The purpose of this study was to analyze the sagittal root position of maxillary anterior teeth and report the frequency of each classification in Korean for immediate implant placement. **Materials and Methods:** A retrospective review of cone-beam computed tomography (cone-beam CT) images was conducted on 120 patients (60 male and 60 female) who fulfilled the inclusion criteria. After reorientation of the axis, cone-beam CT images were evaluated and the relationship of the sagittal root position (SRP) of the maxillary anterior teeth to its associated osseous housing was recorded. Class I, II, and III were classified respectively when the root was positioned on the labial, central, and palatal aspect of the alveolar bone. Class IV was the position that at least two thirds of the root is engaging both the labial and palatal cortical plates. Then, the angulation of the root axis and the alveolar bone axis was measured. Descriptive statistics and Kruskal-Wallis test were used to compare the angulation according to the root position and SRP class. **Results:** The frequency distribution of sagittal root position of maxillary anterior teeth indicated that 81.1%, 10.3%, 1.9%, and 6.7% were classified as Class I, II, III, and IV, respectively. The sagittal angulation at approximately 77.5% of central incisor, lateral incisor, and canine was < 20 degrees, but the angle at more than 42.7% of canine was ≥ 20 degrees. Within the class, the angulation was statistically significantly greater in Class I (16.19) compared to Class II (8.72) and Class III (9.93), and smaller in Class IV (3.79). **Conclusion:** Within the limitation of this study, a majority of the maxillary anterior roots were positioned close to the buccal cortical plate. However, some roots have very thin alveolar bone and sagittal angulation larger than 30 degrees. Therefore, cone-beam CT analyses of the sagittal root position and the sagittal angulation are recommended for the selection of the appropriate dental implant treatment approach. **(J Dent Rehabil Appl Sci 2020;36(2):88-94)**

Key words: cone-beam CT; maxillary anterior teeth; sagittal root position; dental implant

Introduction

Since its introduction in the 1990s, immediate implant placement in aesthetic areas has been widely used as a predictable treatment option to replace tooth loss.[1,2] Immediate implant placement have the advantage of preserving tissue architecture, reducing treatment time, and improving patients' convenience through provisionalization.[3,4] Also, immediate implant placement has been reported to have a high success rates when clinical guidelines are followed.[5,6]

The implant position is one of the most important factors to maintain the aesthetic and function.[7] Implant should be based on prosthetic restoration plans, but are often limited by the morphology of the residual alveolar ridge. When there is a lack of residual bone in extraction socket, various factors should be considered to ensure the primary stability of implant. Factors such as root length, sagittal root position (SRP), and the morphology of the osseous housing are important in determining the feasibility of immediate implant placement, and should be

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evaluated with cone-beam computerized tomography (cone-beam CT).

The root position is critical for implant treatment planning in the maxillary anterior region, especially in immediate implant placement. Kan et al.[8] presented a classification of SRP to aid implant treatment planning, in which the relationship between the root position and its osseous housing is categorized as Class I, II, III, and IV. In the study, 81.1%, 6.5%, 0.7%, and 11.7% of the 600 samples were classified as Class I, II, III, and IV, respectively. However, since Caucasians and Koreans have differences in size and shape of dental arch and soft tissue profiles, it could be assumed that there is a difference in root shape and position.[9-12]

In a study on maxillary central incisor and lateral incisor, Jung et al.[13] reported that 92.2% of central incisor and 94.0% of lateral incisor are positioned buccally. However, very few studies evaluated SRP class IV, in which the root engaged both the labial and palatal cortical plates. SRP class IV was reported to be about 10% which is considered to be contraindication for immediate implant placement.[8,14] Also, angulation between the long axis of the tooth and the long axis of the corresponding alveolar bone was crucial importance in the selection of the appropriate implant approach.[15]

Therefore, the purpose of this study was to evaluate and compare sagittal root position and sagittal angulation of maxillary anterior teeth for immediate implant placement. The first null hypothesis was that there is no difference in sagittal angulation between central incisor, lateral incisor, and canine. The second null hypothesis was that there is no difference in sagittal angulation between SRP classes.

Materials and Methods

This study was approved by the local institutional review board (protocol no. IRB202003-01). A retrospective review of cone-beam CT images was conducted on 120 patients (60 male and 60 female) who met the criteria of this study. The gender and age distribution of patients is in Table 1. The following inclusion criteria were applied as reported by previ-

Table 1. Patient age and gender information

Age	Male	Female
20 - 29	38	30
30 - 39	10	18
40 - 49	4	7
> 50	8	5
Total	60	60

ous studies[8,13]: at least 18 years of age at the time of the cone-beam CT scan; all maxillary and mandibular teeth were present; Angle class I occlusion; no rotation or malposition of anterior teeth; no radiographic evidence of infection, root resorption, or trauma to maxillary anterior dentition; and no history of surgical treatment in the maxillary anterior dentition.

