Cone beam computed tomographic analyses of alveolar bone anatomy at the maxillary anterior region in Chinese adults

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Received 04 January 2013, Revised 27 March 2013, Accepted 29 May 2013, Epub 12 November 2013

Abstract
To provide an anatomical basis for clinical implant esthetics, we evaluated the morphology of the nasopalatine canal (NPC) and analyzed labial and interproximal bone anatomy at the maxillary anterior region. We sought to investigate the effect of maxillary protrusion and tooth labiolingual inclination on labial bone anatomy in Chinese adults. Three dimensional (3D) images were reconstructed using cone-beam computed tomography (CBCT) images from 80 Chinese subjects and by SimPlant 11.04. The dimensions of the NPC, the thickness and profile of the labial bone, the width and height of the interproximal bone, angle sella-nasion-subspinale (SNA) and angle upper central incisor-nasion,subspinale (U1-NA) were measured. The incisive foramen of the NPC was markedly wider than its nasal foramen. The dimension of its labial bone wall demonstrated an increasing width from the crestal to apical measurements. The labial bone at the maxillary anterior region was rather thin, especially at 3 mm below the cemento-enamel junction (CEJ) and the mid-root level; the profile of the labial bone was more curved at the central incisor, and the interproximal bone became wider and shorter posteriorly. There were significant relationships between maxillary protrusion and labial bone profile, tooth labiolingual inclination and labial bone thickness (P < 0.02). To achieve optimal esthetic outcome of implant, bone augmentation is necessary at the maxillary anterior region. For immediate or early placement at the maxillary anterior region, the implant should be located palatally to reduce labial bone resorption and marginal recession; its apex should be angulated palatally to avoid labial perforation at the apical region. To protect the NPC, implants at the central incisor region should be placed away from NPC.

Keywords: cone beam computed tomography (CBCT), nasopalatine canal (NPC), alveolar bone, maxillary anterior region, implant esthetics

INTRODUCTION
The long-term stability of osseointegration is not equivalent to successful implantation at the maxillary anterior region. Apart from the traditional criteria, an optimal esthetic outcome has become another challenge for clinicians operating at this region. From the perspective of dental implant esthetics, the incidence and severity of soft tissue recession occurring labially and interproximally should be a major concern and has already been the focus of numerous studies.

Peri-implant marginal recession is commonly observed after implant placement. It has been reported that the mean recession of free gingiva around single-
tooth implant is 0.5 -1 mm, and approximately 17%–40% subjects have soft tissue recession of 1 mm or more[1,2]. Multiple factors affect the susceptibility to
gingival recession including periodontal biotypes and
the underlying bone anatomy[3]. The term “periodontal
biotype” was first coined by Seibert et al.[4] to catego-
rize the gingiva into “thick-flat” and “thin-scalloped”
biotypes. It was suggested that patients with thin-
scalloped gingiva were more susceptible to recession
while the thick-flat biotype was an important factor
for satisfactory esthetic outcome in implant restaura-
tions[3,5]. Some periodontists investigated the relation-
ship between alveolar anatomy and gingival form, and
indicated that a thin alveolar contour was probably
covered by a similar gingival form. Subsequently,
Ochsenbein et al.[6] demonstrated that gingival contour
was relevant to the underlying bone anatomy accord-
ing to osseous surgery. Consequently, bone anatomy is
the foundation for gingiva support and mainly affects
the soft tissue esthetics around implant restorations.
The optimal 3D implant position with bone available
in all directions was the key to achieve an optimal es-
thetic outcome[7].

Alveolar bone anatomy is related to several factors.
With respect to a relationship between maxillary ante-
rior anatomy and facial type, Gracco et al.[8] found that
individuals with short face type presented a greater
alveolar bone thickness than those with long face type
at upper central incisor. Other studies revealed sig-
nificant positive correlations between central incisor
inclination and the anatomy of alveolar bone[9]. As a
consequence, there may be a relationship among al-
veolar bone anatomy, maxillary protrusion (another
classification of facial type for evaluating the degree
of maxilla development) and labiolingual inclination
of the upper incisors. If the relationship does exist, it
can serve as a part of assessment before implant sur-
gical procedures.

