USE OF HAMULAR NOTCHES AND INCISIVE PAPILLA AS GUIDES FOR SELECTION OF MAXILLARY ANTERIOR TEETH WIDTH

A thesis submitted in partial fulfillment for requirements of Master Degree in Removable Prosthodontics
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Dedication

To my family....

Who always support me.
Acknowledgement

Great thank’ to my very kind and helpful supervisor Dr. Nadia Khalifa who always helped and supported me. Also I want to thank Dr. Magdi Wadae (the Head of (Prosthodontics Department) And special thank' to my colleague dr. Ahmed Khalid (Department of Orthodontics-University of Khartoum) who help me with th statistical analysis. Thanks to all dental students –University of Khartoum among whom this research had been done.

Last but not least thank' to my colleagues in the (Prosthodontics department and Prosthodontics Laboratory) for their help.
Abstract

This study was conducted to evaluate the use of specific anatomical landmarks and their relationships, in determination of the width of maxillary anterior teeth. Eighty maxillary dentate casts from dental students and postgraduate students from University of Khartoum were used in the measurements. The age of the study sample ranged from 25-30 years and comprised of 43 females and 37 males. Distances from the center of the right hamular notch to the center of the left hamular notch (HD), and from the left hamular notch to the incisive papilla (FBI-IP), as well as from the right hamular notch to the incisive papilla (1+1-IP) were measured using an electronic caliper gauge. The widths of maxillary anterior teeth were measured from distal end of right canine to the distal end of left canine, using a flexible ruler. The (HN-IP-HN) distance, when divided by 3 (the predicted value), had a mean of 57.7mm and standard deviation of 2.0 among males, while among females, the mean of the predicted value was 52.9mm with standard deviation of 2.3. The mean of the actual value (the width of maxillary anterior teeth) was 56.7mm with standard deviation of 1.8 among males, while between females the mean of the actual value was 52.9mm with standard deviation 2.2. The P-Value

III
of the correlation between the predicted value and actual value was 0.00, and a correlation between the predicted value and the actual value was found.

The P-Value of the difference between the actual and predicted values was 0.74, and there was no or little difference between the actual and predicted values. The predicted and actual values were higher in males than in females. The results of this study showed that the measurement of IN-NP-N-I-BI divided by 3, is approximately equal to the width of maxillary anterior teeth from the distal end of the right canine to the distal end of the left canine, indicating that these measurements can be of value when setting teeth in edentulous patients.
ملخص البحث

أعدت هذه الدراسة لتقديم استعمال بعض العلامات التشريحية وعلاقتها بحجم الأسنان الأمامية بالفك الأعلى.

أخذت ثمانين طبعة سنوية من طلاب البكالوريوس وطلاب الدراسات العليا بكلية طب الأسنان. جامعة الخرطوم تتراوح أعمارهم بين 25-30 سنة, وتتكون هذه العينة من 43 أنثى و 37 ذكر.

قيست المسافة بين الحديبة الفكية في الجزء الأيمن والحادية الفكية في الجزء الأيسر والمقدمة بين كل من الحديتين الفكية وبين الحليمة القاطعة بواسطة مقياس إلكتروني (برجل). كما قيس عرض الأسنان الأمامية بواسطة مسطرة مرنة.

وجد أن البدع بين الحديتين الفكية والبدع بينهما وبين الحليمة القاطعة مقسمًا على الرقم 3 يكون الناتج المتوسط 57.7ملم, الانحراف المعياري لهذا القياس هو 2 بين الذكور. أما بين الإناث فوجد هذا القياس بمتوسط 52.9ملم بالانحراف معياري 2.3.

بينما وجد متوسط قياس عرض الأسنان الأمامية في الفك الأعلى يساوي 6.5 ملم بانحراف معياري يساوي 2.2(قيمة P.value 0.00, مما يعني وجود علاقة قوية بين القيمتين. وقيمة ال P.value) للعلاقة بين القيمتين التقديرية

(الاختلاف بين القيمتين يساوي 0.74 مما يعني أنه قليل الأهمية أي أنه ليس هناك اختلاف واضح بين القيمتين. أي أنه يمكن استعمال الحديبة الفكية والحليمة القاطعة بحسب الأسنان الأمامية في الفك الأعلى للمرضى الذين يعانون من فقدان الكامل للأسنان.)
# List of Contents

<table>
<thead>
<tr>
<th>Index</th>
<th>Title</th>
<th>Page no</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dedication</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td>Acknowledgement</td>
<td>II</td>
</tr>
<tr>
<td></td>
<td>Abstract (English)</td>
<td>III</td>
</tr>
<tr>
<td></td>
<td>Abstract (Arabic)</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>List of contents</td>
<td>VI</td>
</tr>
<tr>
<td></td>
<td>List of tables</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>List of Photographs</td>
<td>XI</td>
</tr>
<tr>
<td></td>
<td>List of Appendices</td>
<td>XI</td>
</tr>
</tbody>
</table>

## Chapter One

<table>
<thead>
<tr>
<th>1-1</th>
<th>Introduction</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Justification</td>
<td>3</td>
</tr>
<tr>
<td>1-3</td>
<td>Literature review</td>
<td>4</td>
</tr>
<tr>
<td>1-3-1</td>
<td>Photographs and Radiographs</td>
<td>4</td>
</tr>
<tr>
<td>1-3-2</td>
<td>Interalar width</td>
<td>7</td>
</tr>
<tr>
<td>1-3-3</td>
<td>Interpupillary distance</td>
<td>8</td>
</tr>
<tr>
<td>1-3-4</td>
<td>Intercanthal distance</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-------------------------------------</td>
<td>---</td>
</tr>
<tr>
<td>1-3-5</td>
<td>Bizygomatic width</td>
<td>9</td>
</tr>
<tr>
<td>1-3-6</td>
<td>Intercondylar width</td>
<td>10</td>
</tr>
<tr>
<td>1-3-7</td>
<td>Intercanine distance</td>
<td>10</td>
</tr>
<tr>
<td>1-3-8</td>
<td>Anterior teeth width</td>
<td>11</td>
</tr>
<tr>
<td>1-3-9</td>
<td>Hamular distance</td>
<td>15</td>
</tr>
<tr>
<td>1-3-10</td>
<td>Incisive papilla</td>
<td>19</td>
</tr>
<tr>
<td>1-3-11</td>
<td>Effect of Bone resorption on anatomical land marks</td>
<td>20</td>
</tr>
<tr>
<td>1-4</td>
<td>Objectives</td>
<td>22</td>
</tr>
<tr>
<td>1-4-1</td>
<td>General objectives</td>
<td>22</td>
</tr>
<tr>
<td>1-4-2</td>
<td>Specific objectives</td>
<td>22</td>
</tr>
</tbody>
</table>