Cone-beam CT images were analyzed using software (Invivo 5.1, Anatomage, San Jose, USA). The orientation of axis was conducted as reported by previous study.[16] First, the vertical line was set to the line passing through Nasion and Anterior Nasal Spine (ANS) in the sagittal view. Next, the horizontal line was set to the line passing through the Orbitale on both sides in coronal view. Finally, the vertical line was set to the line passing through the ANS and Posterior Nasal Spine in axial view. It was reported that there were no significant differences between the measurements on the right and left sides or between sexes.[17,18] Therefore, in this study, only one side of each subject's cone-beam CT images was selected for evaluation. The Image analysis was conducted in left or right view mode for central incisor and lateral incisor, and in right 3/4 or left 3/4 view mode for canine considering arch form and canine position. Images were clipped by 5 mm and teeth mode was selected for confirming root position.

Each tooth images was classified according to the classification reported by Kan et al.[8] (Fig. 1).

Class I: The root is positioned against the labial cortical plate

Class II: The root is centered in the middle of the alveolar housing without engaging either the labial or the palatal cortical plate at the apical third of the root
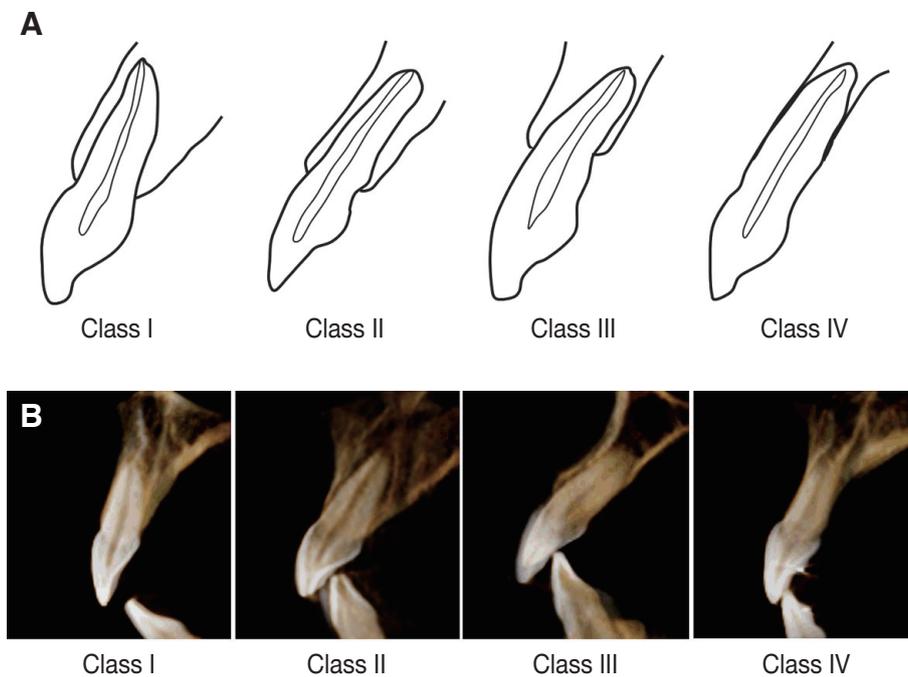
A

Class I   Class II   Class III   Class IV

B

Class I   Class II   Class III   Class IV

Fig. 1. Classification of sagittal root position. (A) Schematic diagram, (B) Cone-beam CT image.

Class III: The root is positioned against the palatal cortical plate

Class IV: at least two thirds of the root is engaging both the labial and palatal cortical plates

The angulation between the long axis of the tooth and the long axis of the corresponding alveolar bone was determined in accordance with the procedure described by Lau et al. (Fig. 2).[19] Line A shows the alveolar bone axis which bisects the angle of the buccal and palatal line. Line B shows the tooth axis which was defined as the line through the lowest point of the crown to the highest point on the apex.