The presence of interdental papillae at the maxillary
anterior region is also significant for dental implant
esthetics. Patients always complain about the disap-
ppearance of this part, the so-called “black” triangle,
which leads to cosmetic deformities, phonetic diffi-
culty and food impaction. Considering the relationship
between gingival form and underlying bone anatomy,
Spear et al.[10] assumed that the presence of approxi-
mately 1.5 mm in bone height could be an important
predictor of papillary appearance. Therefore, the
evaluation of interproximal bone anatomy, especially
height, is important for the prognosis of esthetic out-
come at the interproximal region. All previous studies
on interproximal bone anatomy were performed using
cadavers, which is convenient for direct measure-
ment but difficult to obtain. In this study, the width
and height of the interproximal bone were measured
on a 3D skull model, which was reconstructed by the
SimPlant program using a series of cone beam com-
puted tomography (CBCT) images, which can readily
obtained in daily clinical practice.

The nasopalatine canal (NPC), as an important an-
tomical structure, is usually located in the midline of
the anterior hard palate, posterior to the central inci-
sors. It contains the nasopalatine (incisive) nerve and
the terminal branch of the descending nasopalatine
artery, as well as fibrous connective tissue, fat, and
even small salivary glands. Mraiwa et al.[11] illustrated
that implant contact with neural tissue may lead to
failure of osseointegration or sensory dysfunction. To
reduce these complications, it is necessary to evalu-
ate the morphology and dimensions of the NPC before
implant placement adjacent to the NPC.

The aim of this study was to evaluate the dimen-
sions of the NPC and labial bone anatomy at the
maxillary anterior region, and to analyze the effect of
maxillary protrusion and tooth labiolingual inclina-
tion on labial bone anatomy. The width and height of
the interproximal bone were also measured on a 3D
skull model, providing an anatomical basis for clinical
preservation of the interdental papilla to achieve opti-
mal implant esthetics.

MATERIALS AND METHODS

All the series of 80 evaluated CBCT images of
Chinese adults were chosen from 424 randomly se-
lected images from the authors’ affiliated institution
between September 2010 and April 2012. This study
protocol was approved by the institutional review
board of the authors’ affiliated institution (Permit No.
2011(10)). From their CT images, 80 subjects fulfilled
specific inclusion and exclusion criteria: six maxillary
anterior teeth and the first premolars on both sides
without crowding or spacing, caries, restorations, api-
cal diseases, tooth trauma, periodontal diseases, and
evident nasopalatine pathology (e.g. nasopalatine duct
cyst). There were 33 males and 47 females, and their
age ranged from 18 to 42 years (23.06 ± 6.30 years).

After head positions were standardized and located
with horizontal and vertical reference lines, the sub-
jects were all originally imaged using the same CBCT
machine (New Torn VG 10048S, QR.S.R.L Inc., Ve-
rona, Italy), which was set with exposure at 110 kV,
5 mA, slice thickness at 0.25 mm and total scan time
at 36 seconds. The scanning region covered the whole
skull for each subject. The images were reconstructed
and measured using SimPlant 11.04 (Materialise Den-
tal Inc., Leuven, Belgium).
Four main aspects were measured (Fig. 1 and 2): (1) the dimensions of the NPC, including diameters of the nasal and incisive foramina, the length of the NPC and the width of its labial bone wall; (2) the labial bone anatomy, including bone thickness of teeth at the maxillary anterior region, curvature angle below the root apex, distance from the cemento-enamel junction (CEJ) to the alveolar crest; (3) the width and height of the interproximal bone; (4) angle sella-nasion-subspinale (SNA) and angle upper central incisor-nasion-subspinale (U1-NA) for determining the anteroposterior maxillary protrusion and labiolingual inclination of the central incisor, respectively.

**Dimensions of the NPC and thicknesses of the labial bone wall**

The following landmarks were selected for analyzing the anatomic characteristics of the NPC and the labial bone wall in relation to the NPC (Fig. 1A). Line 1, 2 and 3 represent the diameter of the nasal foramen, incisive foramen and the length of the NPC (a line connecting the midpoint of line 1 and 2), respectively. Line 4, 5 and 6 are three parallel horizontal lines to determine the dimensions of the labial bone relative to the NPC. Line 4 is the most crestal measurement to evaluate the distance from the labial border of the incisive foramen to the facial aspect of the labial bone wall. Line 5 is the second measurement to evaluate the width of the labial bone wall at the most crestal level of the palatal border of the incisive foramen. Line 6 is the most cranial measurement to evaluate the distance from the labial border in the middle of the PNC to the facial aspect of the labial wall.

