



ORIGINAL ARTICLE

# Correlation between the size of the incisive papilla and the distance from the incisive papilla to the maxillary anterior teeth



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Received 18 May 2015; Final revision received 11 September 2015

Available online 4 January 2016

## KEYWORDS

artificial teeth  
arrangement;  
correlation;  
distance;  
incisive papilla;  
maxillary anterior  
teeth

**Abstract** *Background/purpose:* The incisive papilla remains relatively constant in position and is frequently used as an anatomic landmark for anterior teeth. Several attempts have been made to use the incisive papilla as guides to arrange maxillary anterior teeth for edentulous patients. The aim of the present study was to determine the relationship between maxillary anterior teeth and the incisive papilla, while comparing the findings with the classical estimate value.

*Materials and methods:* Horizontal distances between the labial surface of the central incisors and the incisive papilla [the distance from the labial surface of the central incisors and the posterior border of the incisive papilla (CPIP), the distance from the labial surface of the central incisors and the anterior border of the incisive papilla (CAIP), and the distance from the labial surface of the central incisors and the center of the incisive papilla (CCIP)] and the size of the incisive papilla (SIP) were measured by a digital caliper on the stone casts formed for 103 dentate persons. The Pearson correlation coefficient was used to investigate and quantify the correlation, while simple linear regression analyses were conducted to determine the strength of the association between the variables ( $\alpha = 0.05$ ).

*Results:* Pearson correlation coefficients for SIP and the distance between the labial surface of the central incisors and the incisive papilla (CPIP, CAIP, and CCIP) were significant ( $P < 0.05$ ). A simple linear regression analysis of the data was performed, which showed that SIP contributed significantly to the prediction of the distances between the labial surface of the central incisors and the incisive papilla (CPIP and CCIP;  $P < 0.05$ ).

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**Conclusion:** Using regression methods within the population tested, it was determined that the distance between the labial surface of the central incisors and the incisive papilla could be predicted by the size of the incisive papilla.

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## Introduction

Determination of the correct anterior incisal tooth position is important in fabricating conventional complete dentures or implant-supported prostheses.<sup>1</sup> When artificial teeth are set in proper positions, the foundation is correctly laid for natural speech, aesthetics, and normal function.<sup>2</sup> The maxillary anterior teeth should be placed similarly to the original position of the natural teeth for a more natural appearance.<sup>3</sup>

Furthermore, in the anterior portion of the maxilla, extensive ridge resorption takes place following extractions of teeth. As a result, atrophy of the alveolar process progresses with a variable speed, as reported in previous studies.<sup>4–6</sup> Thus, a patient's existing dentures and pre-extraction photographs, or a pre-extraction stone model may be useful in determining the position of the teeth.

The facial expression of edentulous patients provides only limited information about the original position of the natural teeth. The most appropriate position for anterior teeth can be determined from a variety of biometric measurements.<sup>7</sup> The incisive papilla is a landmark within the edentulous maxilla that is used for arranging maxillary anterior teeth in denture prostheses, and can be best described by being lingual to and between the natural central incisors.<sup>8</sup>

According to Harper,<sup>2</sup> a stable incisive papilla was obtained by caliper measurements on pre-extraction and postresorption models over 7 years. In addition, McGee<sup>9</sup> noted that an incisive papilla remains in a constant position after tooth loss. Notably, the shape and localization of the papilla show a wide range of variation between individuals,<sup>6,8,10,11</sup> Nevertheless, the center of the papilla is commonly used as a reference point in denture construction and studies.<sup>2,9,12–14</sup>

Although several studies have researched the horizontal relationship between the incisive papilla and maxillary central incisors, different data prevent clinicians from drawing positive results.<sup>1,2,8,9,12–14</sup> The aim of this study was to investigate the relationship between the maxillary anterior teeth and the incisive papilla, and to compare this with the classical estimate value.

