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2010년 2월 석사학위논문 Anthropometric Analysis of Maxillary Anterior Buccal Bone of Korean Adults Using Cone-Beam CT 이 승 록

2010년 2월
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# Anthropometric Analysis of Maxillary Anterior Buccal Bone of Korean Adults Using Cone-Beam CT

조선대학교 대학원

치 의 학 과

이 승 록

# Anthropometric Analysis of Maxillary Anterior Buccal Bone of Korean Adults Using Cone-Beam CT

Cone-beam CT를 이용한 한국 성인의 상악 협측골에 대한 인체측정학적 분석

2010년 2월 25일

조선대학교 대학원

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# Anthropometric Analysis of Maxillary Anterior Buccal Bone of Korean Adults Using Cone-Beam CT

지도교수 정 재 헌

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# 이승록의 석사학위 논문을 인준함

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# 조선대학교 대학원

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# 국문 초록

## Cone-beam CT를 이용한 한국 성인의 상악 협측골의 형태학적 분석

이 승 록
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상악 전치부 임플란트 치료의 가장 큰 목적은 적절한 심미성을 얻는 것이다. 하지만 얇은 협측골 두께와 돌출된 치근 형태로 인해 그 목적을 이루는 것은 쉽지 않다. 본 연구에서는 cone-beam CT를 사용하여 상악 전치부의 협측, 구개측의 골 두께, 치근 하방 협측골의 외형적 형태, 치근의 직경에 대해 평가하여 심미적인 상악 전치부 임플란트 치료를 위한 술 전 계획의 참고적 치표로 삼고자 하였다.

본 연구에서는 조선대학교 치과병원을 내원하여 cone-beam CT를 촬영한 총 20명(남/여 각 10명씩)의 환자를 대상으로 하였다. cone-beam CT는 조선대학교 치과병원 구강악안면 방사선과에 있는 Hitachi Mercuray cone-bream CT scanner (Hitachi Medico, Tokyo, Japan)가 사용되었다. 이의 3차원 영상 재구성과 분석을 위해서는 ONDEMAND3D (Cybermed, Seoul, Korea) 프로그램이 사용되었다. 상악 전치부 각 치아의 협측 및 구개측의 골 두께, 치근 하방 협측골의 만곡각도, 치근첨에서 협측골의 가장 깊은 만곡점까지의 거리, 치근의 직경을 측정하였고 통계학적 분석을 시행하였다.

연구 결과 상악 중절치, 측절치 협측골의 두께가 매우 얇은 것(기준선 A,B,C)것 이 관찰되었고 상대적으로 구개측 골의 두께가 더 두껍고 치근첨으로 갈 수 록 증가하기 때문에 상악 전치부 임플란트 식립 시 협측골의 흡수를 막기 위해 구개측으로 더 치우쳐 식립해야 할 것으로 사료되었다. 상악 전치부 치근 직경의 측정결과, 상악 측절치의 경우 상악 중절치 및 상악 견

치에 비해 직경이 적어 임상에서 좁은 직경의 임플란트가 추천된다. 그리고 상악 측절치 및 견치에 비해 상악 중절치의 치근 하방 협측골 만곡정도가 가장 크게 나타났다. 이는 임플란트 식립 시 상악 중절치가 측절치, 견치보다 협측골 천공 가능성이 큰 것으로 사료되며 식립시 최대한 협측골에 평행하게 식립해야 할 것이며 또한 첨형 형태의 임플란트 식립이 추천된다. 치근첨에서 치근하방 협측 골 만곡도가 가장 깊은 점까지의 거리는 상악 중절치에서 3.66±1.28mm, 상악 측절치에서, 3.90±1.51mm 상악 견치에서 5.13±1.70mm로 측정되었고 이는 즉시 임플란트 식립 시 길이 선택의 참고적 지표가 될 수 있다.