**Thicknesses and contour of the labial bone adjacent to the maxillary anterior tooth roots**

As shown in Fig. 1B, the tooth root line (Line R) is drawn from the root apex to the midpoint of a line connecting the labial and palatal CEJs. Three reference lines, perpendicular to Line R, are used to measure labial bone thickness over the maxillary anterior tooth roots at different levels. Line A is positioned at 3 mm below the CEJ, line B and line C are placed at the mid-root point and root apex, respectively. Landmark point P represents the most anterior and superior point of the labial bone, point R is on the labial plate intersecting line C. Point D is the deepest point of the labial bone profile, located between point R and P. The value of the angle PDR represents the labial bone contour below the root apex. The distance from the CEJ to the labial alveolar crest was also measured.

**Mesio-distal widths and heights of the interproximal bone**

Line BW is drawn on the 3D model connecting the most apical points of two adjacent teeth, and its length represents the interproximal bone width. Line BH is determined from the top of the interproximal plate to line BW, parallel to the tooth axes, and its length represents the height of the interproximal bone (Fig. 1C).

**Maxillary skeletal (SNA) and central incisor (U1-NA) angles**

Angle SNA and angle U1-NA were used to determine the anteroposterior maxillary protrusion and labiolingual inclination of the central incisor, respec–
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Fig. 2 Reconstructed lateral cephalogram measurement sites. A: angle SNA used to determine the anteroposterior maxillary protrusion. B: angle U1-NA used to classify maxillary central incisor labiolingual inclination.

The cephalometric analyses of both angles were measured using cranial midline sagittal CBCT images, which were used as lateral cephalogram in this study (Fig. 2). Subjects with SNA angle less than 78.8° or more than 86.8° were assigned to group R (maxillary retrusion) or group P (maxillary protrusion), respectively, while the rest were assigned to group N (normal). Individuals with U1-NA angle less than 17.1° or more than 28.5° were categorized as the lingual obliquity group (group 1) or the labial obliquity group (group 2), respectively, while the rest were categorized as the normal group (group 3).

Statistical analyses

All the measurements were carried out by an experienced researcher (Z-XZ) to avoid interobserver bias, and repeated after an interval of two weeks to ensure the reproducibility of values by the same examiner. Intraclass correlation test (ICC) was also used to test the validity and reliability of the values (ICC = 0.6663).

Averages were calculated from the pooled measurements after checking their consistency and reliability using the Statistical Package for the Social Sciences V13.0 (SPSS Inc., Chicago, IL, USA). Values at the same tooth or interdental region on different sides (left/right) were compared, but no significant differences were found (paired-samples t-test, -1.840 < t < 1.970, P > 0.05). Therefore, the data for each examined variable were averaged for the same region in each subject. All the independent measurements were analyzed by using Student’s t-test, one-way ANOVA or univariate general linear model test. The level of probability for statistical significance was set at α = 0.05. If the ANOVA or linear model test was significant, post hoc Scheffé multiple comparison test was performed.

RESULTS

Dimensions of the NPC and thicknesses of the labial bone wall

Evaluation of the dimensions of the NPC revealed a mean diameter of the nasal foramen at 3.06 ± 1.16 mm, and a wider incisive foramen with a mean diameter of 6.10 ± 1.47 mm. The mean length of the NPC was 12.80 ± 2.17 mm. The dimension of the labial wall became widened from the crestal to the apical levels, with corresponding mean values of 8.28 ± 1.32 mm (line 4), 8.32 ± 1.55 mm (line 5) and 8.46 ± 1.78 mm (line 6).

Thicknesses and contour of the labial bone adjacent to the maxillary anterior tooth roots

The mean labial bone thicknesses at the maxillary anterior region are shown in Table 1. The mean thickness of the labial bone at the mid-root level was less than 1 mm. At 3 mm below the CEJ, the thickness was less than 1 mm at the central and lateral incisors. The univariate general linear model test was used for variance analysis among the three tooth regions (P < 0.05) and the three reference line levels (P < 0.05). The post hoc Scheffé tests showed that, compared with the incisors, the labial bone over the canine was significantly thicker at 3 mm below the CEJ (line A), but thinner at the root apical level (line C). Overall, the labial bone was thinnest at the mid-root level (line B) and thickest at the root apical level.