The normality of the data was determined using the Kolmogorov-Smirnov test. Descriptive statistics were presented, including means values, frequencies, and percentages. The Kruskal-Wallis test was used to compare the angulation between teeth and SRP classes because the samples did not follow normal distributions. After that, Mann-Whitney U test with Bonferroni correction was used to verify differences between groups. Statistical analysis was performed with software (SPSS 23.0, IBM Inc., Armonk, USA) and statistical significance was set at $P < 0.05$.
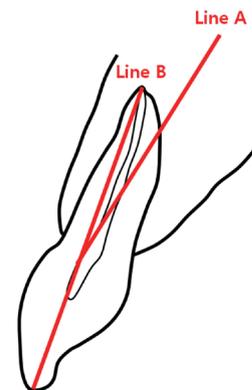

Fig. 2. The angulation between the alveolar bone axis and the tooth axis. Line A: long axis of the alveolar bone, Line B: long axis of the tooth.

Results

In present study, the sagittal root position in relationship to the osseous housing was examined. The frequency distribution was categorized according to tooth position and SRP class (Table 2). A majority of the maxillary anterior roots were positioned more buccally within the alveolar bone. Only seven anterior roots were positioned more palatally.

Table 2. Frequency distribution of the sagittal root position classification

Sagittal root position	Percentage (no.)			
	Central incisor	Lateral incisor	Canine	Overall
Class I	74.2 (89)	81.7 (98)	87.5 (105)	81.1 (292)
Class II	18.3 (22)	5.8 (7)	6.7 (8)	10.3 (37)
Class III	1.7 (2)	3.3 (3)	0.8 (1)	1.9 (7)
Class IV	5.8 (7)	9.2 (11)	5.0 (6)	6.7 (24)
Total	100 (120)	100 (120)	100 (120)	100 (360)

Table 3. Frequency distribution of the sagittal angulation (in degrees)

Angulation	Percentage (no.)			
	Central incisor	Lateral incisor	Canine	Overall
< 10	46.7 (56)	20 (24)	6.7 (8)	24.4 (88)
$\geq 10, < 20$	50.0 (60)	57.50 (69)	51.7 (62)	53.1 (191)
$\geq 20, < 30$	3.3 (4)	20.83 (25)	35 (42)	19.7 (71)
≥ 30	0 (0)	1.67 (2)	6.7 (8)	2.8 (10)
Total	100 (120)	100 (120)	100 (120)	100 (360)

Table 4. Sagittal angulation (in degrees) of the maxillary anterior teeth according to SRP class

Sagittal root position	Central incisor	Lateral incisor	Canine	Overall
Class I	11.78	16.25	19.88	16.19[A]
Class II	6.30	8.67	15.40	8.72[B]
Class III	3.90	3.98	2.80	3.79[C]
Class IV	5.93	12.25	10.33	9.93[B]
Total	10.31[a]	15.03[b]	18.96[c]	14.77

The different lower case letters in rows and the different capital letters in columns indicate significant difference ($P < 0.05$).

The sagittal angulation of the maxillary anterior teeth within the alveolar bone was determined (Table 3). The angulation of the canine showed the largest angulation, followed by lateral incisor, and finally central incisor showed the smallest angulation ($P < 0.05$, Table 4). Within the class, Class I showed the largest angulation and Class III showed the smallest one.

Discussion

The present study evaluated the sagittal root position and sagittal angulation of maxillary anterior teeth in Korean using cone-beam CT. According to the results of the study, the first null hypothesis that there is no difference in sagittal angulation between central incisor, lateral incisor, and canine was rejected. The second null hypothesis that there is no difference in sagittal angulation between SRP classes was partially rejected.

In this study, 81.1%, 10.3%, 1.9%, and 6.7% of the 360 samples were classified as Class I, II, III, and IV, respectively. SRP Class I, in which the root is in contact with the labial cortical bone, has a considerable amount of bone in palatal aspect generally. This provides the primary stability for immediate implant placement. Also, implant-socket gap on labial side allows an aesthetic tissue profile by using bone graft materials. Thus, SRP Class I was categorized as a position that is favorable for immediate implant placement. It means that, if guidelines are followed, the majority of maxillary anterior region could be indi-

cation for immediate implant placement. Especially, Class I was the most common in canine and this result is consistent with the result of previous study.[14] However, clinicians should evaluate the implant insertion angles, because Class I showed the greatest sagittal angulation between the tooth axis and the alveolar axis.

