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Anatomical measurements of orthodontic and edentulous casts to determine the width of the maxillary anterior teeth

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Anatomical Measurements of Orthodontic and Edentulous Casts to Determine the Width of the Maxillary Anterior Teeth

By

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ABSTRACT

Anatomical Measurements of Orthodontic and Edentulous Casts to Determine the Width of the Maxillary Anterior Teeth

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Without dental records of patients' teeth prior to extractions, the selection of maxillary anterior teeth for the edentulous patient is mostly subjective. Several techniques using anatomic landmarks have been suggested for determining the size of 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 of the canine to the distal of the opposite canine. 24 post-orthodontic dentulous patients and 19 edentulous patients were evaluated for maxillary anterior tooth size using the hamular notch-incisive papilla measurements. Measurements were made

on stone casts of post-orthodontic patients to determine if the anatomical measurements correlated to the actual tooth measurements. The edentulous patient measurements were used to select denture teeth from either the Ivoclar Blue Line tooth guide or the Trubyte tooth guide and evaluated for acceptability by the patient and two prosthodontists. The orthodontic patient measurements were measured to compare the correlation of the predicted value of the patients' teeth and their actual measurements. The percent correlation of the orthodontic patients' predicted and actual measurements was 97%. The predicted values for the edentulous patients were used to select the maxillary anterior teeth and were considered acceptable by 18 of the 19 patients. The high correlation between actual tooth size and the (HN-IP-HN) measurement for the orthodontic patients' in this study indicates that this (HN-IP-HN) measurement maybe helpful in the selection of maxillary anterior denture teeth.

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Introduction

Background

Unless dental records prior to extractions are available the principles that are followed for the selection of anterior teeth of edentulous patients have been somewhat arbitrary, or based on proportions of the face to select teeth. Methods have been devised to restore facial harmony as well as the dentition to proper proportions utilizing either averages or by arbitrarily selecting the size of the maxillary anterior teeth. The practitioner then selects the rest of the teeth based on the size of the maxillary anterior teeth. Once the maxillary anterior teeth have been chosen, the rest of the teeth can be selected and the denture teeth can be placed on their bases. The fact that the selection of anterior teeth forms the basis by which we can select all teeth will therefore effect the entire occlusion.

Although natural teeth are proportionally sized in most individuals, approximately 5% of the population have some disproportion among the size of individual teeth.[5] Proportions have been used for centuries to define beauty and according to Leonardo da Vinci, facial proportions are closer to ideal when facial proportions are in a 1/3, 1/3, 1/3 ratio.[3] The same is true with size of the maxillary anterior teeth. The golden proportion ratio has a

fixed 1.618 proportions of a rectangle of esthetic appeal.[3] In 1905, Berry noted that the upper centrals were 1/16 the width of the face.[4] House proposed the central incisor should be approximately the width of the bizygomatic distance divided by 16.[4] Fisher and Frush coined a term "dentogenics," which used sex, personality, and patient age to apply to the anterior tooth size.

Orthodontists have long time realized the importance of tooth size and space for teeth to occupy. If there is not enough space to adequately allow the teeth to occupy then some alternative solution must be sought. Since malaligned and crowded teeth generally result from lack of space, analysis is generally limited to space limitations within the dental arches.[5] This study hopes to be of value to keep the orthodontists' where by taking into account the measurement of the patients casts of the patient to be treated, they will be able to accurately point the width of the anterior teeth, leading to more esthetic results, in conjunction with space analysis. Ultimately, indicating where the teeth need to be moved especially if teeth are missing in the maxillary anterior region. This study will examine the anatomical relationship obtained from dental casts of edentulous patients and dentate patients. Measurements of the distance from the left hamular-notch to the incisive-papilla to the right hamular notch (HN-IP-HN) were added together

and divided by three, the resulting measurement is predicted to give the distance from the distal surface of the right canine to the distal surface of the left canine a method proposed by Dr. Dan Hancock of the Martinsburg Veterans Administrative Hospital, Martinsburg, WV. The dentate patients chosen were post-orthodontic patients that have acceptable esthetic and phonetic results. The hamular notch-incisive papilla-hamular notch measurements were on the maxillary post treatment cast. Each patient's actual measurement will be compared with the predicted measurement from the HN-IP-HN measurements. The measurements will be compared to determine if the measurements relate and are clinically acceptable to use on both dentate patients and edentulous patients. Nineteen dentate patients and twenty-four edentulous patients of record will be used in the study.

Statement of the problem

Esthetics, phonetics and anterior teeth position are all significant factors for the selection of anterior denture teeth, which ultimately affect the entire tooth setup for a denture patient. There is however, no accurate objective method to definitively select the anterior teeth for edentulous patients. Orthodontic methods for figuring tooth size are based on prediction tables, which are convenient, but not always accurate. Also, Bolton analysis can not be used if there are teeth missing. This study

attempts to determine if anatomical measurements could provide an accurate method for selection of maxillary anterior teeth.

Significance of the Study

Edentulous dental patients who have no prior records of tooth size would benefit esthetically and functionally if there were a predictable method to select the correct anterior teeth from anatomical landmarks. Partially edentulous patients would benefit also if a simple measurement could be used to determine the size of their teeth leading to optimal esthetics. Orthodontists would benefit if these measurements accurately predict the tooth size and help determine if there is going to be a tooth size discrepancy**.** Laboratory technicians would be able to accurately pick teeth without actually seeing the patient in the chair. Computers would also be used to scan and measure casts to give images of patients with the teeth in the proper size relationship.

Hypothesis

The “hamular notch-incisive papilla-hamular notch” measurements’ divided by three on edentulous casts and dentate casts can accurately predict tooth size from maxillary right cuspid to maxillary left cuspid.