Table 1 Mean ± SD of labial bone thickness (mm)

| Reference line     | n  | Tooth region |     |     |     | P value |
|--------------------|----|--------------|-----|-----|-----|---------|
|                    |    | Central incisor |     |     |     |         |
| 3 mm below CEJ (Line A) | 80 | 0.96 ± 0.32 | 0.87 ± 0.36 | 1.26 ± 0.62 | 0.000* |
| mid-root level (Line B) | 80 | 0.96 ± 0.24 | 0.59 ± 0.30 | 0.74 ± 0.27 | 0.000* |
| root apical level (Line C) | 80 | 2.04 ± 0.98 | 2.07 ± 1.04 | 1.65 ± 0.66 | 0.000* |

P value

0.000* 0.000* 0.000*

*P < 0.05, statistically significant difference exists. Post-hoc comparison (Scheffe’s test).
The mean value of labial bone curvature angle below the root apex was $136.71 \pm 16.84^\circ$ at the central incisor, $146.10 \pm 11.60^\circ$ at the lateral incisor and $151.08 \pm 9.89^\circ$ at the canine. The curvature angle of the labial bone at the central incisor was significantly smaller than that at lateral incisor and canine ($P = 0.000$ and $P < 0.05$). In other words, the labial bone profile was most curved at the central incisor.

The mean distance from the CEJ to the labial alveolar crest was $1.80 \pm 0.56$ mm at central incisor, $2.01 \pm 0.78$ mm at lateral incisor and $2.05 \pm 0.79$ mm at canine. The statistical analyses revealed that the distance at central incisor was significantly shorter than that at lateral incisor and canine ($P = 0.002, P < 0.05$).

**Mesio-distal widths and heights of the inter-proximal bone**

The mean interproximal bone widths and heights at the maxillary anterior region are shown in Table 2. The univariate general linear model test was used for variance analysis on the widths and heights among four anterior interdental regions ($P < 0.05$). Scheffé test revealed that the width was significantly different between each interdental region, except the pair of the first premolar-canine region and canine-lateral incisor region; while the height was only statistically different between the pair of the first premolar-canine region and central incisor region. Generally, both the interproximal bone width and height were the greatest between the central incisors, and the widths became wider as the heights became shortened posteriorly.

**The effect of anterior maxillary skeletal and labiolingual tooth inclination patterns on labial bone anatomy**

The effects of the three anterior maxillary skeletal patterns on the labial bone curvatures (PDR angles, Fig. 1B) below the central incisor root apices are shown in Table 3. One-way ANOVA revealed a significant difference among group R, P and N for the labial bone profiles at the central incisors ($P < 0.05$). Scheffé tests indicated significant differences among all the three groups with the smallest mean value for group R and the largest for group P. The effects of three anterior maxillary labiolingual tooth inclination patterns on the central incisor labial bone thicknesses at two levels (Lines A and C, Fig. 1B) are shown in Table 4. One-way ANOVA showed significant differences among group 1, 2 and 3 ($P < 0.05$). Scheffé tests indicated significantly thinner labial bone at 3 mm below the CEJ and at the root apical level in group 1 than in group 2 and 3.

**DISCUSSION**

The present study aimed to evaluate NPC morphology and alveolar bone anatomy for implant planning at the maxillary anterior region using CBCT imaging technique. Compared to traditional CT techniques, CBCT has advantages in evaluating the osseous condition around teeth. It has become the standard for implant planning, especially in esthetic zone\[13-16]\. CBCT has multiple advantages, including convenience and low cost, low radiation dose, and accuracy in all three dimension of the alveolar bone\[17]\. In treatment, additional surgical procedures, such as augmentation, may be required to guarantee the availability of bone around dental implant, according to the severity of alveolar deficiency and atrophy by CBCT.

The long-term stability of overlying soft tissues around implant restorations is guaranteed by bone availability in all dimensions, especially labially. Compared to the palatal bone, the labial plate at the maxillary anterior area is thinner and resorption after extraction occurs more easily and severely owing to its composition of bundle bone\[18,19]\. A one-year prospective study of single immediate implant placement at

