Measuring Anatomical Landmark Structures to Determine the Width of Maxillary Anterior Teeth

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Abstract

To determine whether several combinations of landmark structures could be used to determine the width of maxillary anterior teeth. Cross sectional, with 52 subjects (11 male and 41 female) aged 18-35 years. All subjects underwent impression-making of the maxilla using stock tray and irreversible hydrocolloid. Three 3D anatomical landmark structure measurements were taken using a modified digital caliper: right hamular notch to left hamular notch, right hamular notch to papilla insisiva, and left hamular notch to papilla insisiva The widths of maxillary anterior teeth were then measured. The data were analyzed using statistical software. Among patients, there were differences between the distance from right hamular notch to papilla insisiva, as well as from left hamular notch to papilla incisiva, and the width of maxillary anterior teeth. However, the distance between right and left hamular notches or between those notches and papilla insisiva was only able to predict the width of maxillary anterior teeth 25.7% of the time. Anatomical landmark measurements cannot function as a single guide to determine the necessary width of maxillary anterior teeth for denture elements.

Clinical article (J Int Dent Med Res 2018; 11(1): pp. 169-174)

Keywords: Anatomical landmark, width of maxillary anterior teeth, denture element determination.

Received date: 20 September 2017 **Accept date:** 25 October 2017

Introduction

There are many contributing factors affecting the harmony of maxillary anterior tooth alignment, such as the size, shape, and structure of these teeth. Several theories regarding the size and morphologic nature of these denture elements have been studied, yet the results have been inconsistent. For instance, Sitthiphan *et al* assert that the width of maxillary anterior teeth differs based on gender.[1] However, the validity of this statement only refers to a particular population. As such, the analysis in other populations needs to be measured. Despite these variations, one means of esthetic guidance used to determine harmony between the size and shape of the maxillary anterior denture element is the ideal proportion. However, this theory is still debatable, since not all smiles considered to be beautiful or ideal follow the golden proportion theory. Other theories are advised to be considered and explores for esthetic guidance.[1] In the process of making a full denture for an edentulous patient, it is often difficult to select the width of teeth that best suits him or her. There are several methods used to determine the width of a denture element. For the patient without any dental records, anatomical landmark structure is often used as a means of guidance. Previous study concluded that there was no single method that ensured a perfect match, and it was advised to develop and use dentist's esthetic instincts to aid them in selecting the ideally proportional denture elements.[2]

One of the most popular methods used to determine tooth width is by measuring a patient's intercommisural distance. Unfortunately, this is often difficult to measure because the corner of the mouth is a mobile organ. According to Desai, Upadhyay, and Nanda, a patient's inter-commisural area is increasingly in the resting position as his or her age increases.[3] This is caused by a decrease in muscle activity and loss of elasticity and volume of the skin. As a result, a fissure can form in the corner of the mouth,

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making measurements difficult. The same theory was echoed by Varjao and Nogueira, who stated that intercommissural measurement could not be accurately used as a method of denture element selection.[4] According to Guldag *et al.,* the major problem with using biometric measurements of soft tissue to determine the width of denture elements is that there is no static relationship among soft tissues (they often move).[5] Furthermore, the soft tissue could undergo changes caused by several factors, such as age, weight, and shape of the body. Therefore, to ease the selection of denture elements, some researchers have found that using anatomical landmark structure is stable as a study model.

There are several measurements used to guide denture element selection for maxillary anterior teeth. For example, Baker *et al*. successfully used anatomical landmark structures in their study model.[2] In it, they measured the distance from right hamular notch to left hamular notch, as well as from right hamular notch to papilla insisiva, and then compared these measurements to the patient's intercommisural distance.[2] However, this study did not consider the race and gender of its subjects.[2] Furthermore, a study by Guldag *et al.* proposed combining the intercommisural distance measurement with another theory as a means of more reliably selecting denture elements of maxillary anterior teeth.[5] A different perspective was also offered by Baker *et al*. in their study, which showed the distance between hamular notches plus 10 mm could be used as a guideline to determine the width of maxillary anterior teeth.[2] Shetty *et al.* also indicated that hamular notch and the incisive papilla are fixed landmark and do not change over time.[6]

Due to the controversial nature of the above-mentioned studies, it is necessary to confirm which of the proposed theories is most applicable. In an effort to do this, the current study sought to determine whether several combinations of landmark structures could be used to determine the width of maxillary anterior teeth.

