APPROVAL SHEET

Title of Thesis: The Golden Proportion In Denture Teeth

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Master of Science, 2011

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ABSTRACT

Title: The Golden Proportion in Denture Teeth

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Purpose: The purpose of this study was to investigate the proportion of anterior to posterior denture teeth manufactured by two major manufacturers (Ivoclar and DENTSPLY) and determine if they follow the suggested Golden Proportion.

Materials and Methods: Sixty-six maxillary denture teeth from two different companies (Ivoclar and DENTSPLY) were set using a standardized technique. The most popular small, medium and large moulds were tested from each company (n=11). 30-degree posterior teeth were used. All the samples were photographed and the images were analyzed using computer software to measure the visible widths of the maxillary anterior and posterior teeth. The existence of the golden proportion was investigated.

Results: The golden proportion was not found to exist between maxillary anterior and posterior denture teeth.

Conclusion: The measured width of anterior and posterior denture teeth did not equal the calculated width based of the Golden Proportion in either Ivoclar or DENTSPLY denture teeth.

The Golden Proportion In Denture Teeth

By

Elias M Rivera, DDS

Dissertation submitted to the Faculty of the Graduate School of the

University of Maryland, Baltimore in partial fulfillment

of the requirements for the degree of

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Dedication

I would like to dedicate this Master of Science Thesis to my family, for their unconditional support throughout my education, career, and life.

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Table of Contents

List of Tables

List of Figures

1. INTRODUCTION

1.1 Esthetics

In 1750, the philosophy of "esthetics" was created to designate the science of sensuous values, which appreciated beauty. This is in contrast to the science of logic, which valued truth. In later years, the term evolved to relate the fine arts as the theory of beauty (Furnas, 1936).

Esthetics includes the appreciation and response to the beauty in art and nature. Esthetics has been given many definitions in dentistry, but according to Young: "It is apparent that beauty, harmony, naturalness, and individuality are major qualities" of esthetics. The dentist must visualize esthetics in relation to the patient and then translate that visualization into an acceptable esthetic result. The success of these efforts depends upon artistic ability, powers of observation, and experience (Young, 1956).

In1986, Cunningham attempted to mathematically assess physical beauty. In a study rating the attractiveness of 50 females, more than half of whom were finalists in an international beauty pageant, he concluded that: 1. The width of an eye should be three tenths that of the face as measured at eye level. 2. The chin length should be one-fifth

the total height of the face. 3. The vertical distance from the center of the eye to the bottom of the eyebrow should be one-tenth the height of total the face. 4. The height of the visible eyeball should be one-fourteenth the total height of the face. 5. The total area of the nose should be less than five percent of the total area of the face. 6. The ideal mouth is 50 percent of the width of the face measured at mouth level (Cunningham, 1986).

Cunningham's findings suggest that large eyes, a small nose and chin, high cheekbones, and a large balanced smile are considered to be the physical attributes of a beautiful female face. Likewise, the handsome male face will have these same attributes but with the modifications of a relatively small nose, bushy eyebrows, and prominent chin. These mathematical calculations reveal a harmony of proportion between features. When any one of these features is out of harmony, we tend to perceive that person as deviating from normal. If the features are brought into harmony and symmetry, the person is then viewed as attractive (Cunningham, 1986).

In 1974, Lombardi defined "dental esthetics" through visual perception. Visual perception is divided into two categories: composition and proportion. Composition was the relationships existing between objects made visible by the contrasts in color, line, and texture; he said that the prime requisite of composition was unity, which was the ordering of the parts to give the individual total effect of the whole. There are two types of unity; static and dynamic. Age, sex and personality are extremely important

because they provide a type of subjective unity necessary to give the total undivided effect of a specific life, of a specific sex, at a specific place in time. The objective of the dentist should be to provide dynamic unity, not static unity.

Proportion was defined as balance, symmetry, parallel lines, curves and how they work together. Lombardi pointed out that detailed esthetic judgments can only be made by viewing patients from the front, in conversation, facial expressions, and smiling. The dentist's view from above and behind the patient is skewed, differing substantially from the "true" perception of the patient in a mirror or by other people during normal social activities (Lombardi, 1973; Lombardi, 1974).

Levine (1995) said the esthetics of the face encompass three views: the facial, the dentofacial and the dental views and to ensure esthetic success, dental practitioners must respond to patient inquiries with a “codiagnostic” approach, allowing the clear identification of esthetic problems and the visualization of solutions. In Levine’s article, the paramount element of the facial view is the midline, which acts as the centering vertical line, organized around this midline and perpendicular to it are horizontal reference lines: the hair line, the ophriac line (eyebrow), the interpupilary line, the interalar line, and the commissure line. The dentofacial view involved the teeth and the surrounding structures of the gingiva and the lips. This is described as a coincidence of curves created by the contact points, incisal edges, and the lower lip. It

is important to evaluate the amount of tooth exposure in smiling and at rest (Levine, 1995).

The dental view related to the teeth and the gingiva and is defined by contour, texture, color, and proportion. Contour could be further broken down into its important elements of axial inclination, line angles (i.e., contour ridges), heights of contour, incisal edge contour and position, and gingival contour. This structured approach involved a therapeutic mind set, whereby a common esthetic language and a communication triangle is formed between the patient, the dentist, and the technician (Levine, 1995).

Valo (1995) stated that the term esthetic refers to an understanding of beauty. He stated that the challenge of developing a pleasing smile is an artistic venture, which implies the study of how the visual arts have explored the nature of beauty and the elements of artistic composition. This will enhance our artistic abilities in cosmetic dentistry. Therefore, he said, that it is required to have an understanding of beauty and the artistic tools available to develop a beautiful smile (Valo, 1995).

Sarver and Ackerman emphasized the interplay between the dental structures and their surrounding soft tissue envelope. They proposed three requirements for the assessment of dentofacial esthetics: (1) 3-dimensional evaluation of the face and smile both dynamically, from the clinical exam, and statically, from the photographic survey of

the patient. (2) A measure of lip to tooth relationship at rest and during facial animation with emphasis on the clinical appearance over the cephalometric measurement. (3) An analysis of the current interaction between the dento skeleton and the facial soft tissues in the frontal and lateral planes. Furthermore, they stress that this process can be enhanced through the use of computer simulation and patient participation (Sarver & Ackerman, 2000).

1.2 Denture Esthetics

Denture esthetics has been defined as the cosmetic effect produced by a dental prosthesis, which affects the desirable beauty, attractiveness, character, and dignity of the individual (GPT 8) (2005).

As one of the first dental esthetic concepts, the theory of correspondence and harmony was described by White in 1872. White said: “This law of correlation-harmony--running through nature, attracts and enchants us by an infinite diversity of manifestations; the failure to recognize its demands by art is correspondingly abhorrent to our sensibilities”. White described this theory as a correspondence between tooth form and color in harmony with age and gender. This was later accepted as the temperamental theory of denture construction (White, 1872).

In 1978, Tautin stated that denture esthetics is more than tooth selection. Good denture esthetics would compensate for lost alveolar bone, correctly positioning anterior teeth for lip support, and re-establishing the correct vertical dimension of occlusion, in combination with proper tooth selection. Three objectives for denture esthetics were established: (1) Compensate for alveolar bone loss at the impression phase of treatment, (2) Contour occlusion rims properly for adequate support of the musculature and to facilitate placement of teeth and (3) Establish or re-establish the correct vertical dimension of occlusion to restore physiologic muscle length and eliminate a prognathic appearance. Tautin noticed that proper contour and normal physiologic movement of the muscles enhances esthetics of a denture, whereas improper support can severely detract from it. He concluded that denture construction requires the integration of the different steps in order to produce an optimal result (Tautin, 1978).

Vig and Brundo in 1978, conducted a survey on subjects randomly selected from the UCLA dental clinic. No subjects were included with atypical conditions such as traumatized lips, mobile or extruded anterior teeth, extreme abrasion, or prosthetic anterior tooth replacements. The purpose was to correlate measurements of upper lip type, sex, race, and age of dentulous patients with the amount of exposure of the maxillary and mandibular anterior teeth with the lips gently parted. The results showed variability regarding: (1) Gender: The average amount of maxillary incisor exposure in men was 1.91 mm. In women, almost twice as much maxillary tooth exposure was

noted, 3.40 mm; (2) Race: the races broadly classified as Caucasian, Black, and Asian. In this category nothing of particular significance was found; (3) Lip lengths: people with short upper lips display more maxillary tooth structure than people with long upper lips; (4) Lip types: the lip types were categorized as normal, long, short, heavy, or protrusive. The heavy lip was in essence a long lip. The protrusive type had more exposure of both maxillary and mandibular teeth, and (5) Age: the pattern was that of a gradual decrease in exposure of the maxillary central incisor with age. The most interesting finding was the gradual reduction in the amount of maxillary central incisor exposure with an increase in age, accompanied by a gradual increase in the mandibular tooth exposure (Vig and Brundo, 1978).

Tjan et al. in 1984, evaluated 454 full-face photographs of randomly selected dental and dental hygiene students with smiles displaying teeth, the subjects were 207 males and 247 females from 20 to 30 years age. Each subject was compared, analyzed and evaluated by visual judgment rather than by mathematical measurements. The conclusion of this study showed that an average smile exhibits approximately the full length of the maxillary anterior teeth, the incisal curve of the teeth parallel to the inner curvature of the lower lip, the incisal curve of the maxillary anterior teeth touching slightly or missing slightly the lower lip, and displaying the six upper anterior teeth and premolars (Tjan et al., 1984).