Definition of Terms

1. **Edentulism-** without teeth; lacking teeth [1]
2. **Dentate-** with teeth, or possessing some teeth, not without teeth
3. **Osteoporosis-** a medical condition characterized by a decrease in bone mass with diminished density and concurrent enlargement of bone spaces, which produce porosity and fragility [1]
4. **Golden Proportion Rule-** the relative proportionality of Maxillary anterior teeth typically visible in a smile, originally formulated as one of Euclid’s elements, it has been relied upon through the ages as a geometric basis for proportionality in the beauty of art and nature, based on a formula when viewed directly from the front, a smile is considered to be esthetically pleasing if each tooth in that smile starting from the midline is

approximately 60% of the size of the tooth mesial to it. The exact proportion of the smaller to the larger is .618 [6]

5. **Residual Ridge Resorption-** a term used for the diminishing quantity and quality of the residual ridge after teeth are removed. [5]
6. **Tooth size discrepancy-** teeth that are too large or small for the arch that they lie within. Data from tooth size analysis becomes available for the first time when the succedaneous teeth erupt. Bolton Analysis can be used to determine the tooth size discrepancies. [5]
7. **Bolton Analysis-** named after developer is carried out by measuring the mesiodistal width of each permanent tooth, and then a standard table is used to compare the summed widths of the maxillary to the mandibular anterior teeth and the total width of all upper to lower teeth, (excluding second and third molars). [5]
8. **Pterygomaxillary notch (hamular notch) -** the palpable notch formed by the junction of the maxilla and the pterygoid hamulus of the sphenoid bone. [4]

9. **Incisive papilla-** the elevation of soft tissue covering the foramen of the incisive or nasopalantine canal. [4]
10. **Anterior tooth arrangements-** the position of the anterior teeth for esthetics in a dentate patient, likewise for the edentulous patient the anterior tooth setup is the position of the maxillary anterior teeth, which determines the mandibular setup, this setup also can effect facial and lip contours as well as, phonetics and esthetics.
11. **Anterior tooth form-** the outline form as viewed in any selected plane and other contours of an anterior tooth [4]
12. **Intercanthal Distance-** the distance between the eyes
13. **Esthetics-** 1: branch of philosophy dealing with beauty 2: In dentistry, the philosophy that deals with beauty and the beautiful, especially with respect to the appearance of a dental restoration, as achieved through its' form and/or color. Those subjective and objective elements and principles underlying the beauty and attractiveness of an object, design or principle [4]
14. **Phonetics-** the production of speech sounds, which can be used as a guide to the position of the teeth or where the teeth should

be positioned; Generally phonetics is evaluated with a variety of speech sounds.

15. **Denture**- an artificial substitute for missing natural teeth and adjacent tissues [4]
16. **Occlusal Plane**- 1: the average plane established by the incisal and occlusal surfaces of the teeth. Generally, it is not a plane but represents the planar mean of the curvature of these surfaces 2: the surface of wax occlusion rims contoured to guide in the arrangement of denture teeth 3: a flat metallic plate used in arranging an instrument similar to a facebow that indexes to the external to the external auditory meatus and registers the relation of the maxillary dental arch to the external auditory meatus and a horizontal reference plane. This instrument is used to transfer the maxillary cast to the articulator. The earbow provides an average anatomic dimension between the external auditory meatus and the horizontal axis of mandibular denture teeth-comp to CURVE OF OCCLUSION.

Assumptions

- Patients selected do not have osteoporosis or bone resorption diseases
- Orthodontic movement of dentate patents, have taken into account for tooth size discrepancies.
- Bone resorption is not the same for all patients
- Patients who have not had a history of trauma or cancer treatment deforming the oral cavity.
- All patients used for this study had bilaterally symmetrical maxilla

Limitations

- Age of patients
- Trauma to teeth or endodontics prior to extractions
- Skill of surgeon removing teeth and were osteoextomies (bone removal) performed.
- Gender differences
- Ethnic backgrounds
- Health of patient
- Were ridge augmentations performed to rebuild denture patient's residual ridges?

Chapter II

Literature Review

Historical Review

Tooth selection is a critical factor leading to an acceptable esthetic result for patients. Clinicians are faced with this challenge on the edentulous patient and/or the demanding patient seeking esthetically pleasing teeth. All of these factors relate to the size of the tooth and how it relates in proportion to the surrounding oral structures.

Earl Pound devised what he calls the five factors that influence appearance and function. He terms the "five harmonies" that relate to appearance and function as the following: Size, Form, Color, tooth arrangement and framing of the teeth or the development of tissue-tissue harmony.[7] Historical methods date back to 1901 where dentists were taught to select teeth based on the temperamental theory of tooth selection in which each patient was classified as either nervous, sanguine, bilious or lymphatic, and teeth were chosen that had a different design for the tooth in that class.[8] A few years later, Leon Williams was credited for the geometric theory of

tooth selection. The theory states there is a definite relation between the outline form of the face and the outline form of the upper central incisor.[8] In 1920, Nelson did some interesting research of natural dentitions on arch form and alignment in which he discovered there was a "definite relationship" between the form of the maxillary arch and the alignment form of the upper anterior teeth.[9]

Dental companies have tried to simplify tooth selection by supplying the clinician with tools to select teeth and their size. The Trubyte Tooth Indicator (Dentsply, York, PA) predicts the width of the maxillary central incisor by estimating it to be one-sixteenth of the width of the face measured between the zygoma.[10] This measurement was devised by M.M House stating the width of the central incisor is one-sixteenth of the width of the face measured between the zygoma.[11] The combined width of the six maxillary incisors has been predicted to be slightly less than on third of the bizygomatic breadth of the face.[10] The Trubyte tooth indicator is another devised which is placed on the face of the patient, allowing the nose to come through the central triangle. The pupils are centered in the eye-hole and an indicator with a central line is aligned with the patients' midline. The clinician then slides the indicator bar until it touches the patients' face, which gives a reading in millimeters of the width of the central incisor.

There is a bottom bar that is raised until it touches the patient's chin, which gives the length of the central incisor.

The positions of the artificial teeth are influenced by four main factors (1) the function of the surrounding structures, (2) the cellular structure of the basal seat, (3) the mechanical aspects, (4) and anatomical landmarks.[16]

Anatomical landmarks can be used as a guide for clinicians when placing teeth. They effect anterior-posterior relations of the anterior teeth an important factor in esthetics since the teeth give support to the lips, cheeks, and other tissues.[12] Many clinicians do not recommend that artificial teeth positioned in their original place, since the residual ridge are considered a primary control for tooth position.[12] The fact that teeth are not placed in their original position presents the clinician with an extremely difficult job of creating acceptable esthetics. In 1967, Pietrokski and Massler demonstrated that when viewed from the occlusal aspect, the crest of the residual ridge shifts lingually in the maxillae and in the mandible with resorption. The ridge center becomes more palatal, and therefore smaller and different in shape than it was prior to the removal of the teeth.[12] These resorption patterns often lead to malrelationships in the dental arches. Boucher stated in 1960 stated that, "The only correct position of a tooth is the one in which it was placed by nature."[15] This statement is made with a plea that avoids

vertical and horizontal overlap. Keeping esthetics at a premium we follow anatomic landmarks to aid in relocating the original position of teeth. The maxillary casts can be used as a guide to set the central incisor, which is set 10-12 mm anterior to the incisive papilla.[24] Six maxillary anterior teeth occupy the space between the canine eminences, sometimes indicated on casts.