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**Table 2** Mean ± SD of inter-proximal bone width and height (mm)

| Related parameters | $n$ | Inter-dental region                                                                 | $P$ value |
|--------------------|-----|-------------------------------------------------------------------------------------|-----------|
|                    |     | Between 1st premolar and canine                                                     |           |
| Width              | 80  | $8.38 \pm 0.82$                                                                     |           |
| Height             | 80  | $1.57 \pm 0.46$                                                                     |           |
|                    |     | Between canine and lateral incisor                                                 |           |
| Width              | 80  | $8.00 \pm 0.79$                                                                     |           |
| Height             | 80  | $1.81 \pm 0.43$                                                                     |           |
|                    |     | Between lateral and central incisors                                               |           |
| Width              | 80  | $7.49 \pm 0.60$                                                                     |           |
| Height             | 80  | $1.94 \pm 0.52$                                                                     |           |
|                    |     | Between central incisors                                                          |           |
| Width              | 80  | $8.89 \pm 0.95$                                                                     | 0.0001    |
| Height             | 80  | $2.09 \pm 0.62$                                                                     | 0.0001    |

$P < 0.05$, statistically significant difference exists. Post-hoc comparison (Scheffe’ s test).

**Table 3** Labial bone curvature angle at central incisor among different types of maxillary protrusion ($^\circ$)

| $n$ | Group of maxillary protrusion | Labial bone curvature angle below root apex ($\pm$ PDR) |
|-----|-------------------------------|---------------------------------------------------------|
| 17  | R (maxillary retrusion)       | $125.10 \pm 20.91$                                      |
| 16  | P (maxillary prognathism)     | $143.11 \pm 12.77$                                      |
| 47  | N (maxillary normal)          | $130.74 \pm 14.61$                                      |

$P < 0.05$, statistically significant difference exists. Post-hoc comparison (Scheffe’ s test).


the maxillary anterior region revealed that mid-buccal bone recession was nearly 0.5 mm during the first year after implantation\(^2^{20}\). Furthermore, the excessive force caused by implant insertion on the frail wall may lead to microfractures and eventually crestal bone loss. To ensure the availability of hard tissues around implant and to avoid exerting excessive force on the bony wall, it is important to decide the position and angulation of implant in the alveolar bone before placement.

Lee et al.\(^1^{19}\) found that in Korean adults, the thickness of the maxillary anterior buccal plate was very thin within 1 mm. The present data indicated that the thickness of the labial bone of Chinese adults was extremely thin at the maxillary anterior region, especially at 3 mm below CEJ and the mid-root level, the mean thickness of which was almost less than 1 mm. Therefore, the coronal to the mid-part of the labial plate was either easily destroyed or even missing during tooth extraction or implant surgical procedures. As to natural teeth, a great proportion of incisor roots was observed positioned more labially (78.8%); however, from the perspective of peri-implant esthetics, the labially located implant had three times more gingival recession than the palatally located one\(^1^{1,21}\). To protect the frail labial bone and avoid severe marginal recession, the position of implant should be located palatally in the alveolar bone when compared to the primary tooth root\(^2^{22-24}\). Buser et al.\(^7\) recommended that the implant shoulder should be placed 1-2 mm lingual to the emergence of the adjacent teeth. The effect of tooth labiolingual inclination on labial bone thickness at the upper central incisor showed that the thickness at 3 mm below the CEJ and the mid-root level in group 1 (lingual obliquity) was significantly thinner than that in other groups. In other words, the position of an implant inserted in the upper central incisor region should be located more palatally if the primary one is with obviously lingual obliquity.

The natural profile of the extraction socket may misguide clinicians to drill in parallel to the apical long axis. Some researchers recommended immediate implant placement to make a step on the palatal plate in the apical region of the socket by using a round bur before the use of a straight drill\(^2^{21}\). Certainly, there is a gap between the labial wall and implant when immediate implant is located palatally. Caneva et al.\(^2^{25}\) found that the use of a collagen membrane over the gap could better maintain the alveolar crest outline and gradually minimize the gap. Other studies manifested remarkably enhanced bone preservation in the labial gap by utilizing the deproteinized bovine bone mineral particles and collagen membrane\(^2^{26-28}\). Recently, some researchers evaluated the use of Bio-Oss® Collagen (Geistlich Pharma AG, Wolhusen, Switzerland) in the gap of immediate implant placement and concluded that the method augmented the volume of hard tissue at the entrance of previous socket, improved the marginal bone-implant contact and effectively prevented soft tissue recession\(^2^{29}\). However, no method has been proven to be the best way to deal with the labial gap. Spray et al.\(^3^{30}\) suggested that a labial bone thickness of 1.8 mm should be left at the time of implant insertion to avoid crestal loss, but the mean labial bone thickness at coronal region was far less than 1.8 mm at maxillary anterior region in present study. Consequently, we recommended insertion of grafting materials at the labial “gap” for immediately located implant to guarantee enough labial bone thickness.