1.3 Characteristics Of Anterior Teeth

White in 1884, introduced the temperamental theory of anterior tooth selection. It was based on the idea that a subject's temperament or bodily characteristics matched the size, proportion, arrangement, and color of the teeth. Some interesting ideas highlighted by this early esthetic concept included (1) the relationship between age, gender, and appearance, (2) the proper tooth-to-face-size proportion, and (3) color harmony between the face and the teeth (White, 1884).

Hall (1886), was the first to describe what he believed was a correlation between general formation of the head and face, color of the eyes and hair, and the facial outlines of the teeth; "Typal Form Concept." In his series of articles titled "temperaments in mechanical dentistry", he described three temperaments that are linked to the three typical conformations of the natural teeth: The vital to the round-faced, the mental to the semi-round, the motive to the flat-faced varieties. He described the human body as made up of three grand classes or systems of organs, each of which as a system has its special function in the general economy, and denominates them, the Motive, or Mechanical; the Vital or Nutritive; the Mental or Nervous systems, and each of these temperaments is determined by the predominance of the class of organs from which it takes its name, all being necessarily present in every human being. The first, or Motive, is marked by a superior development of the osseous and muscular systems; the second, by the vital organs, giving tone to the

organization; while in the third, or Mental, the brain and nervous system exerts the controlling power (Hall, 1885; 1886a; b).

Berry studied the face of each operative patient, who had a complete natural dentition, and compared the outline form of the upper central incisors with the outline form of the face in repose. In the most pleasing faces, the outline forms were alike. The tooth forms were inverted face forms. In proportion, as the tooth forms were not like the face forms, the facial appearance was not pleasing when the teeth were exposed. This knowledge guided his artificial tooth-form selection. Berry introduced the "Berry Biometric Ratio Method." He concluded that the maxillary central incisor had a definite ratio to the size of the face. The tooth was designated as being one sixteenth that of the width of the face and one twentieth of its length (Berry, 1905).

Williams in 1914, rejected the temperamental theory as a fallacy. He proposed a geometric theory and concluded that the shape of the face and the shape of the central incisor are related. After his anthropologic research, he stated that 3 basic forms of teeth existed: square, tapering, and ovoid. These were termed the typical forms of teeth. He discovered the nature's law of the face-form-tooth-form harmony, following this, he invented a system of artificial anterior teeth that covered a wide range of forms and was easily adaptable to individual requirements. He also invented the Face-Form Guide and a technique that made esthetic tooth-form selection easy, rapid, and more

successful for dentists generally than form selection had ever been. The system succeeded due to its practicality and manufacturer support (Williams, 1914).

Nelson in 1925, was the first to assert that tooth arrangement was the major determinant of tooth-mold appearance and more important to the overall esthetics. From his study of natural dentitions, he concluded that there was a definite relationship between the form of the maxillary arch and the alignment of the upper anterior teeth. He also stated that we could get a cue from the arch form as to what the alignment of the natural teeth had been. Nelson classified arch forms and alignment forms as square, tapering, and ovoid and gave the characteristics of each. He contended that the alignment form was a much more important factor than the outline form of the teeth (Nelson AA, 1925).

French in 1951, grouped denture patients from the standpoint of denture esthetics into two main groups: (1) those of whom we had pre-extraction records and (2) those of whom they did not have pre-extraction records. In both cases, it is advisable to postpone the selection of teeth until the casts are mounted on the instrument in centric relation at the corrected vertical dimension (French, 1951).

Frush and Fisher in 1955, developed a concept of "Dentogenesis" dictated by sex, and personality and age (SPA) as factors for tooth selection. By 1959, five additional articles followed describing the methods of applying the SPA factors (Frush JP and

Fisher RD, 1956b; a; 1957; 1958; 1959). They claimed that if these three qualities were correctly interpreted, the dentures would have a natural appearance. They referred that apart from the esthetic value in complete dentures, maxillary anterior teeth are equally important for correct speech, lip support and provide harmonious incisal guidance. The teeth should be pleasing and aligned relative to the esthetic importance and yield natural appearance and individuality, blend with the mouth and face in order to contribute to dentofacial beauty (Frush JP and Fisher RD, 1955; 1959).

Lombard (1973), introduced the Visual perception in dentures concept to minimize the confusion variables and eliminate the personal perception in the need for learning specific formulas for achieving an esthetic result. Lombard said that the perceptual principles could free dentists from the confusion existing in the field of dental esthetics and enable them to confidently approach the task of enhancing their patients' appearance (Lombardi, 1973).

Mavroskoufis and Ritchie in 1980, compared the outline forms of both maxillary central incisor teeth with the “actual” and “apparent” face-forms in 70 subjects, to determine whether a close similarity of face-forms and tooth forms exists, which would support the “law of harmony” as described [mention by who here] method for the selection of replacement of teeth. The results of the investigation did not support the contention of Williams but rather invalidated this method of teeth selection because more than two-thirds of the individuals showed no similarity between face-form and incisor tooth form (Mavroskoufis and Ritchie, 1980).

Mavroskoufis and Ritchie in 1981, conducted a study to determine the nasal width and incisive papilla as guides for the selection and arrangement of maxillary anterior teeth. For this, they made measurements of the interalar width, the intercanine width and the distance between the labial convexity of the central incisors of 64 dental students with Angle's class I occlusion and skeletal Class I jaw relations and well-arranged intact anterior teeth. The measurements were made clinically and on dental casts. They concluded that: (1) The interalar nasal width is a reliable guide for selecting the mold of anterior teeth, and that the incisive papilla provides a stable anatomic landmark for arranging the labial surfaces of the central incisors at 10 mm anterior to the posterior border of the papilla. (2) The mesiodistal width of the set of anterior teeth (four incisor and the mesial halves of the canines) should be determined by adding 7 mm to the patient's nasal width. (3) The tips of canines on the horizontal plane, should be set on a line which passes through the posterior border of the incisive papilla and (4) The distance between them should equal the patient's nasal width, so that from the frontal view they would each seem to lie on a perpendicular line drawn from each of ala of the nose (Mavroskoufis and Ritchie, 1981).

Zakiah et al. in 2010, studied the relationship between facial measurements and widths of the maxillary anterior teeth. They made standardized frontal digital images from selected 60 adults from 2 ethnic groups (Malay and Chinese), with well aligned maxillary anterior teeth and minimal attrition. Images were evaluated with analyzing

software; the images were used to determine the interpupillary distance (IPD), inner canthal distance (ICD), and interalar width (IA). Widths of the 6 maxillary anterior teeth were measured directly from casts of the subjects using digital calipers. The results showed that means (standard deviations) of IPD, IA, and ICD of the subjects were 62.28 (2.47), 39.36 (3.12), and 34.36 (2.15) mm, respectively. The mesiodistal diameters of the maxillary central incisors, lateral incisors, and canines were 8.54 (0.50), 7.09 (0.48), and 7.94 (0.40) mm, respectively. The width of the central incisors was highly correlated to the IPD (r=0.99), while the widths of the lateral incisors and canines were highly correlated to a combination of IPD and IA (r=0.99 and 0.94, respectively). Authors concluded that in the population studied, the sizes of maxillary central incisors, lateral incisors, and canines are highly correlated to the interpupillary distance and a combination of the interpupillary and interalar distances, and may be predicted by incorporating the regression methods discussed in this study (Isa et al., 2010).

1.4 Characteristics Of Posterior Teeth

Posterior teeth are mainly selected by means of a guide chart based on overall measurements. There are no rules of thumb with respect to posterior tooth selection; however, there are anatomic landmarks and manufacturer aids that can be used as guides in the process.

The selection of the proper tooth size or mold is based upon (1) the capacity of the ridges to receive and resist the forces of mastication, (2) the space available for the teeth, and (3) the esthetic requirements.

1. In most complete denture patients, the lower ridge offers less support to the forces generated by the occlusal surfaces of the teeth. Its smaller area of support to the forces and more rapid resorption pattern progressively narrow and reduce the height of the lower ridge. For these reasons, the determinants for selection are based in the lower ridge.

2. The space available for the posterior teeth is in two dimensions: the mesiodistal space and the interridge space. The mesiodistal space extends from the distal of the lower canine to the apex of the retromolar pad. In some lower ridges, the lower slope is steep. This will limit the available space, since the last tooth should not be placed over this steep incline. A quick and efficient method for selection of the proper tooth size is to measure with a ruler or a space gauge from the distal of the lower canine to the apex of the retromolar pad. This measurement of the actual space available is taken to the mold guide and related directly to the size of available molds of the desired occlusal form. When the ridge is poor or when the lower molar slope is steep, a smaller tooth should be selected to satisfy the functional limitations. The second molar position should always end over firm supportive tissue that does not have a steep sloping rise distally. Artificial teeth of the same occlusal size are manufactured in

various vertical lengths. For the reasons stated, the longest tooth that the interridge space can accommodate without grinding should be selected.