There is also a basic relationship between the facial type, arch form and arrangement of teeth. Even after the lower arch resorbs, the major direction of resorption is downward toward the body of the mandible, and generally the lower arch preserves the outline form.[14]

Natural esthetics and phonetics can be achieved if the artificial teeth are placed as nearly as possible in their original position anterior-posteriorly and in length. Phonetics, or speaking sounds, which can modify the flow of air to produce speech include, (1) the labial sounds, (2) the labiodental sounds, (3) the dental and alveolar (anterior) sounds, (4) the palatal sounds, and (5) the velar (posterior) sounds, Phonetics can also affect the position of the teeth.[13] Esposito says, “the lower lip is the best guide for the vertical position of the anterior teeth, and the maxillary centrals should be set so that they lightly touch the lower lip when the patient articulates the F and V sounds.[18]

Arch forms can be classified as (1) square, (2) tapering, (3) ovoid, and (4) square tapering.[16] Tooth arrangement in the different arch forms can be quite different. The square arch usually has the centrals set in a straight line giving prominence to the canines.[12] Overall, the appearance visually straight from canine to canine, and the teeth tend to be more straight up and down. The tapering arch the centrals are located a greater distance forward than the canines.[12] Characteristically, the centrals are rotated inward and their long axis inward at the distal, and the arrangement does not appear as wide as the other arch forms.[12] Square tapering arches have a square placement of the central incisors and a tapering effect of the laterals and canine.[12] The ovoid arch exhibits definitive curvature with the centrals anterior to the other teeth.[12] As a result, the ovoid arch displays a fullness of labial surface from the canine to the canine.[12]

The harmony of tooth form and face form is a primary consideration in esthetics. One of the first recognized contributions of basic esthetics was Dr. J. Leon Williams, who discovered the harmonious relationships between the outline form of the maxillary centrals and the outline form of the face, as he observed in nature.[19] These findings were further supported by Dr. M.M. House as well as others.[14] Nature tends to group

face forms into four basic classifications: 1) Square 2) Tapering 3) Square Tapering and 4) ovoid-and these are subject to many individual modifications.[14] A recommended method for determining facial outline is the Trubyte Tooth Indicator (Dentsply, York PA). This is useful because the form of the tooth selected is generally the inverse of the face form.[14]

Denture teeth selection size and form can be obtained form 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.

The selection of artificial teeth based on the use of photographic images prior to edentulism has been discussed and denture wearers are often requested to provide photographs as a guide to selecting artificial teeth.[20, 21, 22, 23] Undergraduate dental students and dental staffs were compared in a study by Sellen, Jagger, and Harrison concluded there was little consistency in selecting shade, mould and arrangement of anterior teeth appropriate for the age and sex of patients by both groups.[2]

Chapter III

Materials and Methods

Nineteen subjects requiring maxillary dentures were chosen from the West Virginia School of Dentistry patient population for inclusion in this study. All subjects were screened by an oral exam and complete medical and dental history. The main criteria for selection were verification of an intact maxillary arch demonstrating clear presentation of the incisive papilla and hamular notches. All hamular notch verifications were confirmed on all patients using a periodontal probe to verify the notch exists and is transferable to stone dental casts. If the incisive papilla or hamular notches could not be located due to third molars, anatomical variances, or removal of the hamular notch during removal of a tooth then the subject was excluded from the study.

All subjects requiring maxillary denture fabrication had preliminary impressions made of the edentulous maxillary arch with irreversible hydrocolloid using pre-packaged irreversible hydrocolloid [Jeltrate-Regular Set, L.D. Caulk, Division of Dentsply International, Milford, DE] with a water powder ratio of 21 grams to 55ml of room temperature tap water. The alginate was hand mixed in a rubber bowl and loaded into syringe and

edentulous stock tray. The alginate placed into the syringe was used to inject into the vestibule and the hard palate prior to seating of the metal stock tray. After placement of the tray into the mouth the patient was asked to close their lips together in an attempt to border mold the alginate. The alginate was allowed to set for three and a half minutes to insure an adequate final set. The alginate impression was then removed, rinsed and evaluated for adequate borders and disinfected for ten minutes in a moist headrest cover. All impressions with inadequate border replication were discarded. The impression was removed from the headrest cover after ten minutes and rinsed thoroughly and cast were made using pre-packaged Type 4 die stone (Silky Rock; Whipmix Corp. Louisville, KY) mixed for fifteen seconds by hand, vacuum mixed for twenty seconds, poured into the impression and allowed to set for forty-five minutes. Once the cast were retrieved, a line was drawn on the casts two millimeters short of the intended border of the complete denture. The casts were evaluated for undercuts. Any undercut was blocked out with hard baseplate wax and the incisive papilla areas had wax added to insure no pressure on the incisive papilla during impression procedures. The stone casts then were painted with model releasing agent [Dentsply International, Milford, DE] and one layer of Triad denture base material regular pink unfibered [Dentsply International Milford, DE] was

adapted closely to the model and excess trimmed with a sharp scalpel blade. Air barrier coating [Densply International, Milford, DE] was then applied with a brush to the outside of the triad denture base material and placed into a curing oven for six minutes. After curing, the tray was removed from the model and the inside of the tray was painted with air barrier coating and placed back into the curing oven for two minutes. Afterwards, the tray was removed from the curing oven rinsed and brushed with soap and water. The periphery of the tray was trimmed using a laboratory carbide bur and placed back on the casts until the length of the border matched the line drawn on the casts.

The subject receiving the maxillary denture returned at the second appointment for final impressions. The first step in the final impression appointment was border molding the vestibular areas of the patient in a functional type manner in which the periphery was captured in a functional state. The border molding was done with Type 1 Impression Compound [Kerr U.S.A., Romulus, MI] at 123 degrees. Once the border molding was complete the tray was painted with a polyvinyl adhesive and the tray filled with medium body polyvinyl impression material [Dents ply Caulk, Milford, DE]. The tray was fully seated and all necessary movements of the patient are done to insure the impression was captured in a functional state. The

impression was then allowed to stay in the mouth for six minutes prior to removal. Upon removal of the tray, it was thoroughly examined for completeness of detail for all anatomically necessary structures. The hamular notches were then palpated using a periodontal probe and marked interiorly with a STA stick and the final impression placed back into the patients' mouth and the patient asked to hold their nose a blow so that the soft palate would press downward insuring the transfer of the STA stick onto the impression.