**Chapter Two**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Materials and methods</td>
<td>23</td>
</tr>
<tr>
<td>2-1</td>
<td>Study design</td>
<td>23</td>
</tr>
<tr>
<td>2-2</td>
<td>Study population</td>
<td>23</td>
</tr>
<tr>
<td>2-3</td>
<td>Including criteria</td>
<td>23</td>
</tr>
<tr>
<td>2-4</td>
<td>Excluding criteria</td>
<td>23</td>
</tr>
<tr>
<td>2-5</td>
<td>Study variables</td>
<td>24</td>
</tr>
<tr>
<td>2-6</td>
<td>Sampling</td>
<td>24</td>
</tr>
<tr>
<td>2-7</td>
<td>Equipments and materials</td>
<td>25</td>
</tr>
<tr>
<td>2-8</td>
<td>Impression taking</td>
<td>26</td>
</tr>
<tr>
<td>2-9</td>
<td>Measurements</td>
<td>26</td>
</tr>
</tbody>
</table>
### 2-10 | Data collection | 27
---|---|---
### 2-11 | Data processing | 28
### 2-12 | Data analysis | 28

| Chapter Three: Results |
|---|---|
| 3 | Results | 29 |
| 3-1 | Gender distribution | 29 |
| 3-2 | Age distribution | 31 |
| 3-3 | Measurement of HN-1P-HN/3 | 33 |
| 3-4 | Measurements of maxillary anterior teeth | 35 |
| 3-5 | Predicted and actual value correlations | 37 |
| 3-6 | Predicted and actual values differences | 38 |
| 3-7 | Group statistics | 39 |

| Chapter Four: Discussion and Conclusion |
|---|---|
| 4-1 | Discussion | 40 |
| 4-2 | Conclusion | 44 |
| 4-4 | Recommendations | 45 |
# List of Tables

<table>
<thead>
<tr>
<th>Index</th>
<th>Title</th>
<th>Page no</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gender Distribution</td>
<td>29</td>
</tr>
<tr>
<td>2</td>
<td>Age Distribution</td>
<td>31</td>
</tr>
<tr>
<td>3</td>
<td>Measurements of HN-IP-HN/3</td>
<td>33</td>
</tr>
<tr>
<td>4</td>
<td>Measurements of maxillary anterior teeth width</td>
<td>35</td>
</tr>
<tr>
<td>5</td>
<td>Paired Sample Correlations</td>
<td>37</td>
</tr>
<tr>
<td>6</td>
<td>Predicted and actual Values differences</td>
<td>38</td>
</tr>
<tr>
<td>7</td>
<td>Group Statistics</td>
<td>39</td>
</tr>
</tbody>
</table>
List of Photographs

<table>
<thead>
<tr>
<th>Index</th>
<th>Title</th>
<th>Page no</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Measurement of hamular distance with digital caliper</td>
<td>58</td>
</tr>
<tr>
<td>2</td>
<td>HN-IP-HN triangle on the cast</td>
<td>59</td>
</tr>
<tr>
<td>3</td>
<td>Standardization of cast base using surveyor</td>
<td>60</td>
</tr>
</tbody>
</table>

Appendices

<table>
<thead>
<tr>
<th>index</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>References</td>
</tr>
<tr>
<td>2</td>
<td>Data collection form</td>
</tr>
</tbody>
</table>
Chapter One

Introduction, Justification, Literature review and Objectives
I-I. Introduction

One of the objectives of complete dentures is to satisfy esthetics. The success or failure of a denture frequently depends on how successfully the operator has fulfilled the patient's esthetic requirements. The patient who is unhappy with the facial contours or with arrangement and appearance of the teeth may not cooperate during the early insertion periods.(1)

A denture usually is received as esthetic when the teeth and the bases are in harmony with the facial musculature as well as the size of the head.(2) The goals of prosthodontic treatment for edentulous patients are to construct complete dentures that function well, allow patients to speak normally, are esthetically pleasing and will not abuse the tissues over the residual ridge.(3)

The most important teeth from the point of view of appearance are the maxillary anterior teeth especially the central incisors which are the most exposed during conversation when an individual smiles or laughs.(4)

Photographs, radiographs, study casts and extracted teeth are pre extraction records that can be utilized as guides for selection of artificial teeth.(5) Various guide lines have been suggested for determining the width of the maxillary anterior teeth when pre extraction records are not available, such as bizygomatic width, intercommissural width, Interalar width and canthus distance.