Materials and methods

This was an observational analytic study that employed a cross sectional method. The subjects of this study were dental students, and patients in the dental hospital of the Universitas Indonesia who met the inclusion criteria: having a complete set of maxillary anterior teeth free of caries, restoration, denture attrition, abrasion, and fracture that were not in a malposition, or just in a slight malposition. Subjects who refused to sign the informed consent paperwork were excluded. The size of the sample was measured with a correlative analytical formula, and the result was a 52-patient sample. The study commenced after the subjects were found to meet the established criteria. Impressions of their maxillary anterior teeth were made and their anatomical landmark structures were measured. The impressions were screened before being measured, to confirm the anatomical landmark structures were well duplicated. Next, an outline of each patient's papilla insisiva was made with a mechanical pencil, and the midpoint between the two was marked, which was determined by measuring the distance between anterior and posterior sides and dividing it by two. The midpoint between the hamular notches was identified by locating the meeting point of the line running from the buccopalatal side and the midpoint of line running from the tuberositas maxilla to the pterygoidhamulus (Figure 1).[5]

Following this, the digital calipers were modified. Measurements were completed by sliding the caliper to the midpoint that was previously marked. The measurement indicated in the study model includes the distance between right and left hamular notches, the distance from right hamular notch to papilla insisiva, and the distance from left hamular notch to papilla insisiva. Next, the widths of maxillary anterior teeth were determined using the digital caliper by measuring the widest part of mesio-distal aspect of the tooth. The measurements of maxillary anterior teeth were measured.[5,7]

Data were statistically analyzed using SPSS V.20. Descriptive analytical methods were employed to determine the distribution and frequency of each variable, as well as the mean, standard deviation, and maximum and minimum values of the population sample. Spearman non-parametric bivariate analysis tests were then conducted to uncover the relationship between the anatomical landmark structure measurements and the width of maxillary anterior teeth. The Mann-Whitney non-parametric U test was used to characterize the relationships among gender, anatomical landmark structure measurements, and the width of maxillary

anterior teeth. Multivariate linear regression tests were performed to determine the power of those relationships.