3. Esthetic requirements of posterior teeth are usually satisfied when the proper size teeth have been selected. A harmony of tooth size between the canine and first premolar is necessary for natural appearance. When the canine is large for esthetic reasons but the ridges are poor, which indicates smaller posteriors, it is necessary to use a large first premolar from another mold to satisfy esthetic requirements. The mesiodistal measurement for selection of the posterior teeth as described from the distal of the canine to the apex of the retromolar pad may have to be adjusted for the retrognathic and prognathic ridge relationship, sometimes eliminating a premolar from the setup is the solution for obtaining the proper distal length for the posterior setup. When more reduction in distal occlusal extent is required, the first or second molar can be dropped out of the setup (Sharry, 1974).

Sears wrote about “esthetics refinements “ when the posterior teeth have too straight a line along their bucco-occlusal edges, he said that for the best esthetic effect, and alteration is made by slicing the mesial and distal edges at an angle, leaving points to represent buccal cusps. This will give the illusion of carrying projecting cusps (Sears, 1957).

Parr and Loft (1982), developed the concept of occlusal spectrum in complete dentures, which allows dentist to match a tooth form and arrangement to the individual patient, the maximum esthetics was given to the anatomical balanced occlusion and the less esthetics to the neutrocentic occlusion (Parr and Loft, 1982).

Rahn and Heartwell (1993), stated that the occlusal form of posterior teeth could be decided by the type of occlusion to be developed. If teeth are to be balanced in the centric and eccentric position, a cusp form is indicated and if the posterior teeth are to disocclude when an eccentric jaw movement occurs, either cusp or monoplane teeth can be used. They referred as one the advantages attributed to cusp posterior teeth are they look more like natural teeth and are therefore more acceptable esthetically (Rahn and Heartwell, 1993).

1.5 Golden Proportion

The Golden Proportion has been used since time immemorial and was formulated as one of Euclid's elements. It was used extensively in Greek architecture, e.g., the Parthenon on the Acropolis of Athens, and has been employed in art through the ages. It has been described and studied by many famous artists, scientists, mathematicians, and philosophers. La Corbusier developed a scale, the modular, based on the golden sections of the human body (Levin, 1978).

The Greeks tried to formulate beauty as an exact mathematical concept. They believed that beauty could be quantified and represented in a mathematical formula. This led Pythagoras to conceive the "Golden Proportion" (1/1.618=0.618), and Plato, the "Beautiful Proportion" (1/1.733=0.577). Both concepts stated that a shape or object with specific proportion is perceived as having innate beauty. The most widely used concept in dentistry is that of the Golden Proportion, whose formula is as follows: S/L=L/(S+L) =2/ (1±5) = 0.618 where S is the smaller and L the larger part. The uniqueness of this ratio is that when applied by three different methods of calculation (linear, geometric, and arithmetic), the proportional progression from the smaller to the larger to the whole part always produces the same results (Lombardi, 1973; Levin, 1978).

In dentistry, the most influential factors contributing to a harmonious anterior dentition are the size, shape, and arrangement of the maxillary anterior teeth, particularly the maxillary central incisors as viewed from the front. Applying the rule of the Golden Proportion to the widths of the anterior teeth as viewed in the frontal plane will help create an esthetic and pleasing smile. The perceived width of a tooth should be approximately 62 percent of the width of the mesial tooth in order to be esthetically pleasing. The width of the central incisor relates to the width of the lateral, the lateral to the canine, and the canine to the first bicuspid. It must be clear that the Golden Proportion rule does not apply to the actual width measurements of the teeth but to the way they are perceived when viewed from the front (Donitza, 2008).

Lombardi in 1973, was the first to emphasize the importance of order in dental composition, with a recurring ratio noted between all teeth from the central incisor to the first premolar. He classified most of tooth arrangement errors into an outline based entirely upon two factors: (1) The relationship between the dental composition (the denture) and its background (the patient) and (2) The relationship of the various elements within the dental composition. Furthermore, Lombardi classified esthetic errors according to the following outline: (I) Inharmonious dentofacial ratio: A. Shade disharmony, B. Compositional incompatibility (static denture in dynamic mouth and inharmonious strength or weakness of dental composition compared to background features (Il) Intrinsic dental disharmony: A. Space allocation errors (inadequate vertical space allocation, excessive vertical space allocation and excessive horizontal space allocation), B. Structural line errors (elevated occlusal plane, occlusal plane drops down posteriorly and asymmetrical occlusal plane), C. Unnatural lines (reverse smiling line, unnatural axial inclination, cuspless posterior teeth, gradation errors and age-sex-personality disharmony) , D. Single-line errors (vertical deviation, horizontal deviation and line conflict) and E. Imbalance (midline error, imbalance of directions, artifact error and diastema error). Lombardi suggested that the ratio of visual perceived widths of the central and laterals incisors should be continue as moving distally (Lombardi, 1973).

In 1978, Levin considered manifestations of the proportion in the beauty of nature and art as it applies to dental esthetics. The Golden Proportion is the relationship between a larger and a smaller object. He stated the proportion of the smaller to the greater is the same as the proportion of the greater to the whole. Furthermore, the first Golden Proportion relationship, and the most important to be discovered, is a simple tooth-to-tooth Golden Proportion. The observable width (not the actual size) of the front teeth, from central incisor to premolar are the most significant part of the smile and they are in the Golden Proportion to each other. This phenomenon has been combined in a grid, which can be used to assist us in perfecting the aesthetics of the eight front teeth; the ratio of 1 to 0.618 is the simplest form of the Golden Proportion (Levin, 1978).

In 1982, Ricketts wrote "The biologic significance of the divine proportion and Fibonacci series" with the purpose to demonstrate the application of basic mathematical and geometric principles to the normal morphology of structures regularly involved in orthodontics and dentistry. He evaluated a sample of thirty ideal normal, thirty-two-tooth, racially unmixed adult males using Rocky Mountain Data Systems software. The result showed numerous cephalometric tracings of orthodontic landmarks that followed the Golden Proportion. In the same article, he conducted measurements of cast of the teeth of normal-occlusion subjects, the photographs of the faces of commercial models, and conditions found in lateral and frontal cephalometric head films. Variations of the beautiful photographic models were analyzed together with computerized composites of patients with ideal occlusions. Ricketts noted that

biologists and morphologists understand this, and they speak in terms of "laws." When the human body develops to this divine proportion, it upholds the first law of "conservation of energy", which means that there is maximum performance with minimum effort. It also upholds the second law of "conservation of tissue," which means that a minimum amount of cells and materials are employed to perform the needed task. Therefore, any individuals who conform to this divine proportion are biologically and physiologically arranged to be profoundly efficient and healthy (Ricketts, 1982).

Tjan et al. in 1984, described the average smile revealed 75% to 100% of the maxillary anterior teeth; the incisal curve of the teeth should be parallel to the lower lip and the incisal curve of the maxillary teeth should touch or just fail to touch the lower premolars (Tjan et al., 1984).

McArthur in 1985, wrote an article "Maxillary and Mandibular Teeth Widths", in which he explains that the average ratio of upper central incisor to lower central incisor is 1.62, his study included cast from 100 completed orthodontic patients, 56 women and 44 male with good alignment and a Class I canine relationship. He found that the average width of a natural maxillary central incisor was 8.92 mm. The average width of a mandibular central incisor was 5.5 mm. The average ratio produced by dividing the average maxillary central incisor width by the average mandibular incisor width was 1.62. The factor of 1.5 times the width of a mandibular central incisor produces a maxillary central incisor width that is too narrow. The width of a

mandibular central incisor plus half the width of the mandibular lateral incisor also produces a maxillary central incisor width that was too narrow. He concluded that there might be a tendency to undersize the maxillary dentition. The ratio of 1.62 could be used to select the appropriate width for a missing maxillary central incisor when given the width of the mandibular central incisor.(McArthur, 1985) This ratio of 1.62 was also valuable to verify the dimension of a selected artificial maxillary central incisor when the patient complains that the tooth is too large. If substitutions or adjustments are made in the mold, the desired canine-to-canine measurement produced by the ratio range of 1.3 to 1.38 reported in Parts I and II of this study should be maintained (McArthur, 1985).

Kawakami et al. in 1989, investigated the Golden Proportion balance between eyes, nose and mouth in the facial appearance of typical Japanese individuals. His study included thirty Japanese males and female Japanese subjects with typical profiles, free of any abnormality in facial bone and soft tissue. Comparing the ratios to Caucasians, each ratio was then used for pre and post-operative aesthetic analysis using a standardized method of tridimensional measurement. They found that Japanese tend to have a longer upper lip and shorter chin length compared with Caucasians. They believed that this tendency represents a general facial characteristic of the Oriental population (Kawakami et al., 1989).

Preston in 1993, measured 58 digital images of dental cast and measured anterior to posterior proportion of the 6 anterior teeth with a computer software with the purpose to evaluate the frequency of golden proportion (considered for him to be in the range of 0.61 to 0.63) in the ratios of the perceived width of maxillary central to lateral incisors and lateral to canine. He found only 17% of his samples follow the Golden Proportion ratio between the widths of the maxillary central and lateral incisors and 0% lateral to canine. His results showed the mean in the perceived width maxillary central –lateral ratio of 0.66 and lateral-canine of 0.66 (Preston, 1993).

Gillen et al. in 1994, measured the widths and proportions of the incisors on study cast from 54 patients (Twenty-one white males, 13 black males, 10 white females, and 10 black females) with ages between 18 and 35 year, the purpose was to determine dimensional data (width and length) including tooth proportions. They concluded that there was no Golden Proportion correlation; however the main limitation of this work was low sample numbers (10 each black and white females). They found race and gender affected direct measurements. In his article, they clearly stated that the measurements were of "the entire widths of the incisors", and acknowledges that the Golden Proportion phenomenon applies only to the widths as "seen". (Gillen et al., 1994) This is such a common misconception that it is worth repeating that the Golden Proportion phenomenon applies to the widths of teeth as seen from the front and not the actual widths as measured (Gillen et al., 1994).