The final impressions were boxed, beaded and poured in Type 4 die stone (Silky Rock; Whipmix Corp. Louisville, KY) and allowed to set for forty five minutes before separation of the casts. The casts were used for drawing a line in blue pencil connecting the incisive papilla to the left hamular notch across the soft palate to the right hamular notch back to the incisive papilla (HN-IP-HN). The connection of lines makes a triangle which, using a clear millimeter ruler was used to measure the three lines and add all three measurements in millimeters and dividing by three. The shortest distance between any two points was measured with the millimeter ruler three times to ensure accuracy. No attempt was made to measure the actual linear distance following the tissue and palatal contours (see Figure 1). The number obtained, according to the hypothesis, should be the width

in millimeters from the distal of number six to the distal of number eleven. This measurement was used in the selection of the maxillary anterior teeth. The denture teeth were selected using two different teeth selection guides, Ivoclar Blue line Tooth (Ivoclar, Amherst, NY) selection guide and the Trubyte IPN (Dentsply, York, PA) maxillary anterior tooth selection guide. The mould guide dimension of the six maxillary anteriors, which most closely matched the HN-IP-HN determined distance was selected. In selecting the mould other factors commonly used in tooth selection were also used, including face shape, form and size.

At the clinical try-in appointment the anterior set-up was evaluated by two prosthodontists and the patient for acceptability. All tooth set-ups had to be accepted as esthetic and satisfying the parameters above. If either the patient, or prosthodontist were unhappy with the mould selected a new mould was chosen, again attempting to select a dimension as close to the HN-IP-HN dimension as possible.

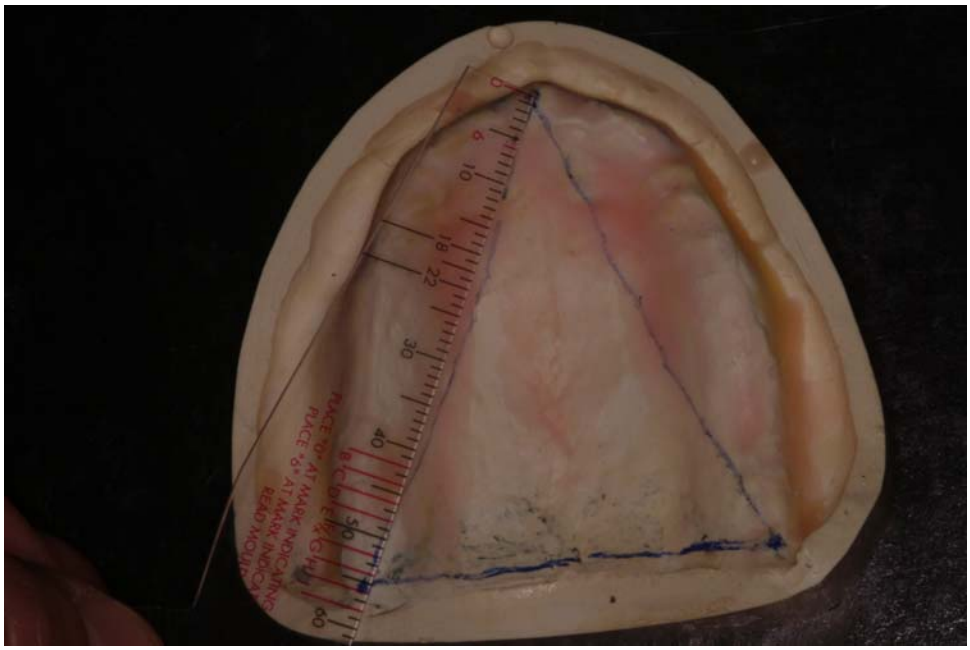


Figure 1.
Measurement of HN-IP-HN distance on an edentulous cast.

Twenty-four patients of record who had currently received orthodontic therapy by full time orthodontic faculty at the West Virginia University School of Dentistry were selected. These patient's post orthodontic casts were evaluated for (1) esthetics (2) arch symmetry (3) occlusion (4) the presence of at least fourteen maxillary teeth, and (5) that all anatomical markers relevant for this study were present.

Of primary importance was that two prosthodontists concurred that the orthodontic result and the patient's tooth size and position were esthetic and in harmony. All post-orthodontic casts were measured in the same manner as described above for the edentulous casts to determine the HN-IP-

HN measurement and divided by three. Using the flexible millimeter ruler the distance from distal facial of tooth number six was measured to the distal facial of tooth number eleven and recorded as the “Actual” distance (see Figure 2).

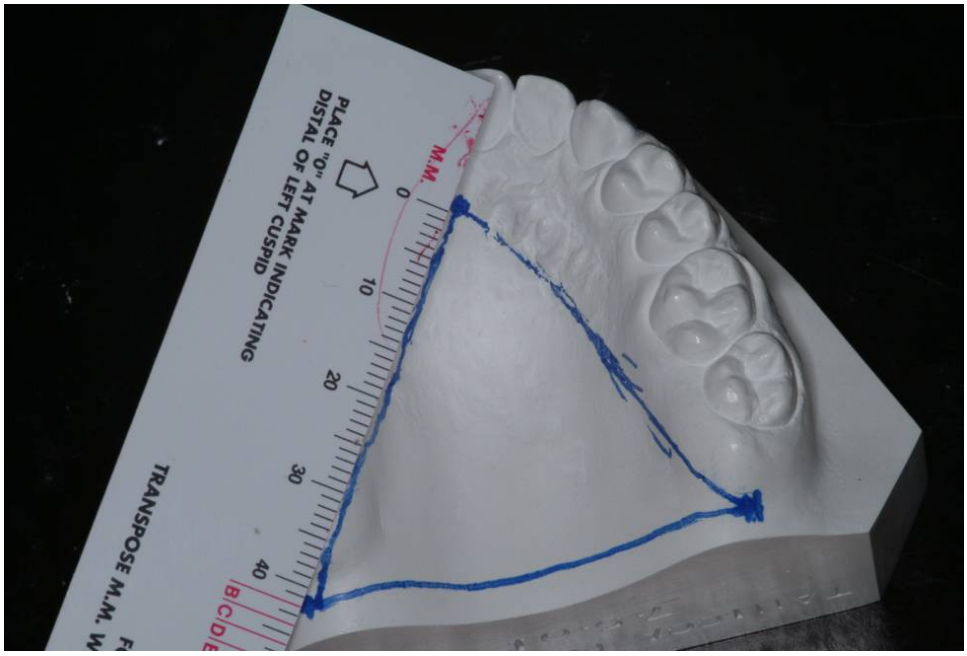


Figure 2.
Measurement of HN-IP-HN distance on an orthodontic dentate cast.

A statistical analysis was run to compare the predicted values for the orthodontic casts to the actual values for these casts. The mean difference, standard deviation and percent correlation between these figures for each patient were calculated. Since teeth were selected for the edentulous patients using the HN-IP-HN dimension, no correlation between this measurement and the selected measurement was attempted.