Many intraoral anatomical landmarks have fixed position that is not altered after missing the teeth, thus, they can be used as reliable guides to select the maxillary anterior teeth e.g. incisive papilla, residual ridges, the comers of the mouth, and the maxillomandibular relations.
In this study specific anatomical landmarks and their relationships obtained from dental casts of dentate patients had been examined. Measurement of the distance from left hamular notch to the right hamular notch (hamular distance) was found in other studies to be equal to the width of the six maxillary anterior teeth (from distal of the left canine to the distal of the right canine), and the right hamular notch-incisive papilla-left hamular (HN-IP-HN) notch distance divided by factor 3 in previous studies found to be equal to the width of the six maxillary anterior teeth. In this way the hamular notches and incisive papilla can be used as guides for measurement of the width of the six anterior teeth and according to the maxillary anterior teeth other teeth can be selected.
1-2. Justification

Several methods have been proposed for determining the width of the maxillary anterior teeth. When there is a pre-extraction record, the width of the anterior teeth can be easily obtained, while in the absence of pre-extraction records it is difficult to determine the width of the anterior teeth. Use of facial measurements and anatomical landmarks approximately give the width of the anterior teeth. Use of facial measurements and anatomical landmarks approximately give the width of the anterior teeth. It is of value to use hamular distance and HN-IP-HN distance to measure the width of the six maxillary anterior teeth as they are reliable anatomical landmarks and easy to be measured.

In this country there is no study that had been done to use the hamular distance or hamular notch-incisive papilla-hamular notch distance as guides for selection of the maxillary anterior teeth.
1-3. Literature Review

Teeth size and form selection can be obtained from a variety of methods. The easiest is from prior extraction record. Other methods include the Trubyte Tooth Indicator, anatomical measurements, marking the canine eminence on the casts, or simply a subjective evaluation of face size and tooth form by the clinician\(^{(6)}\).

Douglas A. Hock (1992) stated that different qualitative guidelines are cited, the best method for the selection of the maxillary anterior teeth is the use of pre-extraction records or old photographs.

Numerous qualitative and quantitative guidelines are cited in the literature for the proper placement of the maxillary anterior teeth\(^{(7)}\).

1-3-1. Photographs and radiographs:

The use of photographs is to be strongly recommended. Particularly useful are those of a patient that were taken when the subjects was dentate or wore dentures which were admired by the patient.
The photographs should realistically show head-on facial views of the patient smiling; failure to do this may not reveal any sign of the anterior teeth. Such views should enable the clinician to see and to measure carefully the ratio of the patient's horizontal intercanine distance, and relate that to the interpupillary distance in the photograph. In the clinic, the clinician may then measure the patient's interpupillary distance and it should be possible establish the horizontal width of the upper six anterior teeth\(^8\).

Wehner et al (1967) stated that a photograph of a patient in which the natural anterior teeth are visible of great help in the selection of the size of the artificial teeth. Radiographs can be meaningful guides for the selection anterior teeth, in the absence of other records they can be useful in selecting crown form, width, and length\(^9\).

Bindra et al (2001) examined a method described by Wehner et al for calculating the width of a missing central incisor using pre-extraction photographs; three photographic views were obtained for each of dentate subjects: full face, oblique, and reduced-size full face. The width of the maxillary right central incisor (MRI) was calculated using a formula. The difference between the actual width and calculated width of MRI was determined for each subject.
The median difference and inter quartile range were determined because the data were skewed. They found that, the width of MRI calculated using the larger full-face view was typically smaller than the actual width, with a median difference of -0.18 mm. The interquartile range of the difference was from -0.42 to 0.05 mm. For both the oblique and reduced-size views, the calculated width was typically larger, with a median difference of 1.19 mm with an interquartile range from 0.82 to 1.76 mm and a median difference of 0.84 mm with an interquartile range from 0.59 to 1.41 mm, respectively. The technique described by Wehner et al is of proven/value in calculating the width of a central incisor when the only available evidence is a pre extraction photograph. However, it is of value only when the photograph is a full1 face portrait of sufficient size\textsuperscript{(10)}.

Gomes VL et al (2M) consider facial analysis with digital photography as h' practical and efficient application to verify the relation between the combined mesiodistal width of the six maxillary anterior teeth and the facial segments (i.e. the width of the eyes, the inner canthal distance (ICD), the interpupillary distance (IPD), the interalar width, and the intercommissural width (IC)). Standardized digital images of 81 dentate Brazilian subjects were used to measure both facial and oral segments when viewed from the frontal aspect through an image processing program.
To measure the distance between the upper canines on a curve, accurate cast were made from the upper right first premolar to the upper left first premolar. The results showed a significant correlation between all facial elements and the combined mesiodistal width of the six teeth, when observed from the frontal aspect. The ICD, IPD, and IC showed the highest probability of being correlated to the mesiodistal width of the teeth.\(^{(11)}\)

1-3-2. Interalar width:

It is determined by measuring the external width of the nose at the widest point. Different views have been reported on the significance of the interalar width in the selection of the anterior teeth. Latta et al observed that the width varied widely even when the population was separated into groups by sex and or race.\(^{(12)}\).

Smith (1965) reported a low relationship between radiographic measurement of the interalar width of the nose and the distance between the maxillary canine tips\(^{(13)}\). Lee(1962) \(^{(14)}\) and Whener et al (1967) \(^{(15)}\) suggested extending parallel lines from the lateral surface of the ala of the nose on the labial surface of the maxillary occlusion rim to estimate the intercanine cusp tip.
Marokouf and Richie demonstrated some relationship between the nasal width and intercanine distance which suggested its use to establish the width of the anterior teeth\(^{(16)}\).

Scandrett (1982) reported a significant correlation between the interalar width and the width of the maxillary anterior teeth\(^{(17)}\).

Fabiana M V and Sergio S N (2006) conducted a study to evaluate the use of the nasal width as a guide for the selection of proper width maxillary anterior denture teeth in four racial groups of the Brazilian population. One hundred and sixty subjects (Whites, mixed, Blacks, and Asians) were selected. Using a sliding caliper, the nasal width and the intercanine distance were measured. A prediction was made of the percentage of subjects of the White, Mulatto, Black, and Asian populations’ . The four racial groups showed a weak correlation between the intercanine distance and the nasal width. The correlation found between the intercanine distance and the nasal width was not high enough to be used as a predictive factor. The relationship between natural tooth width and artificial tooth width as predicted by the nasal width showed that the nasal width method is not accurate for all the studied.\(^{(18)}\)
1-3-3. Interpupillary distance

It is measured from the mid pupil to the other mid pupil. Alsheikh et al conducted study and found a significant correlation between interpupillary width and the width of the anterior teeth of the entire sample but when the samples was divided in to gender, correlation found only in females. Cesario et al (1984) reported that interpupillary distance could be used reliably in selecting maxillary anterior teeth width.