Overall, SRP Class II was 10.3% and generally, the volume of alveolar bone on both the labial and palatal aspects is less than what is encountered in Class I or III.[8] This amount of bone could be inadequate to ensure implant primary stability. Therefore, when considering immediate implant placement in Class II, the available bone beyond the apex of the extraction socket should be evaluated. Next, similar to previous studies, Class III was rarely found. The frequency of Class III has been reported to vary from 0.2% to 1.8%.[19,20]

Class IV was 6.7% and especially 9.2% for lateral incisors in present study. In this case, the root occupies the majority of the alveolar volume, and after tooth extraction, there is a limited alveolar bone for primary stability. Thus, bone grafting procedures are often necessary prior to implant placement. For this reason, Class IV is considered to be a contraindication for immediate implant placement. Frequency of Class IV in this study was less than that of Caucasians, and more than that of Thai people.[8,14] This appears to be due to differences in race and the average age of the subjects studied.

Sagittal angulation between the long axis of the tooth and the alveolar bone was below 10 degrees at 24.4% of maxillary anterior teeth. It is relatively simple to insert implant in this case. The implant can be placed in the same direction along the root, however, slightly palatal to ensure that the labial bone wall is sufficiently thick and to ensure primary stability.[21] In present study, 53.1% of the samples featured a sagittal angulation between about 10 and 20 degrees. More technical placement is needed considering sagittal angulation and may require narrow-diameter implant, angulated abutment, or cement-type prosthesis.

However, about 20% of anterior maxillary teeth showed a sagittal angulation that was greater than 20

degrees and 8% of canine was greater than 30 degrees. In this situation, the tooth root is close to the buccal cortical bone, and difficulties are encountered in setting the implant placement angles. Therefore, socket preservation procedure with late implant placement or narrow-diameter implant with palatal position should be considered for primary stability. It is also recommended to use customized abutment for the aesthetic prosthesis.

The limitation of this study is that cone-beam CT images of normal teeth and alveolar bone is different from the situation weakened by periodontal disease or other reasons. However, the present study could be used as data on the position and angulation of the root that should be considered when planning immediate implant placement for Koreans.

Conclusion

Within the limitation of this study, a majority of the maxillary anterior roots were positioned close to the buccal cortical plate and showed a sagittal angulation that was smaller than 20 degrees. However, some roots have very thin alveolar bone and sagittal angulation larger than 30 degrees, which is inappropriate for immediate implant placement. Consequently, cone-beam CT analysis before tooth extraction is recommended so that the clinicians can choose the appropriate implant treatment approach to achieve aesthetic and functional prosthesis.

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한국인에서 상악 전치의 시상 치근 위치에 대한 연구

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목적: 본 연구는 한국인에서 상악 전치의 치근 위치를 시상면에서 분석하고, 분류에 따른 빈도를 보고함으로써 즉시 식립 임플란트를 위한 방사선학적 자료를 수집하기 위함이다.

연구 재료 및 방법: 콘빔형 전산화단층영상(cone-beam CT)을 촬영한 환자 중 연구 기준에 적합한 120명(남성 60명, 여성 60명)을 대상으로 후향적 분석을 시행하였다. 축의 방향설정을 시행한 후에, 상악 전치부 치아와 치조골 사이의 관계에 대한 시상 치근 위치를 분석하였다. 치근이 치조골의 협측, 중앙, 구개측으로 위치한 경우 각각 Class I, II, III로 분류하였으며, 치근이 협측과 구개측 모두에서 피질골판에 2/3 이상 닿아있는 경우에는 Class IV로 하였다. 다음으로, 치아의 장축과 치조골의 장축 사이의 각도를 측정하였다. 기술적 분석 및 Kruskal-Wallis 분석을 시행하였으며, 치아의 위치 및 분류에 따른 시상각을 비교하였다.

결과: 상악 전치부의 시상 치근 위치에 대한 빈도분석 결과, Class I은 81.1% , Class II는 10.3%, Class III는 1.9%, 그리고 Class IV는 6.7%로 나타났다. 상악 전치부의 77.5%에서 시상각이 20도 이하로 나타났다. 그러나 견치의 경우, 42.7%에서 20도 이상의 시상각을 보였다. 분류에 따라서는 Class I (16.19)에서 Class II (8.72) 및 Class III (9.93)에 비해 통계학적으로 유의하게 높은 시상각을 보였으며, Class IV (3.79)에서 낮았다.

결론: 본 제한된 연구의 결과를 근거로, 상악 전치의 치근은 일반적으로 협측 치조골에 가깝게 위치하고 있으나, 일부 치아는 매우 얇은 치조골을 가지고 있으며, 30도 이상의 큰 시상각을 보였다. 따라서 적절한 치과 임플란트 치료 계획 수립을 위해 시상 치근 위치 및 시상각에 대한 cone-beam CT 분석이 필요할 것이다.

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주요어: 콘빔형 전산화단층영상; 상악 전치; 시상 치근 위치; 치과 임플란트