

# THREE-DIMENSIONAL RELATIONSHIP OF THE MAXILLARY ANTERIOR TEETH TO THE INCISIVE PAPILLA IN YOUNG ADULTS

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The use of the incisive papilla as an important guide for setting maxillary teeth has been applied in prosthetic dentistry. The purpose of this study was to estimate the relationship between maxillary anterior teeth and the incisive papilla of young adults with approximately optimal occlusion in Taiwan. Study casts of 100 young adults (50 males, 50 females; mean age, 22.4 years) were selected in this study. All of the marked points on maxillary casts were measured using a three-dimensional precise measuring device. The relative positions of maxillary teeth landmarks to incisive papilla were measured and analyzed using SAS software (JMP 4.02). Student's *t* test and Pearson's correlation test were used to test the statistical significance of any differences ( $p < 0.05$ ). The results showed that the mesiolabial incisal edge of the upper central incisor was  $7.30 \pm 0.64$  mm anterior to the center of the incisive papilla. There was no significant difference in gender ( $p > 0.05$ ). The intercanine line was  $0.27 \pm 1.30$  mm posterior to the center of incisive papilla. There was no significant difference in gender ( $p > 0.05$ ). The horizontal distances of the mesiolabial incisal edge of the upper central incisor and the intercanine line to the center of the incisive papilla showed only weak correlation ( $r < 0.5$ ). In addition, the three-dimensional relationship of maxillary anterior teeth to the center of the incisive papilla was measured and analyzed. We suggest using the incisive papilla as a reference landmark for the setting of maxillary anterior teeth.

**Key Words:** incisive papilla, maxillary anterior teeth, three-dimensional analysis  
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The achievement of an esthetic restoration is a constant challenge to dentists. To fulfill a natural appearance in the rehabilitation of deficient dentition, the upper anterior teeth should be positioned as close as possible to the positions originally occupied by the natural teeth, because the dentate state usually has proper soft tissue support with younger appearance.

In undertaking any prosthetic work, it is important to examine certain aspects that can provide useful indications for defining the most appropriate teeth positions. It is believed that the application of some anatomic landmarks can provide a reliable reference for arranging and checking the position of the maxillary anterior teeth, especially in complete dentures. The most obvious landmark that seems to survive relatively intact from the dentate state is the incisive papilla. When faced with an edentulous patient that does not provide any natural morphologic references, the use of the incisive papilla of the patient is indispensable for determining the suitable position of the maxillary teeth [1–3].

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The incisive papilla has been used as a landmark on the basis of Caucasian norms, which place the maxillary central incisors 8–10 mm anterior to the center of the incisive papilla [4–11]. Harper suggested that the incisal edges of the upper central incisors should be 5–8 mm in front of the center of incisive papilla [12]. McGee stated that the average distance between the anterior point of the central incisors and the center of incisive papilla is 7.7 mm [13].

Some studies have indicated that a line drawn at right angles to the midline passing through the center of incisive papilla passes through the tips of the upper canines [14–16]. Schiffman found that in 92% of his subjects, the line connecting the tips of the canines was within an area of 1 mm anterior and posterior to the center of incisive papilla [14]. Watt and Likeman suggested that the maxillary canines should be located in a coronal plane passing through the posterior border of the incisive papilla, rather than through its center [1]. In addition, the distance was not affected by gender, age and maxillary tooth arch form [15]. Mavroskoufis and Ritchie reported that, in 93.4% of their subjects, the distance between the center of incisive papilla and intercanine line was less than 2 mm, while in 87% of the subjects, the distance was less than 1.5 mm [9]. The average value in all subjects was 0.6 mm. It has been reported that the labial surfaces of the maxillary central incisors should be 8–10 mm anterior to the incisive papilla [11].

Since most previous studies have been conducted with Caucasian samples, the purpose of this study was to investigate the three-dimensional relationship of the maxillary anterior teeth to the incisive papilla in young Taiwanese adults with approximately optimal occlusion. Prosthetic reference considerations were provided, whereby the positions of the upper anterior teeth were determined.

## MATERIALS AND METHODS

Fifty male and 50 female Taiwanese subjects with 28 teeth congenitally without third molars, with no history of orthodontic treatment, Angle Class I canine and molar relationships, crowding or spacing less than 2 mm in total, no extensive restorations and no history of temporomandibular disorders, were included in this study. The ages of the subjects ranged from 19 to 28 years, with a mean age of 22.4 years.

Maxillary irreversible hydrocolloid impressions (CA38; CAVEX, Haarlem, The Netherlands) were made for our subjects. Stone casts (NEW PLASTONE; GC Corp., Tokyo, Japan) were then immediately poured into these impressions. The manufacturer's instructions were followed accurately.