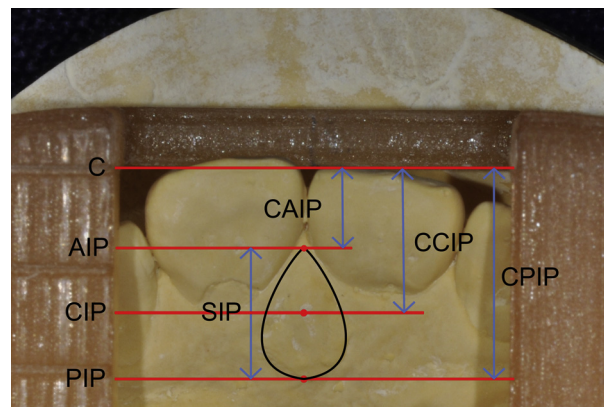
## Materials and methods

Student volunteers from the Herman Ostrow School of Dentistry of University of Southern California, Los Angeles, CA, USA were solicited by a written announcement to participate in the study. The inclusion criteria were as follows: no crown restoration, no tooth loss from the upper

jaw, no orthodontic treatment, Angle Class I maxillomandibular relationship, no pathology that affects the dentition or the surface texture and shape of teeth, and no gummy smile in the participants. The volunteers were examined by the investigator and 103 of them (33 women and 70 men) were selected for the study. The ages of the participants ranged from 19 years to 22 years, with a mean age of  $20.37 \pm 1.1$  years.

Maxillary jaw impressions of the participants were taken using stock impression trays (Teknik Dental Rostrei, Istanbul, Turkey) and irreversible hydrocolloid impression material (Tulip; Cavex Holland, Haarlem, The Netherlands). In order to correctly register the incisive papilla and reduce soft tissue distortion, the impression was made under minimal pressure. The stone casts were obtained using an ADA Type III dental stone (Gilidur; Fachbereich Dental, Ludwigshafen, Germany). Each stone cast was trimmed to allow the base of the stone cast to be parallel to the occlusal plane (anterior reference point: mesiolabial incisal edge of maxillary right central incisors; posterior reference points: mesiobuccal cusp tips of maxillary first molars).

The following three points were indicated on each model for measurement (Figure 1), which were often used as



**Figure 1** Three points (PIP, AIP, and CIP) indicated on each model for measurement, and four measurements (CPIP, CAIP, CCIP, and SIP) made to determine the relationship between the anterior tooth and the incisive papilla. AIP = anterior border of the incisive papilla; CAIP = distance from the labial surface of the central incisors to the anterior border of the incisive papilla; CCIP = distance from the labial surface of the central incisors to the center of the incisive papilla; CIP = center of the incisive papilla; CPIP = distance from the labial surface of the central incisors to the posterior border of the incisive papilla; PIP = posterior border of the incisive papilla; SIP = size of the incisive papilla.

reference points in previous studies<sup>7,8,15</sup>: PIP, the posterior border of the incisive papilla; AIP, the anterior border of the incisive papilla; and CIP, the center of the incisive papilla.

The following four measurements were made to determine the relationship between the anterior tooth and the incisive papilla: (1) CPIP, the distance from the labial surface of the central incisors to the posterior border of the incisive papilla; (2) CAIP, the distance from the labial surface of the central incisors to the anterior border of the incisive papilla; (3) CCIP, the distance from the labial surface of the central incisors to the center of the incisive papilla; and (4) SIP, the size of the incisive papilla.

CPIP and CAIP were obtained by measuring the planar distance on the median line of the palate with a digital caliper (Mitutoyo Corporation, Tokyo, Japan), which had a precision level of 0.01 mm. SIP was calculated from the difference between CPIP and CAIP. Measurement results of the stone casts were recorded in millimeters.

Statistical analysis was performed, using statistical software SPSS 14.0 for Windows (SPSS Inc., Chicago, IL, USA). The data were statistically analyzed with the use of descriptive statistics and Pearson correlation coefficients to determine whether any correlation existed between CPIP (dependent variable) and SIP (independent variable;  $\alpha = 0.05$ ).

## Results

The data were analyzed with statistical software SPSS 14.0 for Windows (SPSS Inc.). The descriptive statistics (mean, standard deviation, minimum, and maximum values) of the recorded measurements are listed in Table 1. The *t* test indicated that CPIP and SIP were higher in men than in women ( $P < 0.05$ ), while no significant differences in CAIP and CCIP were observed between men and women ( $P > 0.05$ ).