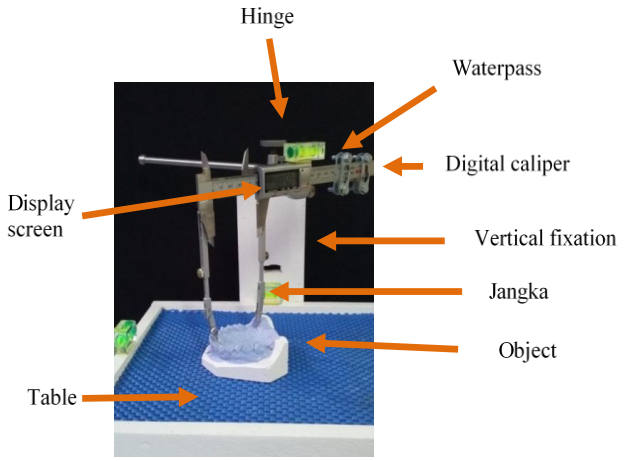

Figure 1. Modified digital caliper used for anatomical landmark measurement

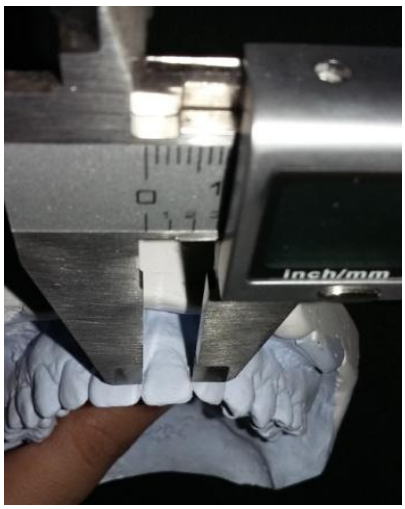

Figure 2. Measuring the width of maxillary anterior teeth

Results

The data were analyzed using SPSS V.20. Univariate analysis was then displayed using a descriptive statistical method to determine the distribution and frequency of each variable measured in the sample population. Before performing the analysis, the data were subjected to a descriptive test in order to construct a picture of anatomical landmarks and the width of maxillary anterior teeth. Those data are displayed in Table 1.

Variable	Mean		Median		Minimum-maximum	
	Male	Female	Male	Female	Male	Female
HN-Ipka	52.37	49.23	52.17	49.45	49.67-56.93	44.16-54.80
HN-Ipki	52.50	49.20	51.27	49.32	49.67-56.34	43.95-54.80
HN-HN	42.75	42.48	42.22	42.6	38.08-49.29	36.82-48.29
Width of anterior teeth	48.89	45.20	55.52	45	45.62-51.38	41.5-50.24

Table 1. Description of anatomical landmarks and the width of maxillary anterior teeth. HN-Ipka: Distance from right hamular notch to papilla insisiva. HN-Ipki: Distance from left hamular notch to papilla insisiva. HN-HN: Distance between right and left hamular notches.

The table shows that the anatomical landmark structure and width of anterior teeth were greater in a male than in female. If the results of the Kolmogorov-Smirnov normality test were not normal, where $p<0.05$, then a Spearmen non-parametric test was performed to determine the relationship between anatomical landmark structures and the width of maxillary anterior teeth.

Distances	Male	Female	r	p-value
right hamular notch - papilla insisiva	52.37 (49.67-56.93)	49.23 (44.16-54.80)	0.394	0.004*
right hamular notch - papilla insisiva	52.50 (49.67-56.34)	49.20 (43.95-54.80)	0.373	0.007*
right and left hamular notches	42.75 (38.08-49.29)	42.48 (36.82-48.29)	-0.124	0.386

Table 1. Relationship between anatomical landmark structures and the width of maxillary anterior teeth. *Statistically different

Where the value r indicated the distance from right hamular notch to papilla insisiva, we found in this study that the correlation was0.394 with a p-value of0.004. When $p<0.05$, it was concluded that there was a significant correlation between the distance from the right hamular notch to papilla insisiva and the width of maxillary anterior teeth. Therefore, the relationship between these two was weak, yet still positive, which means the greater the distance from the right hamular notch to the papilla insisiva, the greater the width of the subject's maxillary anterior teeth. In the second set of landmark measurements, where the value r indicated the distance from left hamular notch to papilla

insisiva, we found that r=0.373 and p=0.007. As p<0.05, we concluded that there was a significant correlation between the distance from the left hamular notch to papilla insisiva and the width of maxillary anterior teeth. This demonstrated another weak, yet positive relationship, and means the greater the distance from the left hamular notch to papilla insisiva, the greater the width of the subject's maxillary anterior teeth. Finally, a correlation analysis of the distance between right and left hamular notches was performed using a Pearson test, resulting in r=-0.124, with p=0.386. As p<0,05, it was concluded that there was no significant correlation between the distance from right to left hamular notch and the width of a subject's maxillary anterior teeth. To determine the relationship between anatomical landmark structures and the width of maxillary anterior teeth based on gender, the Spearman non-parametric test was administered to both male and female subjects.