### Standardization of models

Base former (T.P. Orthodontics Inc., Houston, CA, USA) was utilized to establish the upper casts of all subjects. Prior to each measurement, the bases of the gypsum models were corrected to parallel the granite platform of the three-dimensional precise measuring device.

### Surveying tools, positions and methods

This experiment utilized an accurate three-dimensional precise measuring device (CE-503V; Chien Wei Precise Technology Co. Ltd., Kaohsiung, Taiwan) (Figure 1). The tip of the piezoelectric probe was 0.5 mm in diameter, with a linear accuracy (U1) of  $4+5L/1,000 \mu\text{m}$ . The crowding or spacing of all teeth was measured by touching the most convex points of teeth proximities with the probe of the three-dimensional measuring device, under a magnification of 100 times, and calculated by the computer. To determine the center of the incisive papilla, the border of the incisive papilla

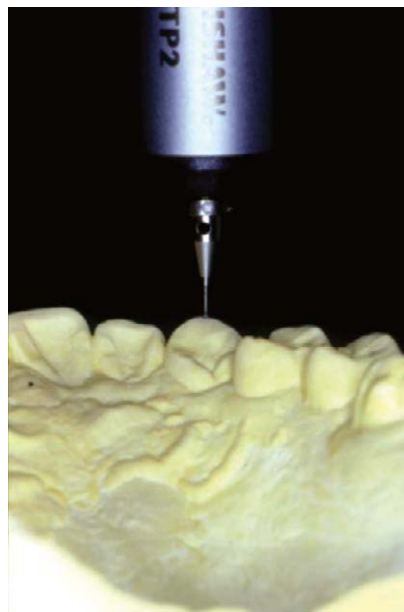


Figure 1. The three-dimensional precise measuring device used in this study.

was outlined under a magnification of 100 times with the three-dimensional measuring device. The most anterior and posterior points of the incisive papilla were then identified using the same method. Finally, the coordinates of the center of the incisive papilla were calculated by the computer. The points of the mesiolabial and distolabial incisal edges of the upper incisors and the cusp tips of upper canines were thereby identified using the same method. The intercanine line formed with the imaginary connection line of the cusp tips of upper canines was recorded by the computer after the cusp tips of the upper canines were recognized. All data were recorded and analyzed using three-dimensional surveying software (KCOMM version 1.60; Ishin Technology Co. Ltd., Taipei, Taiwan).

**Horizontal distance measurement**

Once the orientation of the incisive papilla was determined, the horizontal distances from the mesiolabial incisal edges of the upper central incisors and the intercanine line to the center of the incisive papilla were measured and analyzed using the three-dimensional surveying software.

**Vertical distance measurement**

The tip of the piezoelectric probe touched the center of the incisive papilla and the lowest points of bilateral hamular notches to determine the HIP plane (hamular notch–incisive papilla plane). Once the orientation of the HIP plane was determined, the vertical distances from the cusp tips, mesiolabial and distolabial

incisal edges of maxillary anterior teeth to the HIP plane were measured and analyzed using the three-dimensional surveying software.

**Statistical methods and analyses**

In this study, all measurements were performed by the same person and all calculations were performed using statistical analysis software (SAS) JMP version 4.02 (SAS Institute Inc., Cary, NC, USA). Data were analyzed using the Student’s *t* test and Pearson’s correlation. The significance level was set at *p* < 0.05 for each analysis.

**RESULTS**

The mesiolabial incisal edge of the upper central incisor was 7.30±0.64 mm anterior to the center of the incisive papilla (7.35±0.66 mm in males, 7.24±0.62 mm in females). There was no significant difference in gender (*p* > 0.05). The intercanine line was 0.27±1.30 mm posterior to the center of the incisive papilla (0.23±1.33 mm in males, 0.30±1.28 mm in females). There was no significant difference in gender (*p* > 0.05). (Tables 1 and 2). Correlation analysis showed that the horizontal distances from the center of the incisive papilla to the upper central incisors and canines showed only weak correlation (*r* < 0.5). The measurements of vertical distances between the cusp tips, mesiolabial and distolabial incisal edges of the maxillary anterior teeth to the HIP plane are shown in Figure 2.