If patients have extreme alveolar atrophy or a labial bone defect in the maxillary anterior region, delayed implantation would be chosen instead of immediate implant placement, although there are multiple advantages of immediate implantation. Delayed implantation can be predicted of long-term soft tissue stability owing to sufficient bone infilling and remodeling in the extraction socket during the healing period of a few months. According to the degree of alveolar atrophy, additional surgical procedures with or without socket grafting would be required to increase the rate of bone formation and augment of the bone volume.

The anatomic profile of the labial plate at the apical level is completely different from that of the palatal bone. At the labial side, the natural depression at point A results in the reduction of labial bone thickness at the apical level; while owing to the contour of the palatal vault, the palatal bone is thicker at the more apical area. Clinicians, who prefer to place the implant deeper in alveolar bone for achieving the primary stability, have to face the high risk of labial bone perforation at the apical region. Therefore, it is suggested...
that the apex of dental implant should be angulated palatally at the maxillary anterior region. The results of the present study indicated that the contour of the labial bone was most curved at the central incisor and the effect of maxillary protrusion on the labial bone profile at the central incisor revealed that the curvature angle was the smallest in subjects with retruded maxillae. In other words, clinicians must angulate the apex of implant more palatally at the upper central incisor, especially for patients with retruded maxillae. Nevertheless, we suggest the implant should not be angulated too palatally at the apical area, considering the possibility of overcompensation towards the labial wall at the coronal region to cause fenestration or even the loss of coronal crestal bone.

Considering the close anatomical relationship between the NPC and maxillary central incisors, preoperative radiological analysis is necessary when dental implant is situated at this region. The position and angulation of implant, especially the apical part, should be planned well to avoid the damage of the NPC following implant bed preparation. Mardinger et al.\(^\text{[31]}\) reported that the NPC would enlarge in all dimensions after tooth extraction and with age, with the incisive foramen would be wider by a mean of 32%, occupying up to 58% of the alveolar ridge width. As we mentioned previously, the maxillary anterior region is critical for the patient’s esthetic satisfaction and an adequate alveolar ridge must be present. If the enlargement of the NPC and the lack of adequate ridge width affect the correct placement of implants and the achievement of satisfactory esthetic outcome in central incisor area, an augmentation procedure should be performed, and the canal content would be displaced or sacrificed with complete removal of soft tissue before grafting\(^\text{[32]}\).

Although there are many key factors involved in the presence of the interdental papilla, including distance from the tooth contact point to the alveolar bone and the volume of gingival embrasure, the underlying bone level, especially the vertical osseous dimension at interproximal sites, is significantly essential to the preservation of interdental papilla\(^\text{[33,34]}\). Our data indicated that all the interproximal bone height at the maxillary anterior region was more than 1.5 mm. However, the height of interdental bone is actually less than 1.5 mm or even absent, mainly due to traumatic tooth extraction or severe periodontal diseases. Some techniques have been already recommended for clinicians to rebuild the bone height and maintain the papillary presence, like socket augmentation and guided bone regeneration (GBR). Recently, Telleman et al.\(^\text{[35]}\) found that the interproximal bone loss around platform-switched implants (0.51 ± 0.51 mm) was significantly less than around control implants (0.73 ± 0.48 mm) one year after loading, and suggested that the interproximal bone level would be better maintained at implants with platform-switching technique. We recommended minimally invasive surgery and bone augmentation at the interproximal region during immediate implant placement, which would reduce bone resorption and papilla recession at the interdental region.

In conclusion, at the maxillary anterior region, the labial bone thickness of Chinese adults is very thin and thickness at the central incisor with obvious lingual obliquity is thinner, so the implant should be located palatally to protect the frail labial bone. The labial bone profile is also more curved at the central incisor, in individuals with retruded maxillae in particular, so the apex of implant should be angulated palatally to avoid the perforation of labial bone at the apical region. Regarding bone morphology of the NPC and the close anatomical relationship between the NPC and central incisor roots, the apex of the implant in this region should avoid damage to the NPC contents. Although the mean height of the interproximal bone at the maxillary anterior region is more than 1.5 mm, the post extraction value is actually far less than 1.5 mm and therefore suitable bone augmentation techniques are recommended to maintain the bone height and papillary presence.

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