# I. Introduction

Implant placement on anterior maxillar area is very difficult treatment due to patient's high esthetic demands and difficult pre-existing anatomy.[1] A prominent root position is almost always accompanied by a thin, frail buccal plate that may be damaged during tooth removal, resulting in a deformed edentulous ridge whose bone morphology would require augmentation to place an implant in an optimal position for prosthetic restoration.[1,2]

The resorption of the alveolar process following tooth extraction in both jaw is significantly greater on the buccal aspect than lingual or palatal, so that the reduction in width of the maxillary alveolar ridge is greater than the loss of height.[2-5] Schropp et al[6] reported a reduction of 50% of the width of alveolar ridge at 12 months. Hence, preservation of the alveolus at the time of extraction of prominent roots in the anterior maxilla is crucial to allow optimal implant placement.[2] Maxillary anterior buccal bone resorption following tooth removal is so fast and significant that immediate implant placement is recommended for reducing alveolar bone resorption as much as possible.

One of the first things to be assessed for implant treatment is orofacial ridge anatomy, including whether there is sufficient crest width and the presence or abscence of facial bone atrophy. Deficient alveolar crest width and/or facial bone atrophy require a bone augmentation procedure so that the implant can be positioned in a correct orofacial position. Depending on the extent and morphology of the bone defect, a simultaneous or staged approach is necessary.[1]

Clinical sounding and sophisticated radiograph techniques such as dental computerized tomography(CT) can assist in diagnosing deficiencies in the dimension. Almost previous studies looking at maxillary cortical plate thickness with medical and spiral CT technology used cadaver skulls, not live

subjects, with limited sample size. Cone-beam computed tomography(CBCT) have several advantages compared to conventional techniques for evaluating bone structures around teeth. It is noninvasive, high resolution, and allows a fully three dimensional characterization of the bone structure around teeth.[17] Accurate treatment plan using CBCT before surgical procedure can produce optimal emergency profile, marginal gap so as to enable fabrication of high esthetic prosthesis.

The purpose of this study is to assess the relationship between the maxillary anterior teeth and surrounding alveolar structures using CBCT images for implant placement in Korean adults. It will provide guidelines for choosing proper implant fixture with regard to diameter, length and axis of surgical drilling procedure.

# Ⅱ. MATERIAL AND METHOD

## 1. Subject

Subjects were Korean adults who have been taken CBCT images at the department of oromaxillofacial radiology in Chosun University Dental Hospital. Subjects had all maxillary anterior teeth without obvious periodontal disease. Twenty subjects met the inclusion criteria. The ages ranged from 20 to 39 years (26.3±4.79 years, 10 males/10 females).

## 2. Imaging and Processing

The skulls were imaged with CBCT with the Hitachi CB Mercuray CBCT unit (Hitachi Medical, Tokyo, Japan)(Fig.1). CBCT was set at 110kVp and 10mA while acquiring a total 512 slices with a 10 sec. The images were reconstructed and analyzed using OnDemand3D (Cybermed, Seoul, Korea) (Fig.2). The center of each tooth was measured by sagittal and horizontal plane.

Fig.1. Cone-beam CT (Hitachi Medico,Tokyo,Japan)

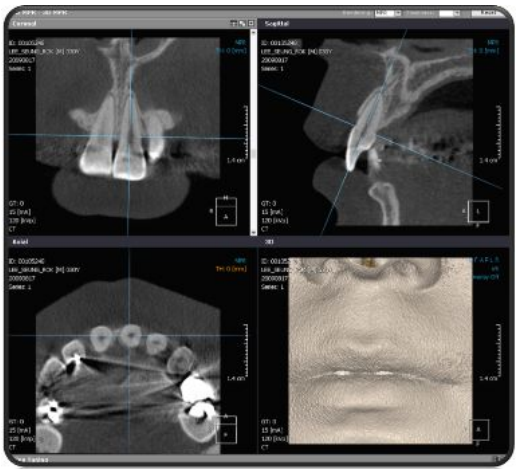

Fig.2. 3D reconstruction program OnDemand3D(Cybermed,Seoul,Korea)

## 3. Measurement

From the 3D images, five aspects of the measurement were made by image-analysis software using OnDemand3D. The distance between CEJ and buccal bone crest, thickness of buccal and palatal plate, root diameter, curvature angles below root apex, and distance from root apex to the most deepest point of the curvature were statistically analysed on the each maxillary anterior tooth.

### 1) The distance between CEJ and buccal crest

The buccal side distance between CEJ and buccal crest was measured in each maxillary anterior tooth (Fig.3).