**Table 1.** Three-dimensional relationship of maxillary anterior teeth to the center of the incisive papilla in male subjects\*†‡

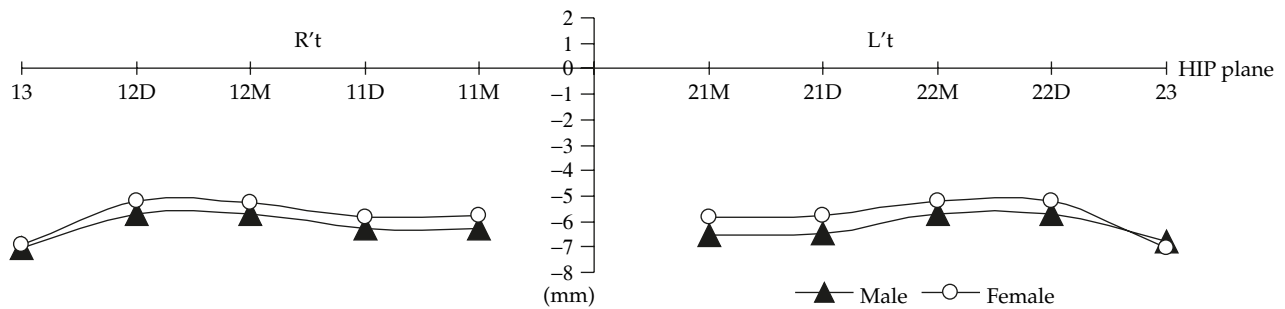
	X value, mm (n=50)		Y value, mm (n=50)		Z value, mm (n=50)	
Reference point						
11 mesiolabial incisal edge	-0.69	(-0.18)	7.35	(0.66)	4.23	(0.86)
11 distolabial incisal edge	-7.89	(-0.47)	6.78	(1.34)	4.25	(0.66)
12 mesiolabial incisal edge	-9.39	(-0.34)	5.38	(0.93)	3.70	(0.56)
12 distolabial incisal edge	-14.32	(-0.60)	3.06	(0.65)	3.67	(0.69)
13 cusp tip	-17.96	(-0.70)	-0.02	(-1.06)	5.10	(0.44)
21 mesiolabial incisal edge	0.66	(0.36)	7.63	(0.91)	4.50	(0.81)
21 distolabial incisal edge	7.81	(0.56)	7.45	(1.27)	4.30	(0.71)
22 mesiolabial incisal edge	9.73	(0.59)	6.53	(1.30)	4.07	(0.72)
22 distolabial incisal edge	14.41	(0.79)	4.06	(1.58)	4.28	(0.73)
23 cusp tip	18.46	(0.71)	-0.84	(-1.57)	5.46	(0.85)

\*Data are presented as mean (standard deviation); †the origin (X, Y, Z=0, 0, 0) is the center of the incisive papilla; ‡positive X, Y and Z values represent the distances right to, anterior to and superior to the origin.

**Table 2.** Three-dimensional relationship of maxillary anterior teeth to the center of the incisive papilla in female subjects\*†‡

	X value, mm (n=50)		Y value, mm (n=50)		Z value, mm (n=50)	
Reference point						
11 mesiolabial incisal edge	-0.82	(-0.16)	7.24	(0.62)	3.88	(1.16)
11 distolabial incisal edge	-7.67	(-0.29)	6.96	(0.84)	3.89	(1.00)
12 mesiolabial incisal edge	-9.54	(-0.33)	5.16	(0.56)	3.13	(0.52)
12 distolabial incisal edge	-13.89	(-0.66)	2.96	(0.59)	3.42	(0.67)
13 cusp tip	-17.37	(-0.31)	-0.45	(-1.27)	5.04	(0.86)
21 mesiolabial incisal edge	0.79	(0.28)	7.42	(0.97)	4.07	(1.03)
21 distolabial incisal edge	7.23	(0.47)	7.27	(0.58)	3.75	(1.02)
22 mesiolabial incisal edge	9.28	(0.33)	5.30	(0.64)	3.50	(1.13)
22 distolabial incisal edge	13.62	(0.63)	3.35	(0.72)	3.60	(0.92)
23 cusp tip	17.44	(0.30)	-0.31	(-1.23)	4.99	(1.21)

\*Data are presented as mean (standard deviation); †the origin (X, Y, Z=0, 0, 0) is the center of the incisive papilla; ‡positive X, Y and Z values represent the distances right to, anterior to and superior to the origin.