Jefferson in 1996, used computer generated photographs and cephalometrics tracing to illustrate a Golden Proportion diagrams to an ideal picture of the whole head. He stated that all living creatures are intimately connected by a biologic phenomenon known as divine proportion and we are all genetically encoded to develop into this ideal shape and form (Jefferson, 1996).

Condon et al. (2010), made one hundred and nine casts in type IV stone of maxillary arch of young Irish subjects (age 18 -25, 40 males and 69 females) and made standardized digital photographs with the purpose to measure the anterior to posterior proportions of six maxillary anterior teeth using Adobe Photoshop 6.0® software. The results showed no statistical difference in proportions between males to females or right to left side, furthermore there was a significant association between the proportions for right lateral incisor to right central incisor and the Golden Proportion guidelines, however no other significant association was found between the proportions recorded and the Golden Proportion guidelines. They concluded that differences between the left to right sides and genders were not significant or clinically relevant. Golden Proportion guidelines could only be applied to the lateral incisor／central incisor proportion (0.618). From the data recorded, they proposed guidelines for the other proportions of 0.58 and 0.89 for the canine／central incisor and canine／lateral incisor proportions respectively (Condon et al., 2010).

2. PURPOSE

The purpose of this study was to investigate the proportion of anterior to posterior denture teeth manufactured by two major manufacturers (Ivoclar and DENTSPLY) and determine if they follow the suggested Golden Proportion.

3. HYPOTHESES

3.1 Null Hypothesis:

- There was no significant difference in the measured proportion of anterior to posterior denture teeth manufactured by Ivoclar and the predicted proportion based on Golden Proportion.
- There was no significant difference in the measured proportion of anterior to posterior denture teeth manufactured by DENTSPLY and the predicted proportion based Golden Proportion.

3.2 Research Hypothesis:

- There was a significant difference in the measured proportion of anterior to posterior denture teeth manufactured by Ivoclar and the predicted proportion based Golden Proportion.
- There was a significant difference in the measured proportion of anterior to posterior denture teeth manufactured by DENTSPLY and the predicted proportion based Golden Proportion.

4. MATERIALS AND METHODS

4.1 Record Base And Wax Rim

One maxillary edentulous typodont was used (FrasacoUSA, Greenville, NC) for all samples. Sixty six record bases were made using Transheet VLC record base material (Triad, DENTSPLY Prosthetics, York, PA), according to the recommendations by Elder (Elder, 1955). Wax rims were made over the record bases using base plate wax (Truwax® Baseplate Wax, DENTSPLY, York, Pa). The dimensions of the maxillary occlusion rims were as follows (Jamieson, 1956):

1. Distance from the maxillary labial sulcus to the incisal edge of the maxillary central incisor was 22 mm.
2. Posterior vertical height of the maxillary occlusion rim was 6 – 8 mm.
3. Distance from the incisive papilla indentation to the labial surface of the maxillary central incisor was 8 mm.
4. The curvature of the maxillary occlusion rim should correspond to the overall curvature of the maxillary arch.
5. Occlusion rims were approximately 8 mm wide.

4.2 Mould

Anterior Mould: The anterior moulds were as follows:

- **Blueline Esthetic Denture Teeth, Vivodent DCL (Ivoclar, Amherst, NY)**: Small A22; Medium: A32; Large: A15

- **Portrait IPN (DENTSPLY Trubyte, York, PA)**: Small: 21D; Medium: 12E; Large: 11H

Posterior Mould: 30º anatomic teeth were used for the posterior moulds as follows:

- **Postaris DCL (Ivoclar, Amherst, NY):** Small PU2; Medium PU3; Large PU4
- **Portrait IPN (DENTSPLY Trubyte, York, PA):** Small 230M; Medium 230L; Large 330

Each anterior mould was arranged with the corresponding posterior mould according to what is suggested by the manufacturer (figure 1). The anterior and posterior denture teeth were arranged to meet the golden proportions as described by Levin (Levin, 1978), and the occlusal rims served as the guide for the arrangement of the denture teeth.

4.3 Arrangement Of Anterior Teeth

The incisive papilla was used to locate the midline of the dental arch and a mark was made on the typodont through the center of the papilla. The mark was then transferred to the occlusion rim as a guide for placement of the maxillary incisors.

Maxillary Central Incisor Arrangement

After selecting the anterior mold, approximately 12mm of the maxillary occlusion rim was removed on one side of the midline around the arch. The right maxillary central incisor was set with the long axis of the tooth perpendicular to the horizontal.

Maxillary Lateral Incisor Arrangement

The maxillary right lateral incisor was set adjacent to the central incisor, with the neck slightly depressed. The arrangement of this tooth followed the remaining anterior occlusion rim and was in symmetry with the central incisor. The incisal edge was parallel with the occlusion rim and was 0.5 mm above that of the central incisor.

Maxillary Canine Arrangement

The maxillary right canine was set so the anterior one half of the incisal edge was in symmetry with the lateral and central incisors as followed the labial contour of the wax occlusion rim. The neck of this tooth was prominent and tilted slightly to the distal. Like the central incisor, the incisal tip of the canine was at the level of the occlusion rim.

4.4 Arrangement Of Posterior Teeth

For the posterior tooth arrangement, this study followed the recommendations by Zarb (Zarb et al., 2004) :

The Maxillary 1st Premolar Arrangement:

The maxillary first premolar was placed with its long axis perpendicular to the plane of the occlusion rim (vertically upright). The buccal cusps were raised 0.5mm from the occlusal plane.

The Maxillary 2nd Premolar Arrangement:

The long axis was perpendicular to the plane of the occlusion rim (parallel to the vertical axis). The buccal cusp was 0.5 mm above the occlusal plane and the palatal cusp touched the occlusal plane.

The Maxillary 1st Molar Arrangement:

The long axis (viewed from side) was slightly inclined mesially. When viewed from the front, the tooth sloped buccally. The mesiobuccal cusp of the first molar was raised 0.5 mm above the plane of the occlusion rim. The mesiopalatal cusp was in contact with the plane of the occlusion rim, and the distobuccal cusp was raised about 1 mm above the occlusal plane.

The Maxillary 2nd Molar Arrangement:

The long axis (viewed from side, cervical area) was slightly inclined mesially. The mesiobuccal cusp of the 2nd molar was raised 1 mm above the plane of the occlusion rim and the distobuccal cusp was 1.5 mm above the occlusal plane. No cusp touched the occlusion rim.

4.5 Image Manipulation

All denture set-ups were photographed using a Digital SLR Camera (Canon 50D, Canon, USA) with a 100mm Macro Lens (EF 2.8f USM, Canon, USA), ring flash (MR14EX, Canon, USA) and camera tripod (Canon Deluxe 200, Canon, USA). All the photographs were made at the same focal distance (50 centimeter) and under the same light source. All the models were placed in the same horizontal position.

All photographs were imported using the provided USB cable from the camera to a personal computer (MacBook Pro 13", Apple, Cupertino, CA), the original JPEG images were opened in Adobe Photoshop® CS5 (Adobe Corporation, San Jose, CA), and saved as Photoshop® Documents (PSD). This allowed for subsequent changes and saves to have similar resolution and quality. The center photograph was cropped to display only the right half. Care was taken to insure the incisal edges of the teeth were maintained with relation to the horizontal plane (Figure 2).

4.6 Image Measurement

Measurements were made using a screen caliper software (Iconico, Inc. Software Services, NY) using 1:1 magnification in Photoshop. Using the software, the following measurements were made: (Figure 3)

(1) Width of the visible part of each maxillary anterior tooth
    a. Central incisor
    b. Lateral incisor
    c. Canine
(2) Width of the visible part of each maxillary posterior tooth
    a. First premolar
    b. Second premolar
    c. First molar
    d. Second molar

All the measurements were recorded in a Microsoft Excel work sheet (Microsoft, Redmond, Washington) (Figure 4). To ensure standardization of the procedure, the same investigator measured all photographs. All models were randomly organized by a second person prior to initializing photography.

The golden proportion for each sample was calculated and compared as follows (Ali Fayyad et al., 2006):

- The width of the central incisor was multiplied by 62% (GP_LI) and compared with the width of the adjacent lateral incisor.
- The width of the lateral incisor was multiplied by 62% (GP_Cn) and compared with the width of the adjacent canine
- The width of the canine was multiplied by 62% (GP_1P) and compared with the width of the adjacent first premolar.
- The width of the first premolar was multiplied by 62% (GP_2P) and compared with the width of the adjacent second premolar.
- The width of the second premolar was multiplied by 62% (GP_1M) and compared with the width of the adjacent first molar.
- The width of the first molar was multiplied by 62% (GP_2M) and compared with the width of the adjacent second molar.

4.7 Statistical Analysis

Data was analyzed using the paired t statistical test. A Bonferroni correction was performed therefore corrected p value of $p=0.008$ was considered significant.

With an N of eleven teeth per group (three "size" groups x two "brand" groups = six groups), a $p \leq 0.05$, and an effect size of 0.20, power for the statistical analysis was 0.90 (Appendix 1).