Latt et al (1991) found no correlation between interpupillary distance and the width of the mouth for the whole population.

1-3-4. Intercanthal distance:
It is the distance between the median angles of palpaberal.

AlWazzan Khalid. A. (2002) found a significant relationship between Intercanthal distance and the measurements of the four maxillary anterior teeth. It is found that biometric ratio of 1:0.267 and 1:0.426 could be used to estimate the central incisor width and the width of the combined six anterior teeth respectively.

Abdullah (2002) described a significant relationship between intercanthal distance and maxillary central incisor mesiodistal width.

Another method, used by the authors, is to ask the patient to smile and to extend a line from the inner canthus of the eye via the lateral border of the alar cartilage and extend that onto the upper rim. This may be done with a ruler or by the use of dental floss. This equates, in a high proportion of cases, to the position of the tip of the upper canine teeth.
I -3-5. **Bizygomatic width:**
Scandrett, F. R. et al (1982) showed that, the ratio of bizygomatic width to the maxillary central incisor width is 16:1. *(25)*

Hasanreisoglu et al (2005) stated Proportional relationships between the bizygomatic width and the width of the central incisor, and the intercanine distance and the interalar width in women were observed.*(26)*

I -3-6. **Intercondylar width:**
Keshaved et al designed a study to investigate the relationship between intercondylar width and interdental width of the upper and lower canines and first molar, to aid in denture teeth positioning. The results showed that a strong correlation existed between intercondylar width and interdental measurements. *(27)*

I -3-7. **Intercanine distance:**
To determine the position of the canine teeth. Earlier reference has been made to the use of pre-extraction records. Where these are not present, some authorities advocate using the position of the corners of the mouth, at rest. Another method, used by the authors, is to ask the patient to smile and to extend a line from the inner
canthus of the eye via the lateral border of the alar cartilage and
extend that onto the upper rim. This may be done with a ruler or by
the use of dental floss this equates, in a high proportion of cases, to
the position of the tip of the upper canine teeth.\textsuperscript{(24)}

Keng SB (1995) conducted study on Chinese subjects to
determine if there was any relationship between the interalar
nose width and intercanine distance. The results show that
men have wider noses and slightly greater intercanine distance
compared to women. These dimensions have been shown to
be generally greater than similar studies conducted on
Caucasian subjects. However there was no demonstrable
correlation between interalar width of nose and intercanine
distance.

Dharap A.S. and Tanuseputro H (1997) compared interalar
width and intercanine distance in Malay males and females.
The mean interalar width of the nose in male subjects was
larger than in female subjects. The mean maxillary intercanine
distance in male subjects was $36.7 \pm 2.6$ mm (range 30-42 mm)
and in female subjects $36.2 \pm 2.3$ mm (range 30-42 mm).\textsuperscript{(29)}

H.-J. AHN et al (2002) examined correlation between the width of
the maxillary central incisor (WMCI), the intercanine distance (ICD), the
The ratio of FW/WMCI, FW/ICD, and IAW/ICD was 17.4, 3.7, and 1.0 respectively.

There were significant correlations between WMCI, ICD, FW, and IAW in Pearson's correlation analysis (p<0.01). The FW and IAW could be very reliable guides for the selection of the maxillary anterior artificial teeth.

**1-3-8. Anterior teeth width:**

Lundström (1956) studied the relationship between the mandibular and the maxillary anterior sum and named it the anterior index. A definite relationship between the form of the maxillary arch and the alignment form of the upper anterior teeth.

The combined width of the six maxillary anterior teeth has been slightly less than one third of the bizygomatic breadth of the face. Lavelle (1973) noted fewer gender differences in the primary dentition than in the permanent dentition.

Male teeth generally recognized to be larger than female teeth. In both the primary and permanent dentitions, the upper canines and upper central incisors show the greatest gender differences, whereas the upper lateral incisor and lower central incisor are the most homogenous. Offman et al suggested that multiplying the interalar width by a factor of 1.31 can help in estimating the combined width of the six anterior maxillary teeth.

Richardson and Malhotra (1975) reported no differences in upper and lower anterior tooth size proportions, indicating that there is a constant 77% ratio for both genders.
More recently, other studies have reported significant differences in tooth size between males and females but no evidence of a significant difference in upper to lower anterior tooth size proportion\(^{(36)}\).

Richardson E R (1975) conducted study of mesio distal crown dimension on teeth of 162 Afro American, equally divided between males and females. The teeth of males were larger than those of females for each type of tooth in both arches, although they exhibited the a similar pattern of tooth size. The ratio of the sum of the widths of canines and incisors of the mandibular dentition to those of the maxillary dentition was 77 per cent. Also, the ratio of the mandibular incisors to the maxillary incisors was 71 per cent in both sexes\(^{(37)}\).

Marvin (1992) compared mesiodistal widths of maxillary anterior natural teeth with the widths of the most commonly used artificial denture teeth 40% of the women and 67% of men had anterior teeth that measured 55 mm or wider. In contrast, the mean width of the most widely distributed artificial maxillary denture teeth (Bioblend) is 50.1 mm, with a range of 44 to 58 mm. Of the 42 molds available, only 5 have a width of 55 mm. Natural teeth were found to be larger than artificial teeth. These findings suggest that one reason for the inappropriate selection of comparatively small maxillary denture teeth is the lack of physiologically sized tooth molds.

13

LavereAM et al (1994) compared the mesiodistal widths of the six maxillary anterior teeth with the widths of denture teeth from six different denture tooth manufacturers, Cast of dental students were measured from the distal aspect of...
each canine across the facial surfaces of the six anterior teeth with a flexible plastic millimeter rule Denture teeth from six manufacturers were compared The results indicated that denture teeth are predominantly smaller and natural teeth are larger.