### 2) The reference line and mean thickness of buccal and palatal alveolar plate

Four reference lines were used. All reference lines were perpendicular to the axis of each tooth. Line A was on 3mm below CEJ, line B was on 4.5mm below CEJ, line C was on the middle 1/2 between CEJ and root apex, line D was on root apex (Fig.3).

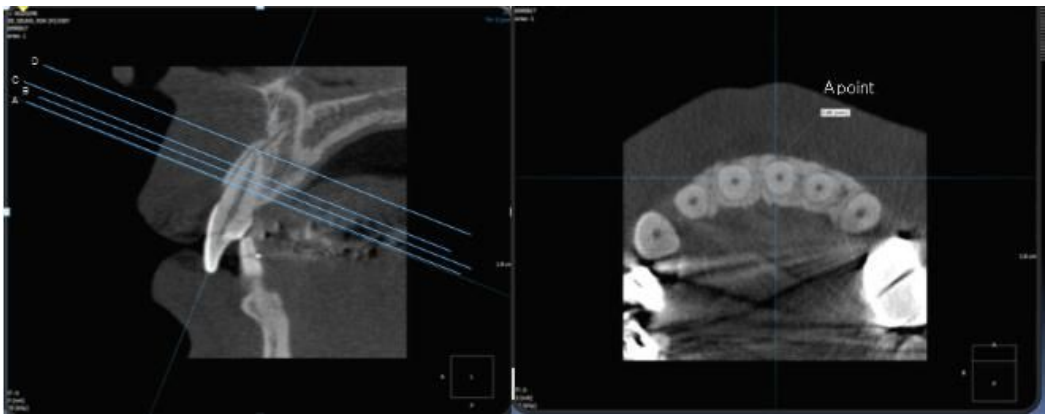


Fig.3. Reference lines and measurement of the thickness of the buccal and palatal alveolar plates of each maxillary anterior tooth.

### 3) Root diameter of the maxillary central incisor, lateral incisor and canine

Mesio-distal and bucco-lingual diameter of each root was measured at reference line A (Fig.4).

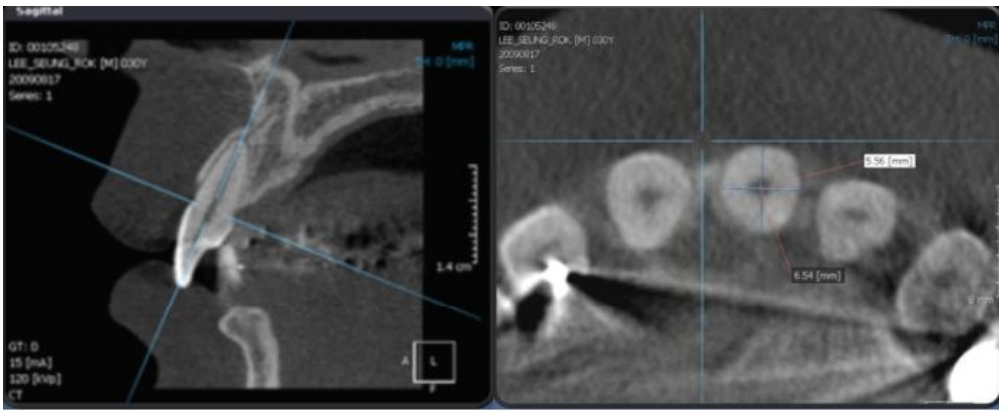

Fig.4. Diameter of maxillary anterior teeth at reference line A.

### 4) Curvature angle(∠PQR) below the root apex

Three reference points were used(P,Q,R hereafter). Reference point of P is the most upper and anterior part of buccal plate, R is the point on buccal plate which meets with reference line D, and Q is the most deepest point on the curvature between P and R. The angle made by the points was measured(Fig.5)

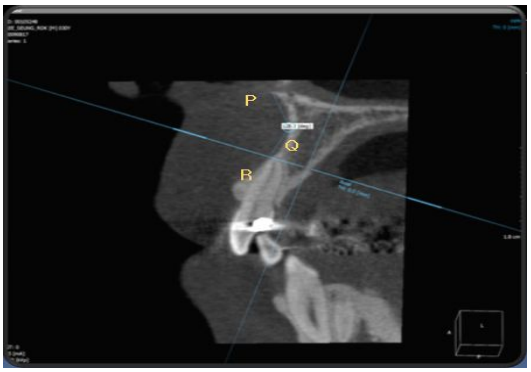


Fig. 5. Curvature angle(∠PQR) below root apex of maxillary anterior teeth.