Chapter 4

Results

The comparison of all twenty-four orthodontic patients measured using the HN-IP-HN line and divided by three gave a predicted value as seen in Table 1 under predicted values. The actual teeth were measured on a curve from the distal of teeth #six to #eleven. These measurements can be seen in Table 1 under actual measurements. The mean standard deviation from the predicted value and the actual value was 0.3 mm (bottom of table 1). The percent correlation between the predicted values and the actual measurements was 97% (Figure 3). The Scatter Graph in Figure 4 illustrates this strong correlation between the predicted measurement and the patients actual tooth size. How close each individual's actual tooth size was to the predicted size can be easily visualized in the bar graph in Figure 5.

The prosthodontic patient measurements were predicted using the HN-IP-HN measurement and dividing by three, giving a predicted width of the six maxillary anterior denture teeth to be selected. The predicted values for the edentulous patients can be seen in Table 2. The actual teeth used were selected from one of two denture teeth selection guides. The maxillary anterior teeth selected were those that most closely matched the predicted width in addition to determining the most appropriate mould for the patient,

other factors commonly used in denture tooth selection were considered, i.e., face shape, form and size. At the clinical try-in appointment, the anterior set up was evaluated by two prosthodontists and the patient for acceptability and esthetics. All set ups were accepted as esthetic and satisfying the parameters mentioned above. The selected mould guide measurements can be seen in Table 2 under “Selected”. The mean difference from the teeth used and the predicted values can be seen in the difference column in Table 2. All selected mould widths were within 0.7 mm of the predicted value except for one patient for whom the selected width was 1.7 mm from that predicted. It was the determination of the two prosthodontists and the patient that the moulds selected using the hypothetical measurements provided a satisfactory result. Only one patient of the nineteen denture patients requested a slightly larger mould.

Table 1. The orthodontic patient predicted measurements with the actual measurements and the difference between the two measurements

patient	Predicted	Actual	Dif
1	53.3	54	0.7
2	51.3	52	0.7
3	54.3	55	0.7
4	55.3	55	0.3
5	52.3	52	0.3
6	51.0	52	1.0
7	53.3	54	0.7
8	52.0	52	0.0
9	50.3	50	0.3
10	51.7	51	0.7
11	50.3	51	0.7
12	51.0	50	1.0
13	51.0	51	0.0
14	47.0	46	1.0
15	52.7	53	0.3
16	50.0	49	1.0
17	52.7	53	0.3
18	52.0	52	0.0
19	55.3	55	0.3
20	49.7	49	0.7
21	50.7	50	0.7
22	50.0	50	0.0
23	51.3	51	0.3
24	51.3	51	0.3
		STDEV	0.3

Table 2. Totally edentulous patient predicted measurements, tooth mould measurement selected and the difference (mm)

	Predicted	Selected	dif
Pros	49.0	49	0.0
Pros	51.7	52	0.3
Pros	50.0	50	0.0
Pros	50.0	50	0.0
Pros	55.0	55	0.0
Pros	55.0	54.5	0.5
Pros	56.7	56.5	0.2
Pros	45.0	45.5	0.5
Pros	48.0	48	0.0
Pros	52.7	52	0.7
Pros	51.0	51	0.0
Pros	54.7	54	0.7
Pros	53.3	53	0.3
Pros	53.3	53	0.3
Pros	53.3	55	1.7
Pros	52.7	53	0.3
Pros	50.0	50	0.0
Pros	51.7	51	0.7
Pros	50.0	50	0.0

Figure 3.
Correlations of Orthodontic patients

	IP-HN-IP Measurements/3	Actual Measurement
IP-HN-IP Measurements/3	1.0000	0.9668
Actual Measurement	0.9668	1.0000