5. RESULTS

5.1 Calculated Golden Proportion Width (GP) Versus Actual Width (Width) Manufactured By Ivoclar

5.1.1 Small Mould

Table 1.A summarizes results from Ivoclar small mould.

There was a significant difference in the small mould teeth manufactured by Ivoclar between the calculated Golden Proportion width of the lateral incisor (M= 80.3 x, SD=1.87 x) and actual lateral incisor width (M=86.1 x, SD=81.76 x), conditions paired t (10) = -13.94, p < 0001.

There was a significant difference in the small mould teeth manufactured by Ivoclar between the calculated Golden Proportion width of the canine (M= 53.4 x, SD=1.09 x) and actual canine width (M=81.6 x, SD=2.25 x), conditions t (10) = -44.37, p < .0001.

There was a significant difference in the small mould teeth manufactured by Ivoclar between the calculated Golden Proportion width of the first premolar (M= 50.06 x, SD=1.39 x) and actual first premolar width (M=54.4 x, SD=2.54 x), conditions t (10) = -5.50, p < .0001.

There was a significant difference in the small mould teeth manufactured by Ivoclar between the calculated Golden Proportion width of the second premolar (M= 33.7 x,

SD=1.58 x) and actual second premolar width (M=46.3 x, SD=2.76 x), conditions t (10) = -18.83, p < .0001.

There was a significant difference in the small mould teeth manufactured by Ivoclar between the calculated Golden Proportion width of the first molar (M= 28.7, SD=1.71) and actual first molar width (M=41.9 x, SD=3.53), conditions t (10) = -15.44, p < .0001.

There was not a significant difference in small mould manufactured teeth by Ivoclar between the calculated Golden Proportion width of the second molar (M= 26.0 x, SD= 0.62 x) and actual second molar width (M=26.9 x, SD=3.15 x), conditions t (10) = -1.34, p = 0.211.

5.1.2 Medium Mould

Table 1.B summarizes results from Ivoclar medium mould.

There was a significant difference in medium mould teeth manufactured by Ivoclar between the calculated Golden Proportion width of the lateral incisor (M= 73.8 x, SD=0.62 x) and actual lateral incisor width (M= 85.2 x, SD= 2.99 x), conditions paired t(10) = - 11.69, p <. 0001.

There was a significant difference in medium mould teeth manufactured by Ivoclar between the calculated Golden Proportion width of the canine (M= 52.8 x, SD= 1.86 x) and actual canine width (M= 74.4 x, SD= 2.94 x), conditions t (10) = -22.51, p < .0001.

There was a significant difference in medium mould teeth manufactured by Ivoclar between the calculated Golden Proportion width of the first premolar (M= 46.1 x, SD= 1.82 x) and actual first premolar width (M= 59.3 x, SD= 2.87 x), conditions t (10) = -14.60, $p < .0001$.

There was a significant difference in medium mould teeth manufactured by Ivoclar between the calculated Golden Proportion width of the second premolar M= 36.7 x, SD= 1.78 x) and actual second premolar width (M= 47.8 x, SD= 2.64 x), conditions t (10) = -13.02, $p < .0001$.

There was a significant difference in medium mould teeth manufactured by Ivoclar between the calculated Golden Proportion width of the first molar (M= 29.6 x, SD= 1.64 x) and actual first molar width (M= 43.1 x, SD= 3.15 x), conditions t (10) = -14.41, $p < .0001$.

There was a significant difference in medium mould teeth manufactured by Ivoclar between the calculated Golden Proportion width of the second molar (M= 26.7 x, SD=1.95 x) and actual second molar width (M=30.4 x, SD=2.87 x), conditions t (10) = -4.31, $p = 0.02$.

5.1.3 Large Mould

Table 1, C summarizes results from Ivoclar large mould.

There was a significant difference in large mould teeth manufactured by Ivoclar between the calculated Golden Proportion width of the lateral incisor (M= 97.1 x,

SD=1.05 x) and actual lateral incisor width (M=102.8 x, SD=1.99 x), conditions paired t (10) = -8.05, p < 0001.

There was a significant difference in large mould teeth manufactured by Ivoclar between the calculated Golden Proportion width of the canine (M= 63.7 x, SD=1.23 x) and actual canine width (M=93.5 x, SD=2.38 x), conditions t (10) = -46.55, p < .0001.

There was a significant difference in large mould teeth manufactured by Ivoclar between the calculated Golden Proportion width of the first premolar (M= 57.9 x, SD=1.48 x) and actual first premolar width (M=65.9 x, SD=1.97 x), conditions t (10) = -12.59, p < .0001.

There was a significant difference in large mould teeth manufactured by Ivoclar between the calculated Golden Proportion width of the second premolar (M= 40.9 x, SD=1.22 x) and actual second premolar width (M=43.7 x, SD= 1.95 x), conditions t (10) = -5.28, p < .0001.

There was a significant difference in large mould teeth manufactured by Ivoclar between the calculated Golden Proportion width of the first molar (M= 27.1 x, SD=1.21 x) and actual first molar width (M=49.6 x, SD=3.36 x), conditions t (10) = -25.23, p < .0001.

There was a significant difference in large mould teeth manufactured by Ivoclar between the calculated Golden Proportion width of the second molar (M= 30.8, x

SD=2.08 x) and actual second molar width (M=11.7 x, SD=2.49 x), conditions t (10) = 34.45, p < .0001.

5.2 Calculated Golden Proportion Width (GP) Versus Actual Width (Width) manufactured By DENTSPLY

5.2.1 Small Mould (table 1, D)

Table 2.A summarizes results from DENTSPLY small mould.

There was a significant difference in small mould teeth manufactured by DENTSPLY between the calculated Golden Proportion width of the lateral incisor (M= 72.3x, SD=1.08 x) and actual lateral incisor width (M=86.9 x, SD=0.94 x), conditions paired t(10) = -35.47, p < .0001 .

There was a significant difference in small mould teeth manufactured by DENTSPLY between the calculated Golden Proportion width of the canine (M= 53.9 x, SD=0.59 x) and actual canine width (M=53.9 x, SD=2.84 x), conditions t (10) = -33.58, p < .0001.

There was a significant difference in small mould teeth manufactured by DENTSPLY between the calculated Golden Proportion width of the first premolar (M= 51.7 x, SD=1.76 x) and actual first premolar width (M=46.9 x, SD=1.81 x), conditions t (10) = 4.66, p < .0001.

There was a significant difference in small mould teeth manufactured by DENTSPLY between the calculated Golden Proportion width of the second premolar (M= 29.1 x,

SD=1.12 x) and actual second premolar width (M=39.5 x, SD=1.86 x), conditions t (10) = -13.99, p < .0001.

There was a significant difference in small mould teeth manufactured by DENTSPLY between the calculated Golden Proportion width of the first molar (M= 24.5 x, SD=1.16 x) and actual first molar width (M=37.9 x, SD=1.70), conditions t (10) = -19.63, p < .0001.

There was not a significant difference in small mould teeth manufactured by DENTSPLY between the calculated Golden Proportion width of the second molar (M= 23.5 x, SD= 1.05 x) and actual second molar width (M=22.1 x, SD=1.81 x), conditions t (10) = -2.12, p = 0.060.

5.2.2 Medium Mould

Table 2.B summarizes results from DENTSPLY medium mould.

There was a significant difference in medium mould teeth manufactured by DENTSPLY between the calculated Golden Proportion width of the lateral incisor (M= 104.9 x, SD=1.18 x) and actual lateral incisor width (M= 113.9 x, SD= 2.63 x), conditions paired t (10) = -12.12, p <. 0001.

There was a significant difference in medium mould teeth manufactured by DENTSPLY between the calculated Golden Proportion width of the canine (M= 70.6 x, SD= 1.63 x) and actual canine width (M= 110.1 x, SD= 2.98 x), conditions t (10) = -34.22, p < .0001.

There was a significant difference in medium mould teeth manufactured by DENTSPLY between the calculated Golden Proportion width of the first premolar (M= 68.3 x, SD= 1.85 x) and actual first premolar width (M= 77.0 x, SD= 3.49 x), conditions t (10) = -6.86, p < .0001.

There was a significant difference in medium mould teeth manufactured by DENTSPLY between the calculated Golden Proportion width of the second premolar (M= 47.7 x, SD= 2.17 x) and actual second premolar width (M= 55.7 x, SD= 3.00 x), conditions t (10) = -9.44, p < .0001.

There was a significant difference in medium mould teeth manufactured by DENTSPLY between the calculated Golden Proportion width of the first molar (M= 34.6 x, SD= 1.86 x) and actual first molar width (M= 54.6 x, SD= 4.82 x), conditions t (10) = -12.74, p < .0001.

There was a significant difference in medium mould teeth manufactured by DENTSPLY between the calculated Golden Proportion width of the second molar (M= 33.9 x, SD=2.99 x) and actual second molar width (M=29.9 x, SD=1.64 x), conditions t (10) = -4.70, p = 0.001.

5.2.3 Large Mould

Table 2.C summarizes results from DENTSPLY large mould.

There was a significant difference in large mould teeth manufactured by DENTSPLY between the calculated Golden Proportion width of the lateral incisor (M= 86.0 x,

SD=1.27 x) and actual lateral incisor width (M=97.7 x, SD=2.69 x), conditions paired t (10) = -14.35, p < .0001.