**5) The distance between root apex and the deepest point(Q) of curvature**

The distance from line D to point Q was vertically measured (Fig.6).

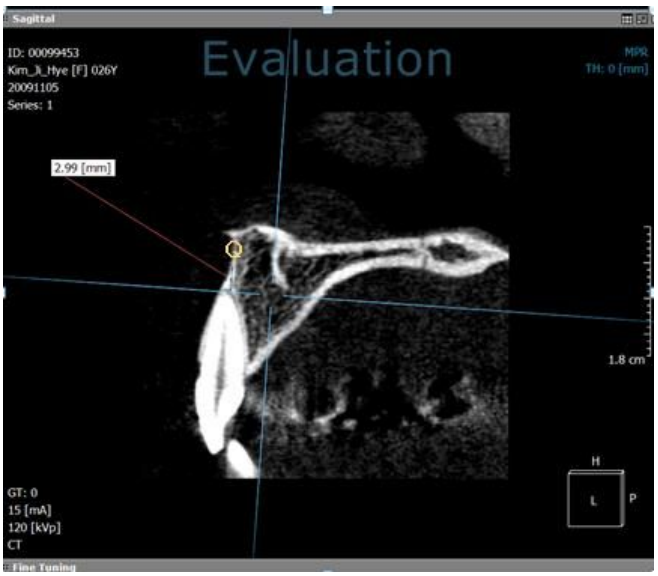


Fig.6. Distance between root apex and the deepest point(Q) of curvature.

## 4. Statistical analysis

Data capture was performed with Microsoft Excel Softwear. Data were presented as an arithmetic means ± standard deviation(SD). All data were statistically analyzed using independent simple t-test and one-way ANOVA. The threshold of significance was set at two-sides $P < 0.05$. SPSS 12.0 (SPSS, Chicago, Illinois, USA) was used for all statistical analysis.

# Ⅲ. RESULTS

**1) The mean distances between CEJ and buccal bone crest(Table 1.)**

Table 1. The mean distances between CEJ and buccal bone crest

| | | Central Incisor | Lateral Incisor | Canine |
|---|---|---|---|---|
| CEJ~ Buccal bone crest | N<br>40 | 2.03 ± 0.61 | 2.46 ± 0.65 | 2.71 ± 0.65 |

*P>0.05,statistically no significant. post-hoc comparison(scheffe)

Generally, buccal bone crest of maxillary anterior teeth existed within 3mm from CEJ.

**2) The thickness of buccal and palatal plate of maxillary anterior teeth (Table 2,3)**

Table 2. The mean thickness of buccal plate of maxillary anterior teeth

(unit : mm)

| Site / Reference line | N | Central Incisor | Lateral Incisor | Canine |
|---|---|---|---|---|
| A | 40 | 0.68 ± 0.29 | 0.76 ± 0.59 * | 1.07 ± 0.80 * |
| B | 40 | 0.69 ± 0.27 | 0.72 ± 0.59 * | 1.24 ± 0.77 * |
| C | 40 | 0.60 ± 0.28 | 0.54 ± 0.76 * | 1.16 ± 0.84 * |
| D | 40 | 0.73 ± 0.17 | 0.84 ± 1.27 | 0.84 ± 0.50 |

*P<0.05,statistically significant. post-hoc comparison(scheffe)

Generally, each thickness of buccal plate in central incisor, lateral incisor and canine was very thin in reference line A and B.

Table 3. The mean thickness of palatal plate of maxillary anterior teeth

(unit : mm)

| Reference line \ Site | N | Central Incisor | Lateral Incisor | Canine |
|---|---|---|---|---|
| A | 40 | 1.53 ± 0.55 * | 1.18 ± 0.66 | 1.42 ± 0.77 |
| B | 40 | 1.94 ± 0.72 | 1.40 ± 0.84 * | 2.39 ± 1.27 |
| C | 40 | 2.36 ± 0.86 | 1.83 ± 0.96 * | 2.95 ± 1.63 |
| D | 40 | 5.39 ± 2.37 * * | 3.81 ± 1.63 * | 7.29 ± 2.90 |

*P<0.05,statistically significant. post-hoc comparison(scheffe)

Each thickness of the palatal plate in central incisor, lateral incisor and canine was thicker than that of the buccal plate and gradually increased from line A to line D(P<0.05) (Table 2, 3).