Pearson correlation coefficients for SIP, and the distance between the labial surface of the central incisors and the incisive papilla (CPIP, CAIP, and CCIP) are demonstrated in Table 2. In certain situations, variables SIP and CAIP show a statistically significant negative ( $r = -0.230$ ) correlation

**Table 1** Mean and standard deviation values, and the range of SIP, CPIP, CAIP, and CCIP.

Variable	Mean (SD), mm	Min, mm	Max, mm	Men, mm	Women, mm
SIP	5.89 (1.08)	5.32	7.16	6.16	5.60
CPIP	11.62 (1.21)	9.42	15.33	11.99	11.21
CAIP	5.72 (0.86)	4.10	8.17	5.83	5.61
CCIP	8.67 (0.90)	6.76	11.75	9.58	9.01

CAIP = distance from the labial surface of the central incisors to the anterior border of the incisive papilla; CCIP = distance from the labial surface of the central incisors to the center of the incisive papilla; CPIP = distance from the labial surface of the central incisors to the posterior border of the incisive papilla; SD = standard deviation; SIP = size of the incisive papilla.

**Table 2** Pearson correlation coefficients (*r*) for the SIP and the distances between the labial surface of the central incisors and the incisive papilla (CPIP, CAIP, and CCIP).

	CPIP	CAIP	CCIP
Pearson correlation( <i>r</i> )	0.727	-0.230	0.481
P	<0.001	0.020	<0.001

$P < 0.05$  indicates significant difference.

CAIP = distance from the labial surface of the central incisors to the anterior border of the incisive papilla; CCIP = distance from the labial surface of the central incisors to the center of the incisive papilla; CPIP = distance from the labial surface of the central incisors to the posterior border of the incisive papilla; SIP = size of the incisive papilla.

**Table 3** Simple linear regression models and corresponding correlation ( $r^2$ ) between the SIP and the distances between the labial surface of the central incisors and the incisive papilla (CPIP and CCIP).

	CPIP ( $y_1$ )	CCIP ( $y_2$ )
Simple linear regression	$y_1 = 6.799 + 0.817$ (SIP)	$y_2 = 6.761 + 0.432$ (SIP)
$r^2$	0.528	0.231

CCIP = distance from the labial surface of the central incisors to the center of the incisive papilla; CPIP = distance from the labial surface of the central incisors to the posterior border of the incisive papilla; SIP = size of the incisive papilla.

( $P < 0.05$ ). The highest *r* between SIP and CPIP is 0.727, which is significant ( $P < 0.05$ ). The relationship between SIP and CCIP is not strong but significant ( $P < 0.05$ ).

A simple linear regression analysis was performed on the data, and two simple linear regression models were considered to study pairwise relationships between (1) SIP and CPIP, and (2) SIP and CCIP. Table 3 shows a simple linear regression model and the values of the square of its corresponding correlation coefficient ( $r^2$ ), suggesting linear relationships between pairs of variables studied. SIP contributed to the prediction of CPIP and CCIP. Every increase of 1 mm in SIP resulted in an increase of approximately 0.817 mm in CPIP. SIP also contributed as a predictor of the outcome with an increase of approximately 0.432 mm in CCIP for every 1 mm increase in SIP. SIP was found to explain 52.8% of CPIP and 23.1% of CCIP of the outcome.

## Discussion

The incisive papilla is a small, pear-shaped eminence composed of a pad of fibrous connective tissue overlying the bony exit of nasopalatine blood vessels—nerves and one of the significant anatomical landmarks in locating maxillary anterior central incisor position in complete denture fabrication procedures.<sup>15</sup>

The horizontal relationship between the incisive papilla and maxillary central incisors has already been investigated by several authors. Harper<sup>2</sup> suggested that the incisal edges

of the maxillary central incisors should be 5–8 mm at the horizontal direction in front of the center of the papilla. McGee<sup>9</sup> stated that the average distance between the anterior point of the central incisors and the center of the incisive papilla was 7.7 mm. Others described a range of 8–10 mm for this measurement.<sup>16–19</sup>

Schiffman<sup>12</sup> described that for 92.1% of 507 casts, the line connecting the tips of the maxillary canines was within an area 1 mm anterior and posterior to the center of the incisive papilla. Maritato and Douglas<sup>20</sup> suggested the use of the intaglio surface of the denture border as a guide in establishing the labial contour of the occlusal rim. Ortman and Tsao<sup>8</sup> reported that the distance between the most anterior part of the maxillary central incisors and the posterior of the incisive papilla was 12.45 mm. In addition, Grave and Becker<sup>7</sup> reported a similar measurement (1213 mm). Many studies showed that the incisal edges of the maxillary central incisors were positioned 8–10 mm in front of the center of the incisive papilla.<sup>2,7–13,15–19</sup>