Sellen P. N. et al (1999) investigated the variability in choice of dental staff to select teeth appropriate to the age and sex of the individual with the aid of a series of three-dimensional guides! Four three-dimensional guides were produced for use in the study. Fifty dentists were asked to complete a questionnaire designed to assess the variability in selection of anterior teeth appropriate for the age and sex of an individual. The study concluded that there was little consistency in the selection of the shade, mould and arrangement of anterior teeth appropriate for the age and sex of the individual by qualified dental staff The development and implementation of an aesthetic perform to guide dental staff, dental undergraduates and patients through the process of choosing tooth mould, shade and arrangement based on age and sex may be helpful. Eustaquio Arognio and Maé:elo Souki (2003) investigated the correlation between anterior tooth size discrepancies and Anglers Class I, II, and III malocclusions, as well as their prevalence in the Brazilian population The mesiodistal width of six anterior teeth in 300 patients, who were selected randomly, was assessed The important conclusions of this study were that individuals with Angle Class I and Class III malocclusions showed significantly greater prevalence of tooth size discrepancies than individuals with Class II malocclusions; and mean anterior tooth size discrepancy for Angle Class III subjects was significantly greater than for Class I and Class II subjects.(40)

Hasan Reisoglu Uof uk et al (1995) analyzed the clinical crown dimensions of maxillary anterior teeth to determine whether consistent relationships exist between tooth width and several facial measurements(41). The dimensions of the anterior
teeth, the occurrence of the golden ratio, the difference between the actual and perceived sizes, and the relationship between the anterior teeth and several facial measurements by gender were analyzed using the information obtained from both the computer images and the casts, the dimensions of the central incisors and canines varied by gender. They found that existence of the so-called "golden proportion" for the maxillary anterior teeth as a whole was not found. The maxillary central incisor and canine dimensions of men were greater than those of women in the Turkish population studied.\(^{(42)}\), with the canines the greatest gender variation. Neither a golden proportion nor any other recurrent proportion for all anterior teeth was determined. V Pioneer investigations on tooth sizes were conducted by Lack in 1902\(^{(43)}\) and Neff (in 1949)\(^{(44)}\). These studies were followed by the classic work of Bolton\(^{(45,46)}\), who quantified the maxillary-to-mandibular tooth size relationship and provided the accepted normative data, Bolton selected 55 cases with optimal occlusions and compared the sums of the mesiodistal widths of the maxillary and mandibular teeth, including the first molars. An overall ratio of 91.3 was obtained, with a standard deviation of 1.91. He also calculated that the ratio for the anterior teeth from canine to canine was 77.2, with a standard deviation of 1.65. This means that the maxillary anterior teeth width was larger than the mandibular anterior teeth width.

Gillen et al., in their study to determine the average dimension of the six maxillary anterior teeth in a targeted population, concluded the golden proportion was not found to correlate with any of the calculated ratios. However, Al-Wazan suggested the use of intercanthal distance as a preliminary method for determining the width of the maxillary anterior teeth\(^{(47)}\).

Mohammed AJi-Eiyyad (2006) investigated the existence of the golden proportion, the recurring esthetic dental (RED) proportion, and the golden
percentage between the widths of the maxillary anterior teeth in individuals with natural dentition. The values of the RED proportion were not constant, and the farther the one moves distally from the midline the higher the values. Furthermore, the results revealed the golden percentage was rather constant in terms of relative tooth width. Both the golden proportion and the RED proportion are unsuitable methods to relate the successive widths of the maxillary anterior teeth. However, the golden percentage theory seems to be applicable to relate the successive widths of the maxillary anterior teeth if percentages are adjusted taking into consideration the ethnicity of the population (47).

I -3-9 Hamular distance:

It is a distance between right and left Hamular notches. Hamular notch is the palpable notch formed by the junction of the maxilla and the pterygoid hamulus of sphenoid bone. Petricevic Nikolå et al (2005) (48) conducted study to determine the relationship between the width of frontal maxillary teeth and the width of the hard palate and also to determine the possibility of reconstructing maxillary frontal teeth dimensions, based on hard palate dimensions. Teeth and hard palate dimensions were measured on maxillary casts of fully dentate individuals of Angle class I occlusal relationship. The maxillary central incisor is the widest among the frontal maxillary teeth and canines are wider than second incisors. The width of the maxillary frontal teeth arch, measured with a flexible ruler is 52.05 mm, hamular distance 47.1 mm, distal maxillary width 46.1 mm, sum of the widths of all maxillary frontal teeth 46.04 mm, frontal maxillary width 35.8 mm, and finally, the width between canine cusp tips is 34.19 mm. Based on the results of this study, the sum of all maxillary frontal teeth widths is equivalent to hamular distance dimension, as
well as distal maxillary width, as there were no statistically significant differences between them.

After extraction of all teeth, distal maxillary width is lost, which is not possible to reconstruct because of the individual rate of alveolar bone resorption. On the other hand, hamular distance remains the same dimension during the lifetime, because it is not determined by teeth position but by anatomical structures. Therefore, the hamular distance dimension is a suitable reference for determination of the dimension of the sum of all maxillary frontal teeth widths.\(^{(49)}\)

Byron A Davis (2005) suggested technique using anatomic landmarks for determining the size of the maxillary anterior teeth. The purpose of this study is to determine the accuracy of using 3 anatomical areas of the oral cavity the "right hamular notch-incisive papilla- left hamular notch (HN-IP-HN) measurement" to calculate the width from the distal surface of the canine to the distal surface of the opposite canine.

Measurements were made on stone casts of post-orthodontic patients to determine if the anatomical measurements correlated to the actual tooth measurements. The prosthodontic patient measurements were predicted using the mg-IPH measurement and dividing by three, giving width of the six maxillary anterior teeth.\(^{(50)}\)

1-3-10. Incisive papilla:
It is the elevation of soft tissue covering the foramen of the incisive or nasoplatine canal. It is situated on the median line of the palate, and in dentate it is just back to the central incisors. On edentulous ridge where resorption has occurred, it is located distally, or on the center of the ridge. Harlrod Ortman has shown that most of incisive papillae are pear shaped with their slender ends pointing at the anterior reference point between the maxillary central incisors.