### 3) The Bucco-lingual and mesio-distal diameter of dental roots (Table 4.)

Table 4. The mean Bucco-lingual and mesio-distal diameter of dental roots in maxillary anterior teeth

(unit : mm)

| | | Central Incisor | Lateral Incisor | Canine |
|---|---|---|---|---|
| Bucco-Lingual (CEJ) | N 40 | 5.63 ± 0.75 | 6.08 ± 0.70 | 6.65 ± 0.98 |
| Mesio-Distal (CEJ) | 40 | 5.63 ± 0.55 | 5.14 ± 0.72 | 6.67 ± 0.85 |
| Bucco-Lingual (3mm below CEJ) | 40 | 5.13± 0.37 | 4.58 ± 0.46 | 5.93 ± 0.47 |
| Mesio-Distal (3mm below CEJ) | 40 | 4.67 ± 0.49 | 4.04 ± 0.40 | 5.79 ± 0.61 |

*P<0.05,statistically significant. post-hoc comparison(scheffe)

At 3mm below CEJ, the diameter of the root shows large value in order of canine, central incisor and lateral incisor in size(P<0.05).

**4) The curvature angle(∠PQR) below root apex of maxillary anterior teeth (Table 5.)**

Table 5. The curvature angle(∠PQR) below root apex of maxillary anterior teeth.

(unit ° )

| | | Central Incisor | Lateral Incisor | Canine |
|---|---|---|---|---|
| ∠PQR(°) | N 40 | 134.7 ± 17.5 | 151.0 ± 13.9 | 153.0 ± 9.5 |

*P<0.05,statistically significant. post-hoc comparison(scheffe)

Curvature angle of maxillary central incisor has the smallest value, which means central incisor being curvated the most highly.

**5) The distance between root apex and the deepest point(Q) of curvature (Table 6.)**

Table 6. The distance between root apex and the deepest point(Q) of curvature

(unit : mm)

| | | Central Incisor | Lateral Incisor | Canine |
|---|---|---|---|---|
| Root apex ~Q point | N | * | | |
| | 40 | 3.67 ± 1.28 | 3.90 ± 1.51 | 5.13 ± 1.70 |
| | | | * | |

*P<0.05,statistically significant. post-hoc comparison(scheffe)

The distance between root apex and the deepest point of curvature in canine has the larger value compared to that of lateral and central incisor(P<0.05).

# Ⅳ. DISCUSSION

Implant therapy in the anterior maxilla is challenging for the clinician because of the esthetic demands of patients and difficult pre-existing anatomy. In this area of the mouth, the clinician is often confronted with tissue deficiencies caused by various conditions. These various conditions can be divided into anatomic and pathologic categories.[1)]

Having a facial bone wall of sufficient height and thickness is important for long-term stability of harmonious gingival margins around implants and adjacent teeth.[9,10)] Esthetic failures can also be caused by inappropriate implant positioning and/or improper implant selection. Placement of implants in a correct 3-dimensional position is a key to an esthetic treatment outcome regardless of the implant system used. The relationship of the position between the implant and the proposed restoration should be based on the position of the implant shoulder, because this will influence the final hard and soft tissue response.

It is important for the clinician to understand that ridge anatomy includes the soft tissues and the supporting bone in all dimensions, and that soft tissue contours around an implant are heavily influenced by the bone anatomy.[1)] So, this study was to elucidate the topography of the roots and surrounding alveolar bones in maxillary anterior teeth in order to get guideline for the proper implant placement in Korean adults using the cone-beam CT images.