Several attempts have been made to obtain repeatable, accurate measurements for cast analysis. In addition, various authors studied the relationship between the anatomic location of the incisive papilla and that of the maxillary anterior teeth, by measuring the distance between the center of papilla and the labial surface of central incisors, even though the center of the incisive papilla is somewhat obscure and subjective in definition. The tip of the canine is also commonly used as a reference point. The posterior border of the incisive papilla is easily identified for this purpose. Furthermore, this region is likely to be least affected by the changes in anatomy of the region. Thus, in this study, the posterior border was selected as a reference point, following the method described by others.<sup>7,8,21</sup>

Original and modified sliding calipers have generally been used for measurement of the dental cast, but it can be difficult to measure the dimension from a vector or plane to a point on the dental cast using such tools. Recently, three-dimensional scanners have been used in dentistry, and the accuracy of hardware and specialized software has been demonstrated.<sup>22,23</sup>

The difficulty with these measurements is that many are not standardized three dimensionally. Standardization is complicated by the fact that linear measurement between two points, in a three-dimensional relationship, when the points are not aligned on the same plane, may introduce parallel error if measurement is affected by the different angulations of the measuring devices. Some methods used to overcome these problems include the use of surveyor or contour meters to establish a consistent reference plane.<sup>7,21,24</sup>

Nevertheless, difficulties in determining a reference plane still remain. Some authors have used the occlusal plane, which is somewhat arbitrary. The occlusal plane is primarily defined as the average plane established by the incisal and occlusal surfaces of the teeth.<sup>25</sup> Generally, it is not a plane, but rather represents the planar mean of the curvature of these surfaces. Another definition of the occlusal plane, which is related to denture fabrication, is the surface of wax occlusal rims contoured to guide the arrangement of artificial teeth. Recently, a new, modified reference plane was designed onto virtual, three-

dimensional casts, and the orthographic anteroposterior distance between the posterior border of the incisive papilla and a reference point or vector was measured.

In this study, the occlusal plane established by the incisal and occlusal surfaces of the teeth has been used to measure distances, including the size of the incisive papilla.

Corelationships between SIP, and the distances between the labial surface of the central incisors and the incisive papilla (CPIP, CAIP, and CCIP) were explored. The Pearson correlation coefficient was calculated, and regression models were applied to the data and the correlations were calculated after deriving the regression model.

The descriptive statistics (mean, standard deviation, minimum, and maximum values) of the variables measured are listed in Table 1, which shows that the results of the measurements made in this study are similar to those of other studies, in which it was shown that values differ among different groups. The first step taken in this study was to investigate Pearson correlation coefficients ( $r$ ) and the significance of the  $r$  value for SIP and the distances between the labial surface of the central incisors and the incisive papilla (CPIP, CAIP, and CCIP). Small correlation values may imply either the independence of the variables or, possibly, the existence of a more complicated nonlinear relationship of the variables, and that the population correlation,  $\rho$ , may be equal to zero. It is of interest to test the validity of the hypothesis  $H_0: \rho = 0$  with the test statistic, which was derived from a  $t$  distribution. The values were compared at a significance level of 0.05. Table 2 shows the result of this hypothesis testing, and the correlation values obtained were considerably larger, ranging from  $-0.230$  to  $0.727$ . The general result of this test shows that  $H_0$  is rejected.

Regression methods yielded two regression models for predicting from a combination of SIP and the distances between the labial surface of the central incisors and the incisive papilla (CPIP and CCIP). Table 3 shows the simple linear regression models and the corresponding correlations. Given the extent to which data were investigated/verified, the small correlation obtained should be cautiously interpreted.

The aim of restoring edentulous patients is to have the maxillary anterior teeth restore optimal dentolabial relations in harmony with the overall facial appearance. There may be no universally reliable method for using the incisive papilla to determine the position of artificial denture teeth, and the continuing process of alveolar bone resorption may cause difficulties in restoring the lost tissues in approximately the same amounts and in the same positions from which they were lost. However, the use of regression formulas similar to those used in the current study (Table 3) may help in arranging artificial teeth for complete dentures.

Due to limited data, further studies including different races and different age groups should be conducted to validate our findings. Within the limitations of this study, the size of the incisive papilla is highly correlated to the distances between the labial surface of the central incisors and the incisive papilla, and may be predicted by incorporating the regression methods discussed in this study.



## Conflicts of interest

The authors have no conflicts of interest relevant to this article.

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