Figure 4
Scatterplot Matrix of Orthodontic patients

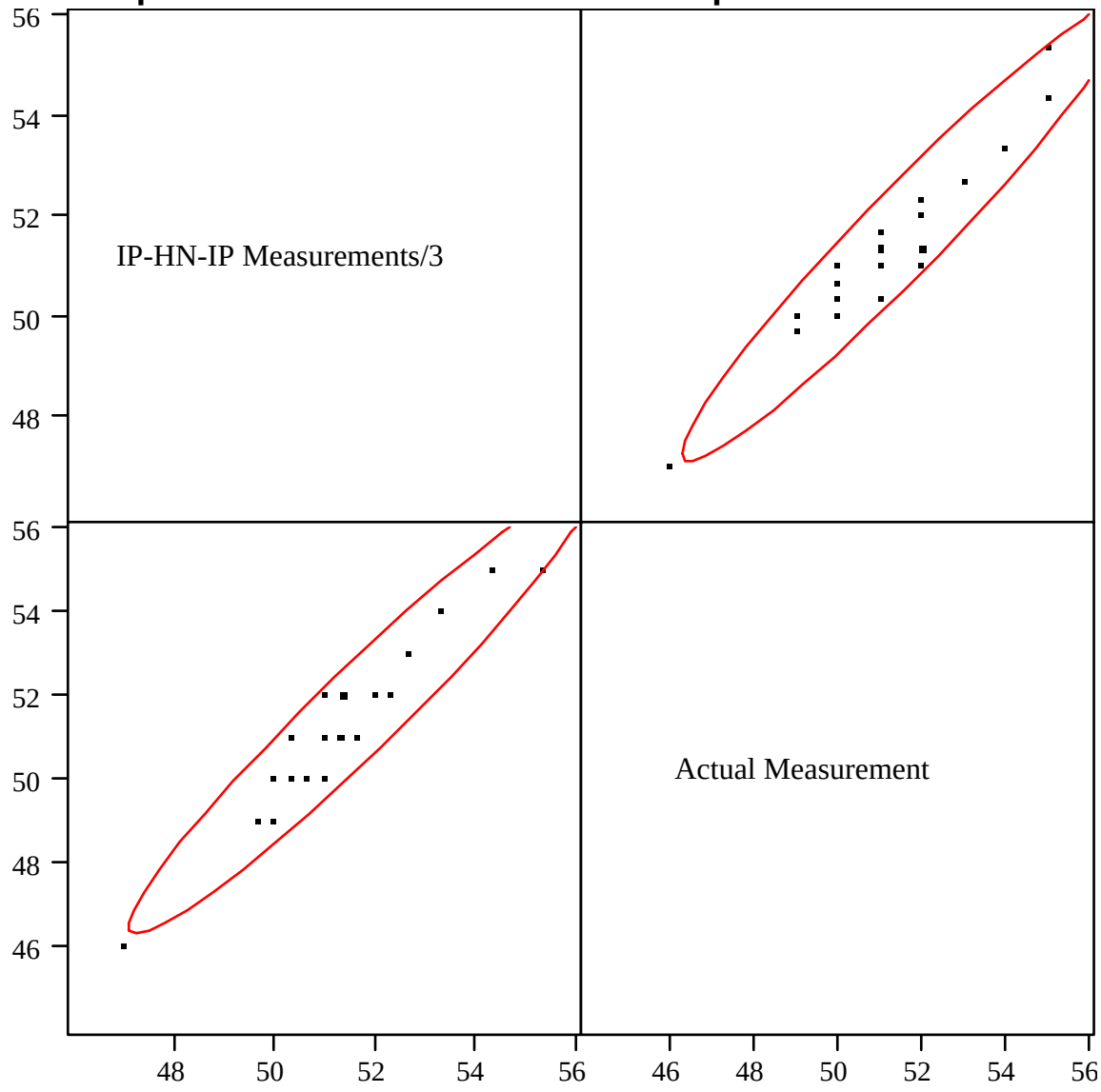
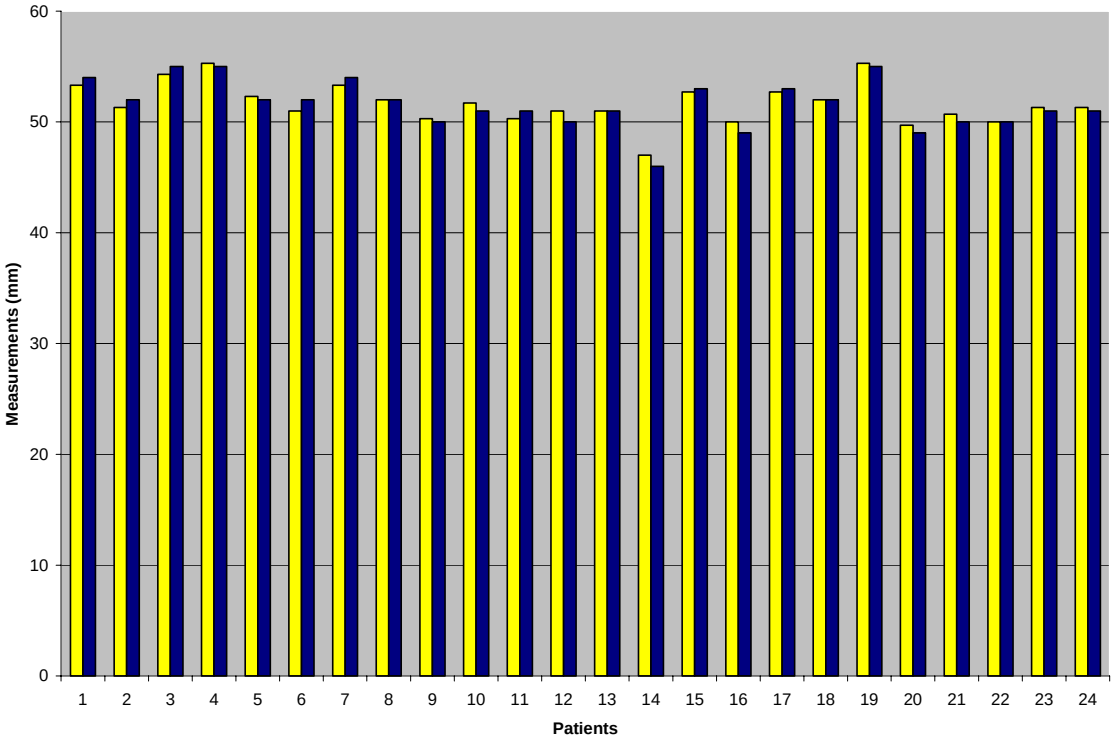


Figure 5. Bar Graph Actual vs. Predicted



Chapter 5

DISCUSSION & CONCLUSIONS

Since the time of Leonardo da Vinci, dentists have sought a more objective method for determination of tooth size.[3] Although, many methods have been utilized with satisfactory results, a more scientific or objective method would greatly assist both dentists and laboratory technicians. The simple process of measuring HP-IP-HP offers such an objective technique. The high correlation found in this study between this measurement and the actual measurement in patients with ideal tooth positioning after orthodontics strongly supports the use of this technique in both the practice of Orthodontics and Prosthodontics.

The second part of this study involving total edentulous patients and tooth selection strongly indicate the feasibility of using this technique for tooth selection in edentulous patients. Except for patient number 15, all selected tooth moulds were within 0.7 mm of the predicted distance. Patient number 15 was the only patient who desired a different mould than the one selected, asking for a slightly larger tooth size. A mould with a cuspid to cuspid distance of 1.7 mm greater than the predicted size was selected and satisfied the patient. The two attending prosthodontists who viewed both

selected moulds felt both were satisfactory, the first selected only being 0.3 mm larger than the predicted size.

Prosthodontists who treat a large number of edentulous patients realize that there are a number of these patients who cannot be satisfied esthetically, functionally or both. For these patients, even a more objective selection criterion will be unsuccessful. However, for the majority of edentulous patients, a simple objective technique involving anatomical measurements would provide at least a starting point for tooth selection. This is most valuable for patients who request denture fabrication and have no previous denture or dental records to utilize for this process. Boucher and others [24] have recommended measuring from the distal of the cuspid eminences to establish the size of teeth needed to fill this space. This figure can, however, vary greatly depending on the amount of ridge resorption and arch form the patient may have. Often the cuspid eminence is lost when the cuspids are extracted or after excessive ridge resorption. From this current study it appears that measuring the HN-IP-HN may be a much more consistent and accurate way to arrive at this measurement for tooth selection.

The Trubyte Tooth Indicator provides a prediction of the size of the maxillary central incisors. Additional studies comparing the use of the HN-

IP-HN measurement and the Trubyte Tooth Indicator are needed to compare the feasibility of each technique.

The high correlation between actual tooth size and the HN-IP-HN measurement for orthodontic patients in this study indicate that this measurement might be very helpful in space analysis and determination of final tooth position. Further studies are indicated to determine if these measurements would be more accurate and provide better results than the currently used standard tables of tooth size.