**Figure 2.** Average vertical distances of upper anterior teeth from the HIP plane.

## DISCUSSION

The use of the incisive papilla as a reference for setting artificial teeth is based on the assumption that the incisive papilla is a stable landmark. Harper stated that the incisive papilla did not change position up to 7 years after teeth extraction [12]. Watt and Likeman studied alveolar ridge resorption in 25 subjects over a period of 2.5 years and found that, on average, the papilla moved forward about 1.6 mm and upward about 2.3 mm. Such anterior and superior movement of the incisive papilla must be considered when used as a reference for positioning maxillary anterior teeth [1]. Klemetti et al concluded that the location of the incisive papilla was significantly dependent on the duration of edentulousness in the maxillae [17]. The longer the teeth had been absent, the more anteriorly the papilla was situated because of the flatness [17]. In the case of previous tooth extractions, it is best to evaluate the position of the incisive papilla, which can give useful indications

about the original position of the teeth. Indeed, the location of the incisive papilla seems to be affected very little by postextraction osseous resorption. To compensate for the movement of the incisive papilla in edentulous subjects, we suggest that the horizontal distance between the mesiolabial incisal edge of the upper central incisor and the center of the incisive papilla should be less than 8 mm (not larger than  $7.30 \pm 0.64$  mm). By doing so, one could avoid an overly protrusive appearance and excessive offset forces, which might dislodge the prosthesis. The incisive papilla can therefore be considered a reliable reference for defining the correct position of anterior restorations in maxilla.

The distances measured in this study were compared with those from previous studies. There were differences between the Taiwanese population and Caucasian groups in the mean distance from the maxillary central incisor to the incisive papilla [3,7,9]. However, there were very similar distances among the Taiwanese in this study (7.30 mm), the Japanese

in Sugaya et al's study (7.2 mm) [18] and the Chinese in Han's study (7.52 mm) [19].

One significant factor is that canines are usually the last extractions in the maxilla, and are more reliable landmarks for artificial teeth arrangement. However, the use of the incisive papilla as a reference point must be cautious, because of its migration in edentulous situations. The distance from the intercanine line to the center of the incisive papilla in this study was similar to that in Schiffman's study, in which the intercanine line within an area 1 mm anterior and posterior to the center of the incisive papilla was 92% [14]. According to Ehrlich and Gazit, 57.6% of intercanine lines passed through the center of the incisive papilla [15]. Mavroskoufis and Ritchie claimed that the tips of the maxillary canines should be set on a line approximately 0.6 mm posterior to the center of the incisive papilla [9]. Lau and Clark investigated a Southern Chinese population and concluded that, in 57.3% of their subjects, the intercanine line passed through the middle third of the incisive papilla [20]. In a study of Taiwanese, Huang et al found that the intercanine line passed through the middle third of the incisive papilla in 72.84% of subjects [21].

Cooperman searched the upper arches of the attritionally occluded skulls for anatomic landmarks coinciding with nature's plane of occlusion. Observations finally determined that three anatomic points were in this plane—namely, the left and right hamular notches and the area of the incisive papilla of the maxilla. Hence, the name HIP (hamular-incisive-papilla) plane was devised in 1975 [22]. The frontal connection of the vertical distances from the maxillary anterior teeth to the HIP plane in this study was parallel to the HIP plane in the frontal view (Figure 2). This implied that the HIP plane might be used as a reference plane for the orientation of the frontal occlusal plane [23].

In this study, as in that of Sugaya et al [18], a three-dimensional measuring device was used to measure maxillary casts, and the accuracy was higher than with a two-dimensional device. The tip of the piezo-electric probe was used to touch the check points; then, the horizontal and vertical distances data were easily calculated using software.

This study found that the incisive papilla may be used as a clinical practice guideline for the setting of maxillary anterior teeth in Angle class I subjects. However, further study must be carried out to investigate the validity of this method in various skeletal

and dental morphologies, and the use of incisive papilla as a reference landmark must be performed with caution, because its migration is anteriorly dependent on the duration of edentulousness in the maxillae.

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# 年輕族群上顎前牙與門齒乳突三次元 分析之研究

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補綴物製作時，門齒乳突經常作為上顎前牙位置之重要參考。本研究之目的在探討國人青年群正常齒顎者其門齒乳突和上顎前牙之關係位置。以 100 位正常齒顎關係者(男 50 位，女 50 位，平均年齡 22.4 歲) 齒列模型為樣本，本實驗利用三次元精密測量儀器測量門齒乳突與上顎前牙相對位置。所得之數據以 SAS 程式作統計與相關性分析，以探討性別間的差異及彼此間的相關程度。分析結果顯示：上顎中門齒近心唇側切端位於門齒乳突中點前方約  $7.30 \pm 0.64$  mm 處，男女間無顯著差異 ( $p > 0.05$ )。上顎犬齒咬頭尖端連線位於門齒乳突中點後方約  $0.27 \pm 1.30$  mm，男女間無顯著差異 ( $p > 0.05$ )。相關性分析方面，門齒乳突中點至上顎中門齒近心唇側切端與門齒乳突中點至上顎犬齒咬頭尖端連線之水平距離無顯著相關 ( $r < 0.5$ )。本研究顯示門齒乳突可作為上顎前牙位置的指標。

**關鍵詞：** 門齒乳突，上顎前牙，三次元分析

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