**1) The mean distances between CEJ and buccal bone crest(Table 1.)**

The apicocoronal positioning of the implant shoulder follows the philosophy  as shallow as possible, as deep as necessary as a compromise between esthetic and biologic principles. Implant placement within the apical danger zone (located anywhere 3 mm or more apical to the proposed gingival margin) can result in undesired facial bone resorption

and subsequent gingival recession. The coronal danger zone is invaded with a supragingival shoulder position, leading to a visible metal margin and poor emergence profile.[1)]

In this study, the mean distance between CEJ and buccal bone crest was 2.03±0.61mm in central incisor, 2.46±0.65mm in lateral incisor and 2.71±0.65mm in canine. Generally buccal bone crest of maxillary anterior teeth existed below 3mm from CEJ. Theses results support the implant head should be at least 3mm apical to an imaginary line connecting the cementoenamel juctions(CEJs) of the adjacent teeth.[8)]

### 2) The thickness of buccal and palatal plate of maxillary anterior teeth (Table 2, 3.)

In reference line A, B, C and D, each thickness of buccal plate in central incisor, lateral incisor and canine was very thin within 1 mm (Table 2). Each thickness of the palatal plate in central incisor, lateral incisor and canine was thicker than that of the buccal plate (Table 2, 3).

Theses results support that implant platform should be placed more palatally when doing implant surgical drilling procedure because of Korean adult's buccal plate was very thin within 1mm.

It is important to place the axis of the implant correspond to the incisal edges of the adjacent teeth or slightly palatal to this landmark[7,16)] otherwise implant can perforate the buccal alveolar plate. Kan and Rungcharassaeng[11)] recommend that primary implant stability is achieved by engaging the palatal wall and bone approximately 4 mm to 5 mm beyond the apex of the extraction socket. So, this is achieved by positioning the burs bodily against the palatal wall of the socket during the sequential osteotomy.

In the Kan's experience, the necessity of bone grafts depends on the thickness of the labial plate rather than the size of the gap. Although a thick labial plate is generally resistant to resorption and grafting is

unnecessary, bone grafting is frequently used to prevent collapse and minimize resorption of the thin labial plate, regardless of the gap size.[11)]

### 3) The Bucco-lingual and mesio-distal diameter of dental roots (Table 4.)

It is important to select proper size because of the possiblity of fixture exposure, which can be encountered by bone resorption and gingival recession. Esthetic failures can also be caused by improper implant selection, mainly because of the use of oversized implants.

The final implant diameter was within the confines of the tooth socket, without engaging the coronal portion of the labial plate (which is generally thin) to prevent perforation. A minimal distance of 2 mm between the implant and adjacent teeth recommended to minimize marginal bone loss due to encroachment. When this is not possible, an augmentation procedure is necessary prior to or during implant placement.[11,13)] The suggested diameter for implants in the central incisor and canine areas is approximately 5 mm to 6 mm.[14,15)] The suggested implant diameter for lateral incisors is approximately 3 mm to 4 mm.[15)]

At 3mm below CEJ, the diameter of the root shows large value in order of canine (5.93±0.47mm), central incisor (5.13±0.37mm) and lateral incisor (4.58±0.46mm) in size (Table 4.). So, wide neck implants are not recommended for use in the anterior maxilla and we also recommend the narrow neck implant is most often recommended in lateral incisor areas due to the small diameter in Korea adult. Buser et al[1)] suggest that the narrow neck implant with a shoulder diameter of 3.5 mm is most often used in lateral incisor areas with a minimal gap size of 5.5 mm.

### 4) The curvature angle(∠PQR) below root apex of maxillary anterior teeth(Table 5.)

In this study, curvature angle(∠PQR) of maxillary central incisor has

the smallest value, which means central incisor being curvated the most highly (Table 5.).

Buccal alveolar bone appearance of below root apex in maxillary central incisor have high curvature. So, the long axis of the drill when surgical drilling procedure in the central incisor should be parallel to buccal alveolar plate especially in order to prevent buccal plate perforation. Also, a tapered implant may be recommended.

### 5) The distance between root apex and the deepest point of curvature (Table 6.)

In case of immediate implant placement following extraction, the length of implant fixture should be selected as long as possible for initial stability.[18] In this study, the mean distance between root apex and he deepest point of curvature was 3.66mm in central incisor, 4.89mm in lateral incisor, 5.13mm in canine. This may be the guideline for selecting proper implant fixture length to prevent buccal plate perforation.

# Ⅴ. CONCLUSIONS

In this study, The mean distance between CEJ and buccal bone crest, the mean thickness of buccal and palatal plate, root diameter, the curvature angle below root apex, the distance between root apex and the deepest point in maxillary anterior teeth were analysed using cone-beam CT.