There was a significant difference in large mould teeth manufactured by DENTSPLY between the calculated Golden Proportion width of the canine (M= 60.6 x, SD=1.67 x) and actual canine width (M=86.5 x, SD=2.12 x), conditions t (10) = -43.01, p < .0001.

There was a significant difference in large mould teeth manufactured by DENTSPLY between the calculated Golden Proportion width of the first premolar (M= 53.6 x, SD=1.31 x) and actual first premolar width (M=67.2 x, SD=1.83 x), conditions t (10) = -21.35, p < .0001.

There was a significant difference in large mould teeth manufactured by DENTSPLY between the calculated Golden Proportion width of the second premolar (M= 41.7 x, SD=1.14 x) and actual second premolar width (M=50.8 x, SD= 2.89 x), conditions t (10) = -10.75, p < .0001.

There was a significant difference in large mould teeth manufactured by DENTSPLY between the calculated Golden Proportion width of the first molar (M= 31.5 x, SD=1.79 x) and actual first molar width (M=47.5 x, SD=1.97 x), conditions t (10) = -23.68, p < .0001.

There was not a significant difference in large mould teeth manufactured by DENTSPLY between the calculated Golden Proportion width of the second molar

(M= 29.4, x SD=1.22 x) and actual second molar width (M=32.0 x, SD=2.45 x), conditions t (10) = -3.53, p =0.50

Relationship shows the relation between the suggested width based in Golden Proportion and actual values acquired in this study.

6. DISCUSSION

It is important to determine a mathematical or geometrical relationship between teeth in order to achieve an esthetic restorative result. It would be helpful if statistical relationships existed to support the Golden Proportion theory. However, most of the studies do not support this theory (Preston, 1993; Gillen *et al.*, 1994). Magne et al. noted a limitation in using the Golden Proportion rule in the maxillary arch of natural anterior teeth. A strict adherence to the guidelines would result in an abnormal narrow arch with insufficient teeth visible as one progress distally in the arch (Magne *et al.*, 2003).

This study was conducted on 66 denture set ups with the purpose to investigate the anterior to posterior denture tooth proportion between teeth of two major manufacturers. There was a significant difference between the suggested Golden Proportion width and actual width of anterior and posterior denture teeth manufactured by Ivoclar and DENTSPLY; thus accepting the null hypothesis. These findings are in accordance with studies conducted by several authors (Mahshid et al., 2004; Ali Fayyad et al., 2006; Murthy & Ramani, 2008). In individuals with an esthetic smile, they evaluated the existence of golden proportions by measuring the mesio-distal width of six anterior teeth on digital photographs. They concluded that the Golden Proportion did not exist in natural dentition.

Although some authors suggest that the first molar should be visible when smiling and therefore part of the Golden Proportion analysis (Miskinyar, 1983), all previous studies were performed only on anterior teeth. This is the first study that evaluates posterior denture teeth. A significant difference was found between the suggested Golden Proportion width and actual width of the posterior teeth except for the second molar small mould manufactured either by Ivoclar and DENTSPLY.

Regarding the mould size (small, medium, large), this study did not follow the Golden Proportion rule and this may suggest the manufacturers reduced the size proportionally.

There were several limitations to the conducted study: 1) The study was performed on representative moulds for each manufacturer, not all moulds were studied, 2) The teeth were set by one investigator at the same degree of arch curvature, changing the curvature may change the observed Golden Proportions and 3) This in-vitro study was done on a typodont. Consequently findings must be applied cautiously.

Alternate experiments might be designed to have an increased mould sample, or a study design that includes casts from actual patients with small, medium and large ridges.

7. CONCLUSION

In this study, the measured width of anterior and posterior denture teeth did not equal the calculated width based on the Golden Proportion in either Ivoclar or DENTSPLY denture teeth.

8. TABLES

Table 1: Paired Samples Test Between Calculated Golden Proportion Width (GP) and Actual Width (Width) Manufactured by Ivoclar.

A-Ivoclar- Small Mould

Pair		N	Mean	Std. Deviation	t	df	p
1-Lateral incisor (LI)	GP_LI	11	80.2618	1.8675	-13.942	10	0.000
	Width_LI	11	86.09	1.758			
2-Canine (Cn)	GP_Cn	11	53.3764	1.09002	-44.373	10	0.000
	Width_Cn	11	81.64	2.248			
3-1st premolar (1P)	GP_1P	11	50.6145	1.3939	-5.497	10	0.000
	Width_1P	11	54.36	2.541			
4- 2nd premolar (2P)	GP_2P	11	33.7055	1.57516	-18.825	10	0.000
	Width_2P	11	46.27	2.76			
5- 1st molar (1M)	GP_1M	11	28.6891	1.71127	-15.435	10	0.000
	Width_1M	11	41.91	3.534			
6-2nd molar (2M)	GP_2M	11	25.9836	2.19123	-1.336	10	0.211
	Width_2M	11	26.91	3.145			

*** All the values are in pixels (X)**

B- Ivoclar- Medium Mould

Pair		N	Mean	Std. Deviation	t	df	p
1-Lateral incisor (LI)	GP_LI	11	73.78	0.62	-11.69	10	0.000
	Width_LI	11	85.18	2.994			
2-Canine (Cn)	GP_Cn	11	52.8127	1.85624	-22.51	10	0.000
	Width_Cn	11	74.36	2.942			
3-1st premolar (1P)	GP_1P	11	46.1055	1.82395	-14.596	10	0.000
	Width_1P	11	59.27	2.867			
4- 2nd premolar (2P)	GP_2P	11	36.7491	1.77738	-13.023	10	0.000
	Width_2P	11	47.82	2.639			
5- 1st molar (1M)	GP_1M	11	29.6473	1.6361	-14.414	10	0.000
	Width_1M	11	43.09	3.145			
6-2nd molar (2M)	GP_2M	11	26.7164	1.94989	-4.308	10	0.002
	Width_2M	11	30.36	2.873			

*** All the values are in pixels (X)**

C- Ivoclar - Large Mould

Pair		N	Mean	Std. Deviation	t	df	p
1-Lateral incisor (LI)	GP_LI	11	97.1145	1.04751	-8.049	10	0.000
	Width_LI	11	102.82	1.991			
2-Canine (Cn)	GP_Cn	11	63.7473	1.23435	-46.552	10	0.000
	Width_Cn	11	93.45	2.382			
3-1st premolar (1P)	GP_1P	11	57.9418	1.47668	-12.593	10	0.000
	Width_1P	11	65.91	1.973			
4- 2nd premolar (2P)	GP_2P	11	40.8636	1.22297	-5.277	10	0.000
	Width_2P	11	43.73	1.954			
5- 1st molar (1M)	GP_1M	11	27.1109	1.21149	-25.234	10	0.000
	Width_1M	11	49.64	3.355			
6-2nd molar (2M)	GP_2M	11	30.7745	2.07996	34.445	10	0.000
	Width_2M	11	11.73	2.494			

*** All the values are in pixels (X)**

Table 2 : Paired Samples Test Between Calculated Golden Proportion Width (GP) and Actual Width (Width) Manufactured by DENTSPLY.

A-DENTSPLY - Small Mould

Pair		N	Mean	Std. Deviation	t	df	p
1-Lateral incisor (LI)	GP_LI	11	72.3	1.08	-35.47	10	0.000
	Width_LI	11	86.9	0.94			
2-Canine (Cn)	GP_Cn	11	53.9	0.59	-33.58	10	0.000
	Width_Cn	11	83.4	2.84			
3-1st premolar (1P)	GP_1P	11	51.7	1.76	4.66	10	0.000
	Width_1P	11	46.9	1.81			
4- 2nd premolar (2P)	GP_2P	11	29.1	1.12	-13.99	10	0.000
	Width_2P	11	39.5	1.86			
5- 1st molar (1M)	GP_1M	11	24.5	1.16	-19.63	10	0.000
	Width_1M	11	37.9	1.70			
6-2nd molar (2M)	GP_2M	11	23.5	1.05	2.12	10	0.060
	Width_2M	11	22.1	1.81			

*** All the values are in pixels (X)**

B- DENTSPLY- Medium Mould

Pair		N	Mean	Std. Deviation	t	df	p
1-Lateral incisor (LI)	GP_LI	11	104.9	1.18	-12.12	10	0.000
	Width_LI	11	113.9	2.63			
2-Canine (Cn)	GP_Cn	11	70.6	1.63	-34.22	10	0.000
	Width_Cn	11	110.1	2.98			
3-1st premolar (1P)	GP_1P	11	68.3	1.85	-6.86	10	0.000
	Width_1P	11	77.0	3.49			
4- 2nd premolar (2P)	GP_2P	11	47.7	2.17	-9.44	10	0.000
	Width_2P	11	55.7	3.00			
5- 1st molar (1M)	GP_1M	11	34.6	1.86	-12.74	10	0.000
	Width_1M	11	54.6	4.82			
6-2nd molar (2M)	GP_2M	11	33.9	2.99	4.70	10	0.001
	Width_2M	11	29.9	1.64			