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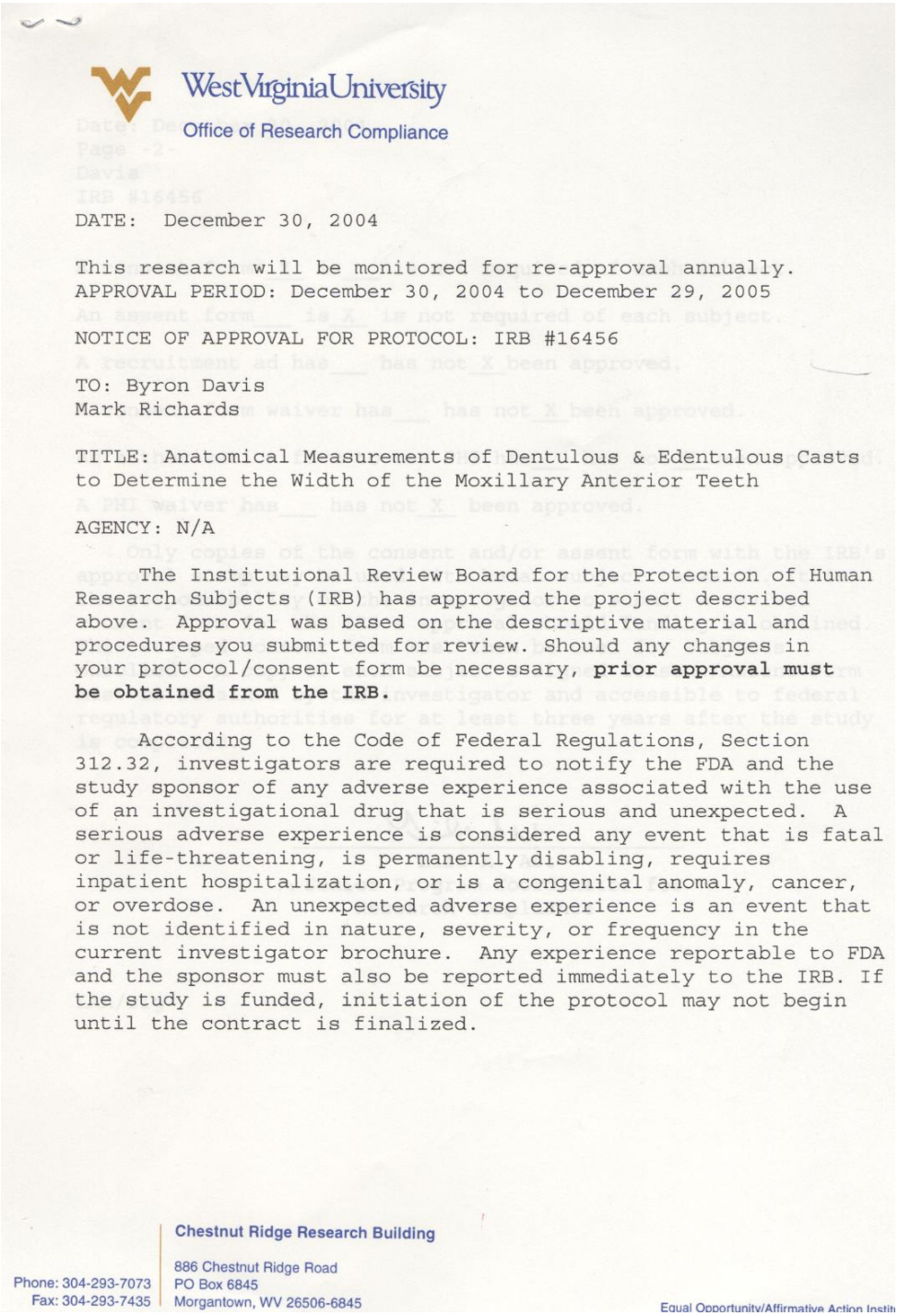
APPENDIX A

Institutional Review Board Approval Form



West Virginia University
Office of Research Compliance

DATE: December 30, 2004

This research will be monitored for re-approval annually.
APPROVAL PERIOD: December 30, 2004 to December 29, 2005

NOTICE OF APPROVAL FOR PROTOCOL: IRB #16456

TO: Byron Davis
Mark Richards

TITLE: Anatomical Measurements of Dentulous & Edentulous Casts to Determine the Width of the Moxillary Anterior Teeth

AGENCY: N/A

The Institutional Review Board for the Protection of Human Research Subjects (IRB) has approved the project described above. Approval was based on the descriptive material and procedures you submitted for review. Should any changes in your protocol/consent form be necessary, **prior approval must be obtained from the IRB.**

According to the Code of Federal Regulations, Section 312.32, investigators are required to notify the FDA and the study sponsor of any adverse experience associated with the use of an investigational drug that is serious and unexpected. A serious adverse experience is considered any event that is fatal or life-threatening, is permanently disabling, requires inpatient hospitalization, or is a congenital anomaly, cancer, or overdose. An unexpected adverse experience is an event that is not identified in nature, severity, or frequency in the current investigator brochure. Any experience reportable to FDA and the sponsor must also be reported immediately to the IRB. If the study is funded, initiation of the protocol may not begin until the contract is finalized.

Chestnut Ridge Research Building
886 Chestnut Ridge Road
PO Box 6845
Morgantown, WV 26506-6845

Phone: 304-293-7073
Fax: 304-293-7435

Equal Opportunity/Affirmative Action Insti

A consent form* X is ___ is not required of each subject.

An assent form ___ is X is not required of each subject.

A recruitment ad has ___ has not X been approved.

A consent form waiver has ___ has not X been approved.

An authorization form to use PHI has ___ has not X been approved.

A PHI waiver has ___ has not X been approved.