Harper was the first to assume that the incisive papilla is a stable anatomical landmark. The significance of the relationship between the maxillary anterior teeth and the incisive papilla in prosthetic dentistry is that it is one of biometric guides used for the design of complete dentures.

Walt DM and Likeman PR stated that, the incisive papilla and the palatal gingival margin works as landmarks for estimating pre-extraction dimensions of the ridge. After teeth are extracted resorption is most rapid in the labial and buccal bone It can be used as guide to set 10-12mm anterior to it.

A study by F M Varjao (2004) conducted that the incisive papilla was not a very accurate guide for selection of width of anterior teeth but could be used to establish the initial selection of artificial teeth size.

1-3-11. Effect of Bone resorption on anatomical landmarks:
Resorption of residual ridge is a common occurrence after the extraction of teeth. However, the total amount of bone loss and the rate of resorption varied among different patients. In addition, for a given patient at different times, Doglass Atwood discussed the factors influencing the rate of residual ridge resorption and divided them into anatomic, metabolic, functional, and prosthetic factors. Atwood and Coy found that the mean ratio of anterior maxillary residual ridge resorption to anterior mandibular ridge resorption was 1:4. Lam studied the resorption of anterior maxillary tooth sockets and found that the resorption was rapid in the first five months post-extraction and there was no further change between the fifth and twelfth post-extraction months.

Atkinson and Johnson showed no change in the posterior part of the vault of the palate over 3 years of examination to a serial of cephalometric radiographs. Walt and Likeman studied the pattern of alveolar resorption and found that anterior and superior movement of the incisive papilla must be considered when the papilla is used as a guide for anterior teeth positioning. To compensate for this, they suggested the use of the posterior border of the papilla as the reference. They claimed that the anterior portion may be affected or damaged during extraction of maxillary anterior teeth or because of the resorption that takes place following loss of teeth. The average post-extraction change appeared to be slightly less in males than in females. The atrophy of residual ridges affected the shape of the palate and its contour in a given plane widened as the atrophy of the ridges progressed. The area of the palate affected by change extended towards the center of the palate until only a small median area remain unchanged.

1-4. Objectives
1-4-1. General objectives:

To study the usefulness of the hamular notches and incisive papilla as biometric guides for measurement of the artificial maxillary anterior teeth in a sample of Sudanese population.

1-4-2. Specific objectives:

1. To measure the width of:
   - Maxillary anterior teeth (from distal of right canine to the distal of left canine)
   - Hamular distance.
   - HN-IP-IIN distance.

2. To compare the HD to the width of six maxillary anterior teeth.

3. To compare HN-IP-HN distance to the width of six maxillary anterior teeth.

4. To correlate these measurements to certain parameters (age, gender).

5. To compare results with other studies.
Chapter Two

Material and Methods
2. Materials and methods

2-1. Study design:
Cross-sectional descriptive study

2-2. Study population:
Dental students and dental post graduated students at the University of Khartoum.
The participants were both males and females with an age range 18-30 years.

2-3. Including criteria:
1. Normal occlusion with angle class I relationship.
2. Full permanent dentition with both hamular notches and intact incisive papilla.

2-4. Excluding criteria:
1. History of osteoporosis or bone resorption disease.
3. Teeth mobility.
5. Missing teeth.
6. Attrition.
7. Abnormalities in tooth size or shape.
8-History of surgical treatment involving the area of hamular notches or incisive papilla

2-5.Study variables:

Variables in this research were defined as following:
   a- Universal variables: name, age, gender; and index of the study cast.
   b- Dependent variables: hamular distance, hamular notch-incisive papilla distance, and maxillary anterior teeth width.
   c- Independent variables: the intercanine distance

2-6.Sampling:
The sample was representative The method was systematic random selection.
The sample size with help from previous study( 62) found to be 80

2-7.Equipments and materials:

- Perforated Stock trays (maxillary)
- Rubber bowls
- Stainless steel spatula.
- Modeling wax.
- Alginate irreversible hydrocolloid impression material (Zhermack. Povigo-Italy)
- Dental stone.
- Plaster of paris.
- Wax knives.
- Dental mirrors and Periodontal probes
2. Vibrating table.
2. Flat long table.
2. Electronic digital caliper (Narex-Czechoslovakia).
2. White papers
2. Blue pens.
2. Indelible pencil.
2. A flexible millimeter ruler.

2-8. Impression taking:

Maxillary perforated stock trays were modified using modeling wax in the labial, buccal flanges, palatal area and posterior end of the trays. According to manufacture instructions, a measured amount of alginate was mixed with measured amount of water in a rubber bowl using stainless steel spatula.

The impression material had been loaded on to the stock tray and seated in the patient mouth while the patient was seated in an upright position on the dental chair, with the head being parallel to the floor.

The impression was removed after setting had been completed and rinsed with water to remove excess of saliva. The impression then was poured using dental stone. The cast was removed after setting and a base was made using plaster of paris.

2-9. Measurements:

Marking both right and left hamular notches
Marking the incisive papilla

The base of the cast had been flat and parallel to the occlusal plane to standardize the measurement and reduce the measurement bias that can take place if the base was inclined or with irregular surface. The cast was seated with its flat base on a flat table.
Using an electronic caliper, the distance from the center of the buccal side of the right hamular notch to the center of the buccal side of left hamular notch was measured. Also the distance between the right hamular notch and incisive papilla, and between the left hamular notch and incisive papilla from the center of the buccal side of the hamular notch to the center of the posterior border of the incisive papilla were measured using electronic caliper gauge.