The results were as follows;

1. The mean distance between CEJ and buccal bone crest was 2.03±0.61mm at central incisor ,2.46±0.65mm at lateral incisor, and 2.71±0.65mm at canine.

2. The mean thickness of buccal plate at each maxillary anterior tooth in reference line A(3mm below CEJ) was 0.68±0.29mm of central incisor, 0.76±0.59mm of lateral incisor, 1.07±0.80mm of canine.

3. The mean thickness of palatal plate at each maxillary anterior tooth in reference line A(3mm below CEJ) was 1.53±0.55mm of central incisor, 1.18±0.66mm of lateral incisor, 1.42±0.77mm of canine.

4. The bucco-lingual diameter 3mm below CEJ level of central incisor root was 5.64±0.55mm, 5.14±0.72mm of lateral incisor, 6.67±0.85mm of canine. The mesio-distal diameter 3mm below CEJ level of central incisor root was 6.63±0.75mm, 6.08±0.70mm of lateral incisor, 6.65±0.98mm of canine.

5. The curvature angle(∠PQR) below root apex was 134.7±17.5° at central incisor, 151.0±13.9° at lateral incisor, 153.0±9.5° at canine. Curvature angle

of central incisor has the smallest value, which means central incisor being curvated the most highly($P<0.05$).

6. The distance between root apex and the deepest point(Q) of curvature was 3.67±1.28mm at central incisor, 3.90±1.51mm at lateral incisor, 5.13±1.70mm at canine. Canine has the larger value compared to those of lateral and central incisors($P<0.05$).

In conclusion, accurate treatment plan using CBCT before surgical procedure can produce an enabling and highly esthetic fabrication with optimal emergence profile and minimum marginal gap.
Based on the result of this limited study, careful implant selection and treatment planning remain significant.

Within the limitation of this study, we found that the thickness of maxillary anterior buccal plate was very thin. Relatively the thickness of palatal plate was thick. Therefore implants should be placed more palatally when doing immediate implant surgical drilling procedure.

Buccal alveolar plate appearance of below root apex in maxillary central incisor have high curvature. Therefore the long axis of the drill in immediate surgical drilling procedure on central incisor should be parallel to buccal alveolar plate especially in order to prevent buccal plate perforation. Also, a tapered implant may be recommended. The mean distance between root apex and the deepest point(Q) of the curvature was 3.66mm in central incisor, 4.89mm in lateral incisor, 5.13mm in canine. This may be the guideline for selecting proper implant fixture length to prevent buccal plate perforation.

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# 저작물 이용 허락서

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| 논문제목 | 한글 : Cone-beam CT를 이용한 한국 성인의 상악 전치부 협측골에 대한 형태학적 분석 | | | | |
| | 영어 : Anthropometric Analysis of the Maxillary Anterior Buccal Bone of Korean Adults Using Cone-Beam CT | | | | |

본인이 저작한 위의 저작물에 대하여 다음과 같은 조건아래 -
조선대학교가 저작물을 이용할 수 있도록 허락하고 동의합니다.

- 다 음 -

1. 저작물의 DB구축 및 인터넷을 포함한 정보통신망에의 공개를 위한 저작물의 복제, 기억장치에의 저장, 전송 등을 허락함
2. 위의 목적을 위하여 필요한 범위 내에서의 편집·형식상의 변경을 허락함. 다만, 저작물의 내용변경은 금지함.
3. 배포·전송된 저작물의 영리적 목적을 위한 복제, 저장, 전송 등은 금지함.
4. 저작물에 대한 이용기간은 5년으로 하고, 기간종료 3개월 이내에 별도의 의사 표시가 없을 경우에는 저작물의 이용기간을 계속 연장함.
5. 해당 저작물의 저작권을 타인에게 양도하거나 또는 출판을 허락을 하였을 경우에는 1개월 이내에 대학에 이를 통보함.
6. 조선대학교는 저작물의 이용허락 이후 해당 저작물로 인하여 발생하는 타인에 의한 권리 침해에 대하여 일체의 법적 책임을 지지 않음
7. 소속대학의 협정기관에 저작물의 제공 및 인터넷 등 정보통신망을 이용한 저작물의 전송·출력을 허락함.

**동의여부 : 동의( 0 ) 반대( )**

2010년 2 월 25 일

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