*** All the values are in pixels (X)**

C- DENTSPLY - Large Mould

Pair		N	Mean	Std. Deviation	t	df	p
1-Lateral incisor (LI)	GP_LI	11	86.0	1.27	-14.35	10	0.000
	Width_LI	11	97.7	2.69			
2-Canine (Cn)	GP_Cn	11	60.6	1.67	-43.01	10	0.000
	Width_Cn	11	86.5	2.12			
3-1st premolar (1P)	GP_1P	11	53.6	1.31	-21.35	10	0.000
	Width_1P	11	67.2	1.83			
4- 2nd premolar (2P)	GP_2P	11	41.7	1.14	-10.75	10	0.000
	Width_2P	11	50.8	2.89			
5- 1st molar (1M)	GP_1M	11	31.5	1.79	-23.68	10	0.000
	Width_1M	11	47.5	1.97			
6-2nd molar (2M)	GP_2M	11	29.4	1.22	-3.53	10	0.005
	Width_2M	11	32.0	2.45			

*** All the values are in pixels (X)**

9. FIGURES

Figure 1. Set Up Arrangement

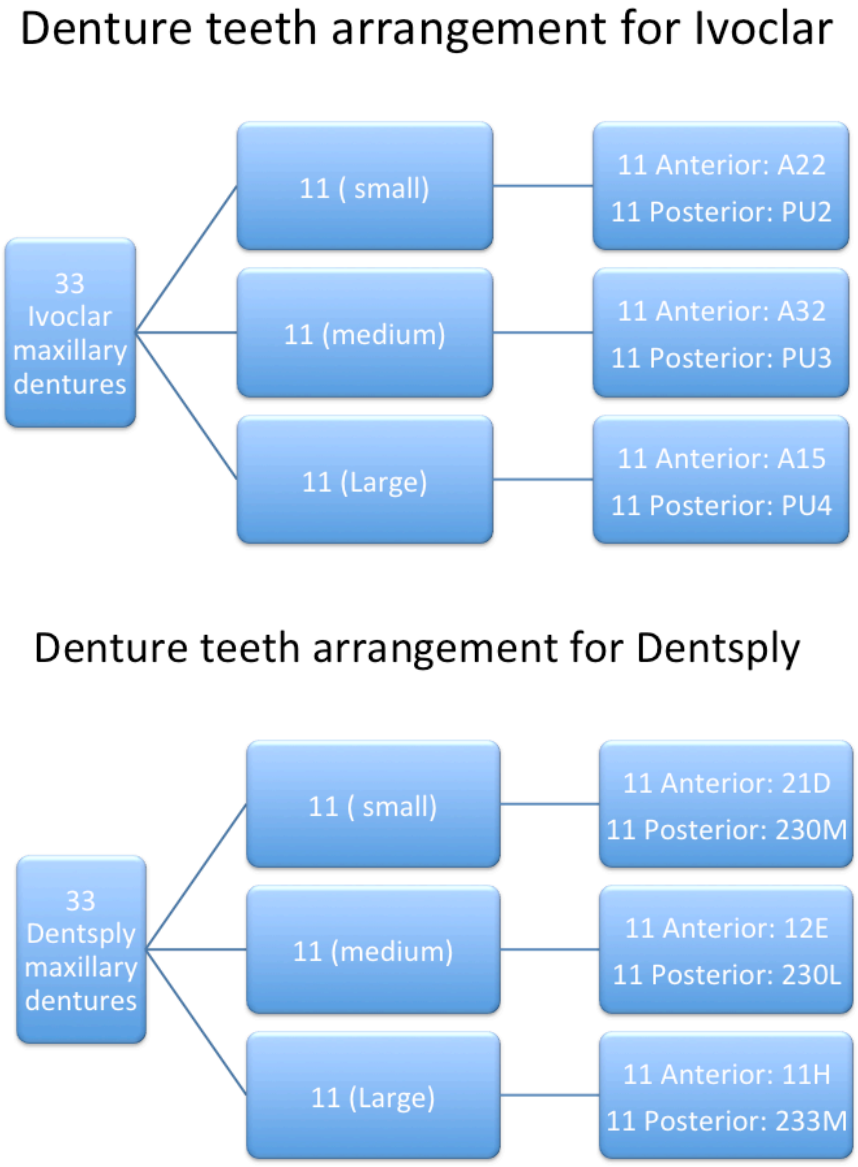

Figure 2. Processed Image in Photoshop CS5

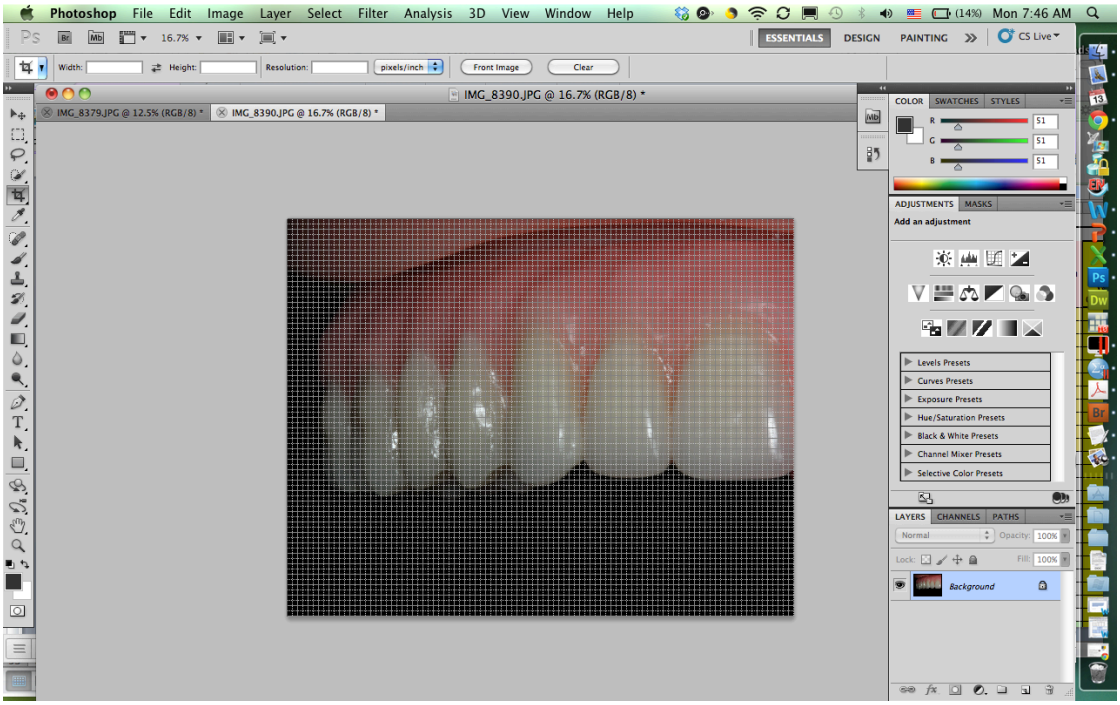

Figure 3. Processed Image In Photoshop CS5 With The Grid And Screen Caliper Software