	Gender	Mean	r	p-value
Distance from right hamular notch to papilla insisiva	Male	52.37(49.67-56.93)	0.436	0.180
	Female	49.23(44.16-54.80)	0.093	0.567
Distance from left hamular notch to papilla insisiva	Male	52.50(49.67-56.34)	0.282	0.401
	Female	49.20(43.95-54.80)	0.063	0.697
Distance between right and left hamular notches	Male	42.75(38.08-49.29)	0.123	0.719
	Female	42.48(36.82-48.29)	-0.227	0.159

Table 2. Relationship between anatomical landmark structures and the width of maxillary anterior teeth based on gender.

As p>0,05, no statistically significant relationship was found between the distance from right hamular notch to papilla insisiva and the width of maxillary anterior teeth in male or females group. The same result was found when analyzing the distance from right to left hamular notch and the width of maxillary anterior teeth in male or females group. With p>0.05, it was concluded that that there was no statistically significant relationship in either case. The Mann-Whitney non-parametric U test was performed to determine the relationship between anatomical landmarks and the width of maxillary anterior teeth based on gender.

	Male Mean (SD)	Female Mean (SD)	*p-value*
HN-Ipka	52.37(2.53)	49.23(2.21)	0.000*
HN-Ipki	52.50(2.23)	49.20(2.29)	0.000*
HN-HN	42.75(3.81)	42.48(2.95)	0.882
Width of maxillary anterior teeth	48.89(1.97)	45.20(1.89)	0.000*

Table 3. Relationship between anatomical landmarks and the width of maxillary anterior teeth. *Statistically different
HN-Ipka: Distance from right hamular notch to papilla insisiva
HN-Ipki: Distance from right hamular notch to papilla insisiva
HN-HN: Distance between right and left hamular notch.

The analytic test found that for the distance between right hamular notch and papilla insisiva, p= 0.000 (p<0.05 being statistically significant). This indicates that there were statistically different values when comparing the distance from right hamular notch to papilla insisiva and the width of anterior maxillary teeth between male with female group. As the r value of the distance from left hamular notch to papilla insisiva was 0.000 (p<0.05), it showed that there were statistically different values when comparing the distance from left hamular notch to papilla insisiva and the width of anterior maxillary teeth between male with female group. For the distance between right and left hamular notches, p=0.0882 (p>0.05), meaning there were no statistically different values between male and female when it came to the distance from right to left hamular notch and how that related to the width of maxillary teeth. Multivariate analysis of the relationship between anatomical landmark structure measurements and the width of maxillary anterior teeth based on gender. A multivariate analysis in this study was done using a linear regression test.

Variable	**B**	**S.E.**	**p-value**
Distance from right hamular notch to papilla insisiva	0.472	0.424	0.272
Distance from left hamular notch to papilla insisiva	0.001	0.418	0.998

R square = 0.257

The data show that the distance from right hamular notch to papilla insisiva was only a reliable predictor of the width of anterior maxillary teeth approximately 25.7% of the time, while the remaining of 74.3% of cases must be predicted by other variables that were not examined in this study. Based on the findings of the multivariate analysis, the respective distances from right

hamular notch to papilla insisiva and left hamular notch to papilla insisiva did not have a statistically significant relationship, because p>0.05. As such, these values could not be used as a formula to predict the width of maxillary anterior teeth.

Discussion

This was an observational analytic study using cross sectional methods aimed at understanding the significance of several relationships as they relate to the width of maxillary anterior teeth, including: the distance between right and left hamular notches, the distance from right hamular notch to papilla insisiva, and the distance from left hamular notch to papilla insisiva. We also sought to investigate these relationships as they related to gender. This study was performed on 52 subjects, consisting of 40 female and 11 male aged 18-35 years. The subjects of this study were dental students, and patients in the dental hospital Universitas Indonesia, who met the inclusion criteria: a complete set of maxillary anterior teeth free of caries, restoration, denture attrition, abrasion, fracture and not in a malposition or just in a slightly malposition. However, before beginning the study, the subjects were screened to determine whether they had a third molar or not, because those who had did often possessed an unclear hamular notch.