The width of the six anterior maxillary teeth were measured from distal of left canine to the distal of right canine at the widest area using flexible millimeter ruler. Inter canine distance was measured from the tip of the right canine to the tip of the left canine using electronic caliper gauge. Then the width of each one of the anterior teeth was measured individually from its widest area using a flexible millimeter ruler. All measurement had been made and recorded by one operator.

2-10. Data collection:

Data are collected by:

1. Data collection form

2. Diagnostic casts

2-11. Data processing:

1. Categorizing the data

2. Coding

25
3- Summarizing the data in master sheet.

2-12. **Data analysis:**

- Descriptive data analysis.
- All statistical values were calculated (mean, standard deviation, mode, etc) for several readings and the frequency by cross tabulation for each variable was compared.
- T-test was used to assess the statistical significance.

All this had been achieved by the statistical package for social sciences (SPSS) version 15.
Chapter Three

Results
3. Results

3-1. Gender distribution

The sample consisted of 43 females (53.8%) and 37 males (46.2%)

<table>
<thead>
<tr>
<th>Gender</th>
<th>Frequency</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>37</td>
<td>46.2</td>
</tr>
<tr>
<td>Female</td>
<td>43</td>
<td>53.8</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>

Gender Distribution
(Table 1)
3-2. Age Distribution

The age range was 21 to 30 years, with most frequent age was 23 years, and the least frequent ages were 27 and 28 years.

<table>
<thead>
<tr>
<th>Age</th>
<th>Frequency</th>
<th>Valid percentage %</th>
<th>Cumulative percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>13</td>
<td>16.3</td>
<td>16.3</td>
</tr>
<tr>
<td>23</td>
<td>36</td>
<td>45.0</td>
<td>61.3</td>
</tr>
<tr>
<td>24</td>
<td>11</td>
<td>13.8</td>
<td>75.0</td>
</tr>
<tr>
<td>25</td>
<td>11</td>
<td>13.8</td>
<td>88.8</td>
</tr>
<tr>
<td>26</td>
<td>3</td>
<td>3.81</td>
<td>92.5</td>
</tr>
<tr>
<td>27</td>
<td>1</td>
<td>3.13</td>
<td>93.8</td>
</tr>
<tr>
<td>28</td>
<td>1</td>
<td>2.5</td>
<td>95.0</td>
</tr>
<tr>
<td>29</td>
<td>2</td>
<td>2.5</td>
<td>97.5</td>
</tr>
<tr>
<td>30</td>
<td>2</td>
<td>2.5</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Age distribution

(table2)
3-3. Measurement of HN-1P-HN/3
(The predicted values)

Measurements carried out in 80 dentate maxillary casts revealed that the distance (hamular notch- incisive papilla- hamular notch) divided by three had a mean predicted value of 55.064 mm, with a minimum value of 46.7 mm, maximum value of 61.3 mm and standard deviation of 3.245.

<table>
<thead>
<tr>
<th>Predicted value</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>80</td>
</tr>
<tr>
<td>Range</td>
<td>14.6</td>
</tr>
<tr>
<td>Minimum</td>
<td>46.70</td>
</tr>
<tr>
<td>Maximum</td>
<td>61.30</td>
</tr>
<tr>
<td>Mean</td>
<td>55.064</td>
</tr>
<tr>
<td>Std .Errr</td>
<td>0.3674</td>
</tr>
<tr>
<td>Std .D</td>
<td>3.245</td>
</tr>
</tbody>
</table>

Measurements of HN-IP-HN/3
(Table 3)
3-4. Measurements of maxillary anterior teeth

(The actual values)

The width of maxillary anterior teeth from the distal end of the right canine to that of the left canine revealed the mean of the actual value to be 55.079 mm with a minimum value 47.30 mm, a maximum value 60.80 mm and standard deviation of 3.104.

<table>
<thead>
<tr>
<th>No</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std Error</th>
<th>Std D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual value</td>
<td>80</td>
<td>13.50</td>
<td>47.30</td>
<td>60.80</td>
<td>55.086</td>
<td>0.3514</td>
</tr>
</tbody>
</table>

Measurements of Maxillary anterior teeth width

(Table 4)
3-5. Predicted and Actual value correlations

The P-value was found to be 0.00, which means that the test was significant and there were correlations between the predicted values and the actual values (the predicted value approximately equal to the actual value).

<table>
<thead>
<tr>
<th>Pair Predicted and Actual value</th>
<th>No</th>
<th>Correlation</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>80</td>
<td>0.973</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Paired Samples Correlations

(table5)
The differences between the actual and the predicted values had a P-value of 0.740, which wasn't significant. This means that there was no difference or there was a little difference between the actual and the predicted values.

### Paired Differences

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std Deviation</th>
<th>Std Error Mean</th>
<th>Confidence Interval of the Difference</th>
<th>Std Deviation</th>
<th>Std Error Mean</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair Predicted value - Actual value</td>
<td>0.02855</td>
<td>0.74670</td>
<td>0.08565</td>
<td>0.19918</td>
<td>0.333</td>
<td>75</td>
<td>0.740</td>
</tr>
</tbody>
</table>

**Predicted and actual values differences**

(Table 6)
3-7. Group statistics

The mean of the predicted value among females was 52.909 mm, with a standard deviation of 2.328 (the predicted value — 52.909 ± 2.328 mm).

The mean among males was 57.71 mm with a standard deviation of 2.016 (the predicted value 57.71 ± 2.016 mm).

The mean of the actual value among females was 52.860 mm with a standard deviation of 2.117 (the actual value 52.860 ± 2.117 mm).

The mean of actual value among males was 57.667 with a standard deviation of 1.775 (the actual value 57.667 ± 1.775 mm).