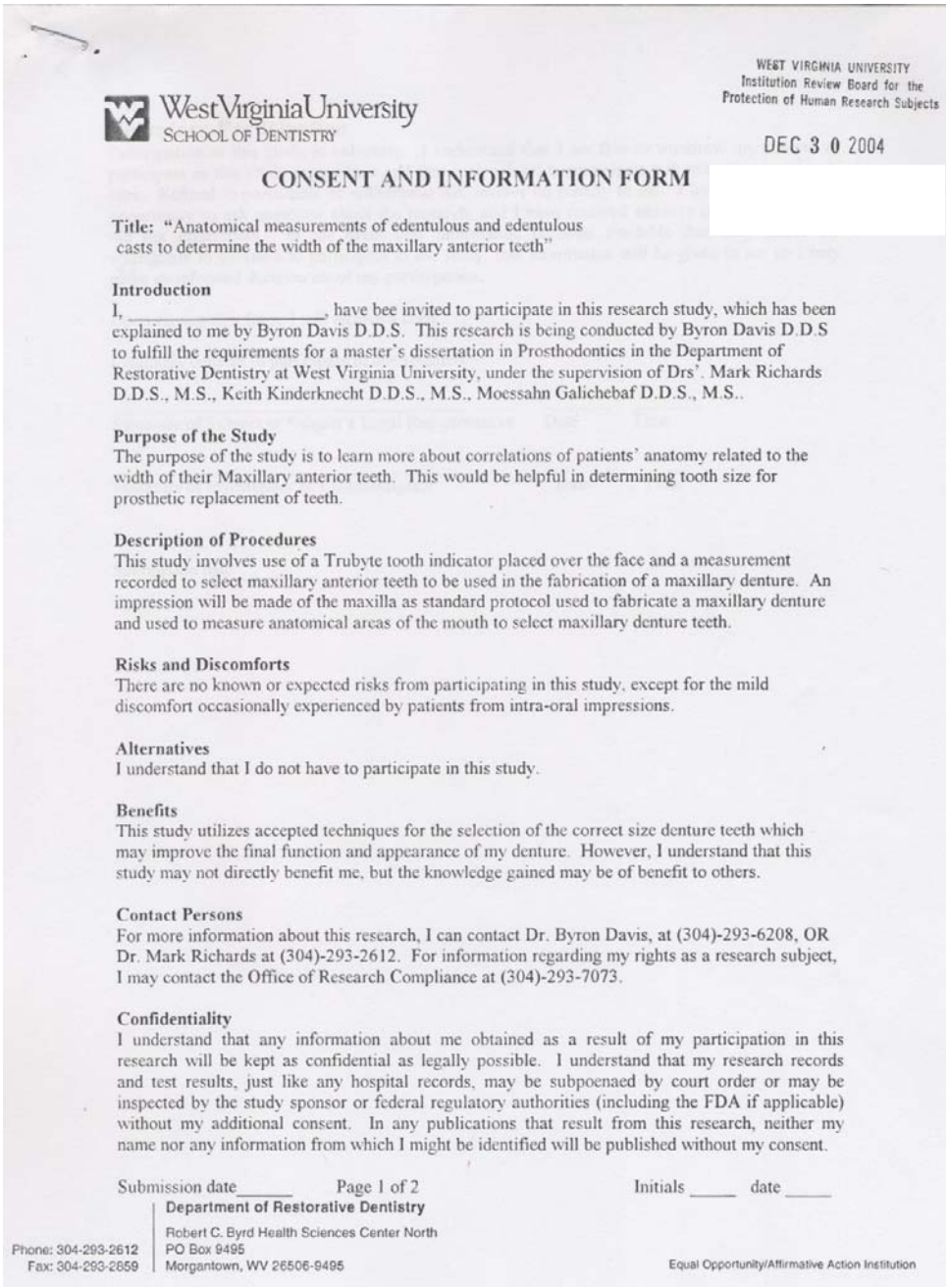
Only copies of the consent and/or assent form with the IRB's approval stamp may be used with human subject research. It is the responsibility of the investigator to submit a revised consent form for the IRB's approval should funding be obtained. This stamped consent form must then be used for subjects enrolled. A copy of each subject's signed Consent/Assent Form must be retained by the investigator and accessible to federal regulatory authorities for at least three years after the study is completed.

Lilo A. Ast
Senior Program Coordinator for
Research Compliance

LAA/clg

APPENDIX B

Consent Form



WEST VIRGINIA UNIVERSITY
Institution Review Board for the
Protection of Human Research Subjects

DEC 3 0 2004

WestVirginiaUniversity
SCHOOL OF DENTISTRY

CONSENT AND INFORMATION FORM

Title: "Anatomical measurements of edentulous and edentulous casts to determine the width of the maxillary anterior teeth"

Introduction
I, _____, have bee invited to participate in this research study, which has been explained to me by Byron Davis D.D.S. This research is being conducted by Byron Davis D.D.S to fulfill the requirements for a master's dissertation in Prosthodontics in the Department of Restorative Dentistry at West Virginia University, under the supervision of Drs'. Mark Richards D.D.S., M.S., Keith Kinderknecht D.D.S., M.S., Moessahn Galichebaf D.D.S., M.S..

Purpose of the Study
The purpose of the study is to learn more about correlations of patients' anatomy related to the width of their Maxillary anterior teeth. This would be helpful in determining tooth size for prosthetic replacement of teeth.

Description of Procedures
This study involves use of a Trubyte tooth indicator placed over the face and a measurement recorded to select maxillary anterior teeth to be used in the fabrication of a maxillary denture. An impression will be made of the maxilla as standard protocol used to fabricate a maxillary denture and used to measure anatomical areas of the mouth to select maxillary denture teeth.

Risks and Discomforts
There are no known or expected risks from participating in this study, except for the mild discomfort occasionally experienced by patients from intra-oral impressions.

Alternatives
I understand that I do not have to participate in this study.

Benefits
This study utilizes accepted techniques for the selection of the correct size denture teeth which may improve the final function and appearance of my denture. However, I understand that this study may not directly benefit me, but the knowledge gained may be of benefit to others.

Contact Persons
For more information about this research, I can contact Dr. Byron Davis, at (304)-293-6208, OR Dr. Mark Richards at (304)-293-2612. For information regarding my rights as a research subject, I may contact the Office of Research Compliance at (304)-293-7073.

Confidentiality
I understand that any information about me obtained as a result of my participation in this research will be kept as confidential as legally possible. I understand that my research records and test results, just like any hospital records, may be subpoenaed by court order or may be inspected by the study sponsor or federal regulatory authorities (including the FDA if applicable) without my additional consent. In any publications that result from this research, neither my name nor any information from which I might be identified will be published without my consent.

Submission date_____ Page 1 of 2 Initials _____ date _____

Department of Restorative Dentistry
Robert C. Byrd Health Sciences Center North
PO Box 9495
Morgantown, WV 26506-9495
Phone: 304-293-2612
Fax: 304-293-2659

Voluntary Participation

Participation in this study is voluntary. I understand that I am free to withdraw my consent to participate in this study at any time and that such refusal to participate will not affect my future care. Refusal to participate or withdrawal will involve no penalty to me. I have been given the opportunity to ask questions about the research, and I have received answers concerning areas I did not understand. In the event new information becomes available that may affect my willingness to continue to participate in the study, this information will be given to me so I may make an informed decision about my participation.

Upon signing this form, I will receive a copy.

I willingly consent to participate in this research.

_____ _____ _____

Signature of Subject or Subject's Legal Representative Date Time

_____ _____ _____

Signature of Investigator or Co-Investigator Date Time

Submission date_____

CURRICULUM VITAE

BIOGRAPHICAL DATA

Name: **Byron Allen Davis**

Date of Birth: **August 22, 1977**

Place of Birth: **Parkersburg, WV**

Education

Marshall University		**1997**
West Virginia University	**D.D.S.**	**2002**
West Virginia University	**M.S., Certificate in Prosthodontics**	**2005**