The findings of this study revealed that the distance between right and left hamular notches was the same between male and female. Additionally, the distance from right hamular notch to papilla insisiva, the distance from left hamular notch to papilla insisiva, and the width of axillary anterior teeth were different between male and female group, and the anterior teeth were bigger in male than female. These results were in agreement with those found in a study conducted by Sitthiphan et al, who proposed that gender affected the width of maxillary anterior teeth, especially central insisiva and caninus.[1] Furthermore, a study conducted by Horvath *et al.* using a 3D analyser concluded that the variation in shape and size of the maxillary anterior teeth differed between genders.[8]

In addition to these comparisons, this study found no correlation between the distance from right to left hamular notch and the width of maxillary anterior teeth, which means the distance between right and left hamular notches cannot be used to predict the width of maxillary anterior teeth. The same results were reported in a study conducted by Guldag *et al*., which stated that inter-hamular notch distance could not be used as a means of predicting the width of maxillary anterior teeth.[5] However, the results were different in a study conducted by Baker *et al*., which claimed that measuring the distance from right and left hamular notches to the papilla insisiva, then adding 10 mm was an applicable predictor for the width of maxillary anterior teeth.[2]

As noted, this study found no correlation between the distance from right and left hamular notches to the papilla insisiva and the width of maxillary anterior teeth. However, if the value of both gender groups were combined, there would be a statistically significant relationship, although weak. Despite its weak nature, this relationship indicates that the use of this method should be combined with other methods in order to reliably predict the width of maxillary anterior teeth. This may be due to the fact that the number of male and female subjects was disproportional. Specifically, the sample population consisted of more females than males. Since this study found no correlation between the distance from right and left hamular notches to the width of maxillary anterior teeth, the relationship cannot be used to predict the width of maxillary anterior teeth. This result differs from Bakers et al. studies that have concluded there was in fact a relationship between inter-hamular notch distance and the papilla insisiva with regards to the width of maxillary anterior teeth.[2] The discrepancy may be caused by the different sizes of jaws being measured. For instance, Mohammad *et al.* stated that several factors affected the width of the dental arch, such as the size and the shape of the jaw, muscle involvement, environment, and genetics.[9] Furthermore, the size of the teeth affected the length of the jaw more than the width of the jaw. The same study found that the size and width of the male's jaws were greater than female's.[9,10]

In contrast to other measurements, this study found that there was a correlation between the distance from right or left hamular notch and the papilla insisiva with the width of maxillary anterior teeth. As the positive relationships revealed in this study were weak, further studies are needed that use other variables affecting the

measurements or combining the anatomical landmark measurements with other methods as a means to predict the width of maxillary anterior teeth. As an example, a study conducted by Berksun *et al.* stated that there was a relationship between a subject's face, his or her dental arch, and the shape of his or her teeth based on a dentist's perspective.[11] This study showed that there was a relationship between the distance from right and left hamular notches to the papilla insisiva and the width of maxillary anterior teeth, yet this measurement could only predict the width of maxillary anterior teeth approximately 25.7% of the time, while remaining 74.3% of cases could be predicted by another variable that was not examined in this study. Limitations encountered in this study included the fact that the method of measurement was often difficult because the landmarks were not in a plane. Additionally, for purposes of comparison, a 3D scanner and software should have been used.

Conclusions

This study bore out two conclusions. Firstly, it showed that there is a relationship between the distances from right or left hamular notches to the papilla insisiva and the width of maxillary anterior teeth, yet this measurement could not be used to reliably predict the width of maxillary anterior teeth. Secondly, it found that gender affected the distance from right hamular notch to the papilla insisiva, from left hamular notch to the papilla insisiva, and the width of maxillary anterior teeth.

Declaration of Interest

The authors report no conflict of interest and the article is not funded or supported by any research grant.

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