<table>
<thead>
<tr>
<th>Sex Distribution</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD Male</td>
<td>37</td>
<td>57.124</td>
<td>3.3804</td>
<td>0.556</td>
</tr>
<tr>
<td>Female</td>
<td>43</td>
<td>52.288</td>
<td>2.8126</td>
<td>0.429</td>
</tr>
<tr>
<td>ICD Male</td>
<td>37</td>
<td>37.446</td>
<td>1.5835</td>
<td>0.2603</td>
</tr>
<tr>
<td>Female</td>
<td>43</td>
<td>35.347</td>
<td>1.8765</td>
<td>0.2862</td>
</tr>
<tr>
<td>Predicted value</td>
<td>Male</td>
<td>37</td>
<td>57.711</td>
<td>2.0158</td>
</tr>
<tr>
<td>Female</td>
<td>43</td>
<td>52.909</td>
<td>2.32766</td>
<td>0.3549</td>
</tr>
<tr>
<td>Actual value</td>
<td>Male</td>
<td>37</td>
<td>57.667</td>
<td>1.7749</td>
</tr>
<tr>
<td>Female</td>
<td>43</td>
<td>52.860</td>
<td>2.1169</td>
<td>0.3266</td>
</tr>
</tbody>
</table>

Group Statistics
(table7)
Chapter Four

Discussion
Conclusions
Recommendations
4-1. Discussion

Selection of artificial teeth is very important in removable prosthodontics because of its esthetic value. Decision on the selection of artificial teeth has to be based on the proper shape and exact dimensions. Central position of the frontal teeth, especially maxillary frontal teeth, has the strongest influence on esthetics.

The mesio-distal width is more important than the inciso-gingival length and the former measurement has attracted much debate. Research has focused on measurements of extracted teeth, racial and gender differences, together with facial landmarks such as the bizygomatic width. House and Loop postulated that the mesio-distal measurement of the central incisor was 1/16 of the bizygomatic width. Other studies have also sought to assign geometric values for the mesiodistal width of the centrals, e.g., 1/16 of the face height or the width of the iris.

Latta et al. (1991) suggested the use of more than one facial measurement to estimate the combined width of the maxillary anterior teeth. Measurements of the combined width of the maxillary anterior teeth were reported by several investigators.

This study found that the width of maxillary anterior teeth among females was 52.909 mm, and larger among males (57.667 mm). Scadrett et al. (1982) found the width of the six maxillary anterior teeth to be 53.61 mm, similar to McArthur (1985) whose results were 54.6 mm among males and 52.3 mm among females. Nikola Petr évié et al found the width of maxillary frontal teeth arch (measured with a flexible ruler) was 52.05 mm. All these results were approximately in agreement with the results of this study.
Shilligburg et al (1972) found that the width of maxillary anterior teeth was 45.8 mm\(^{(60)}\), Aleem et al (1997) found it was 43.0 mm\(^{(65)}\). Hoffman et al (1986) result was 44.85 mm\(^{(66)}\). These results are lower than this study result, which might be due to race or environmental variations or to variation in the methods of measurements or in the sampling. Mafgkeri\$a Santoro et al\(^{(67)}\) found that male teeth width measurements were slightly larger and showed a higher variability than the female measurements but follow the same distribution pattern. This supports this study results which revealed higher measurements in males than in females.

Byron A Davis used the I-IN-IP-HN line divided by three to give a predicted value and the width of maxillary six anterior teeth as an actual value, and found that the correlation between the two values was 97% which illustrated strong correlation between the predicted measurement and the patients actual teeth size, these results are in agreement with the results of this study.

Even Petriéevié, Nikola et al showed that the sum of all maxillary frontal teeth widths is equivalent to hamular distance dimension. They mentioned that after extraction of all teeth, distal maxillary width is lost, which is not possible to reconstruct because of the individual rate of alveolar bone resorption. They pointed out that, on the other hand, the hamular distance remains the same dimension during the lifetime, because it is not determined by teeth position but by anatomical structures. Therefore, the hamular distance dimension is a suitable reference for determination of the dimension of the sum of all maxillary frontal teeth widths\(^{(48)}\).

The process of measuring HN-IP-I-IN on the cast in the absence of the patient is a simple enough technique taking in to consideration that a high correlation exists between measurements taken from the cast and the actual measurements from patients with ideal tooth positioning.

The problems that may arise might be due to measurements taken from inaccurate casts which can have several causes.
Some of the problems that may be due to faulty clinical or laboratory procedures leading to measurements taken from inaccurate casts. Even though the methods used in this study relatively easily applied, other studies using facial anatomical landmarks such as interalar width, bizygomatic width, interpupillary line etc., are more accessible and may be better and quicker methods of choice.
4-2 Conclusion

At the absence of pre-extraction records, post extraction records such as anatomical landmarks, can be used to select a suitable sizes of the artificial teeth that are in harmony with the patient's face, gender and personality. This study showed a strong correlation between the width of maxillary anterior teeth and (the hamular notch to hamular notch to incisive papilla distances) divided by three. There was little or no difference between the two values, which led to the conclusion that the hamular notch to incisive papilla distances can be used in selection of the width of artificial teeth in edentulous patients.
4-3 Recommendations

- Although this study revealed that the hamular notches and incisive papilla are of value in determining the width of maxillary anterior teeth, further studies of this method using larger and more varied sample size, could be of benefit.

- Computerized analysis of these anatomical landmarks from casts might help avoid errors of obtaining manual measurements
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Appendices
Data collection form

Name index ............................................
Age ..................................................TN..........

Gender:

Male       Female

Measurements:

1- Hamular distance (mm):

<table>
<thead>
<tr>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2- Right hamular notch-incisive papilla distance (mm).

<table>
<thead>
<tr>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

3- Left hamular notch-incisive papilla distance

<table>
<thead>
<tr>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>
4-Anterior teeth width (mm):

<table>
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<tr>
<th>Measurements</th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
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<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

Mean

6-The total width of six maxillary anterior teeth:

<table>
<thead>
<tr>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>Mean</th>
</tr>
</thead>
</table>
Measurement of hamular distance with digital caliper

Photograph 1
HN-IP-HN triangle on the cast

Photograph  2
Standardization of cast base using dental surveyor

Photograph 3