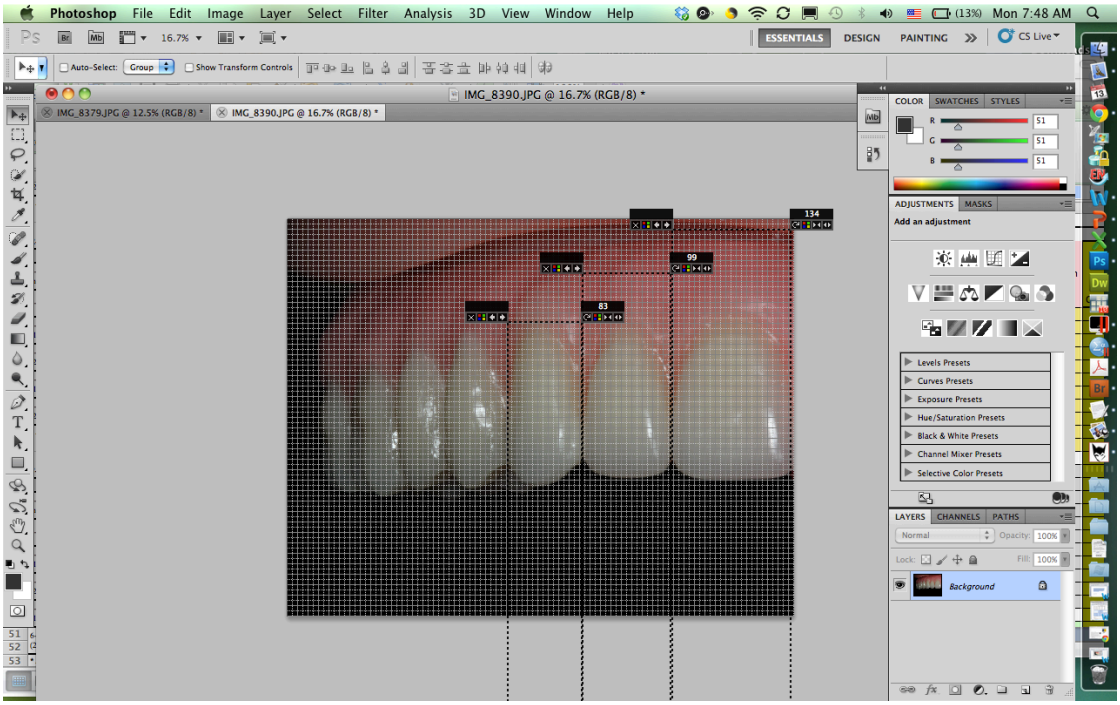

Figure 4. Excel Worksheet, Used For Recollection Of Data For Each Manufacturer

N	Width Central (C) (mm)	C/L proportion	Width Lateral (L) (mm)	L/Cn proportion	Width Canine(Cn) (mm)	Cn/1P Proportion	Width 1st Premolar (1P) (mm)	1P/2Pproportion	Width 2nd Premolar (2P) (mm)	2P/1M Proportion	Width 1st Molar (1M) (mm)	1M/2M Proportion	Width 2nd Molar (2M) (mm)
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
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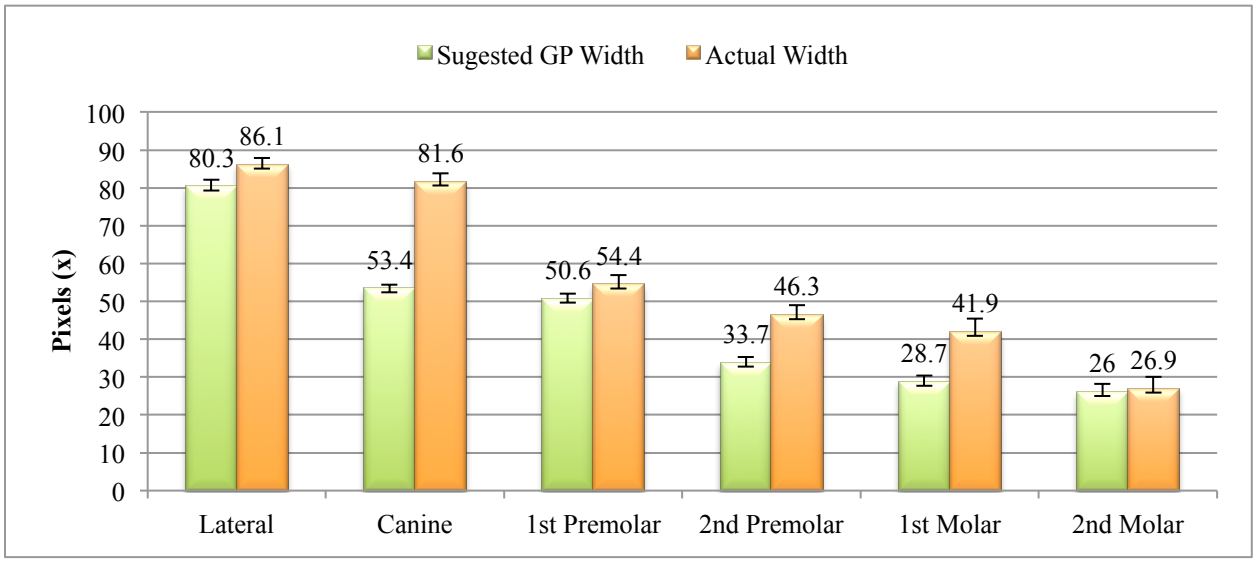
26													
27													
28													
29													
30													
31													
32													
33													

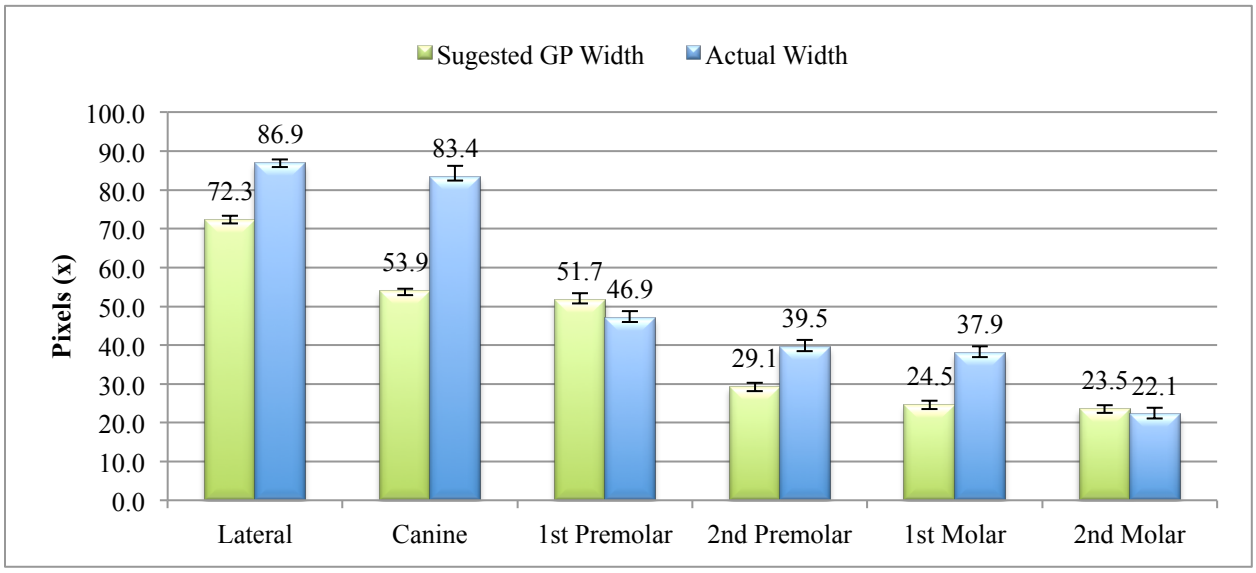
Low Value													
High value													
Range													
Mean													
SD													

Figure 5. Relationship Between The Calculated Golden Proportion Width Golden Proportion And Values Acquired In This Study

A. Ivoclar



B. DENTSPLY



10. APPENDIX 1: POWER ANALYSIS

```
            n =       11

. sampsi 1.6 1.681, sd1(0.08) onesample

Estimated sample size for one-sample comparison of mean
  to hypothesized value

Test Ho: m =    1.6, where m is the mean in the population

Assumptions:

         alpha =   0.0500  (two-sided)
         power =   0.9000
 alternative m =    1.681
            sd =      .08

Estimated required sample size:

            n =       11
```

11. APPENDIX 2: RESULTS OF STATISTICAL ANALYSIS

1. Paired t test for Ivoclar – Small Mould

Paired Samples Statistics*

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	GP_LI	80.2618	11	1.8675	0.56307
	Width_LI	86.09	11	1.758	0.53
Pair 2	GP_Cn	53.3764	11	1.09002	0.32865
	Width_Cn	81.64	11	2.248	0.678
Pair 3	GP_1P	50.6145	11	1.3939	0.42028
	Width_1P	54.36	11	2.541	0.766
Pair 4	GP_2P	33.7055	11	1.57516	0.47493
	Width_2P	46.27	11	2.76	0.832
Pair 5	GP_1M	28.6891	11	1.71127	0.51597
	Width_1M	41.91	11	3.534	1.066
Pair 6	GP_2M	25.9836	11	2.19123	0.66068
	Width_2M	26.91	11	3.145	0.948

*** All the values are in pixels (X)**

Paired Samples Test

		Paired Differences		t	df	Sig. (2-tailed)
		95% Confidence Interval of the Difference				
		Lower	Upper			
Pair 1	GP_LI - Width_LI	-6.76066	-4.89752	-13.942	10	0.000
Pair 2	GP_Cn - Width_Cn	-29.67903	-26.84097	-44.373	10	0.000
Pair 3	GP_1P - Width_1P	-5.2688	-2.22938	-5.497	10	0.000
Pair 4	GP_2P - Width_2P	-14.05478	-11.07977	-18.825	10	0.000
Pair 5	GP_1M - Width_1M	-15.1284	-11.3116	-15.435	10	0.000
Pair 6	GP_2M - Width_2M	-2.46911	0.6182	-1.336	10	0.211

2. Paired t test for Ivoclar – Medium Mould

Paired Samples Statistics*

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	GP_LI	73.78	11	0.62	0.18694
	Width_LI	85.18	11	2.994	0.903
Pair 2	GP_Cn	52.8127	11	1.85624	0.55968
	Width_Cn	74.36	11	2.942	0.887
Pair 3	GP_1P	46.1055	11	1.82395	0.54994
	Width_1P	59.27	11	2.867	0.864
Pair 4	GP_2P	36.7491	11	1.77738	0.5359
	Width_2P	47.82	11	2.639	0.796
Pair 5	GP_1M	29.6473	11	1.6361	0.4933
	Width_1M	43.09	11	3.145	0.948
Pair 6	GP_2M	26.7164	11	1.94989	0.58791
	Width_2M	30.36	11	2.873	0.866

* All the values are in pixels (X)

Paired Samples Test

		Paired Differences		t	df	Sig. (2-tailed)
		95% Confidence Interval of the Difference				
		Lower	Upper			
Pair 1	GP_LI - Width_LI	-13.575	-9.22864	-11.69	10	0.000
Pair 2	GP_Cn - Width_Cn	-23.68409	-19.41773	-22.51	10	0.000
Pair 3	GP_1P - Width_1P	-15.17735	-11.1572	-14.596	10	0.000
Pair 4	GP_2P - Width_2P	-12.96296	-9.17522	-13.023	10	0.000
Pair 5	GP_1M - Width_1M	-15.52182	-11.36546	-14.414	10	0.000
Pair 6	GP_2M - Width_2M	-5.53381	-1.76073	-4.308	10	0.002

3. Paired t test Ivoclar – Large Mould

Paired Samples Statistics*

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	GP_LI	97.1145	11	1.04751	0.31584
	Width_LI	102.82	11	1.991	0.6
Pair 2	GP_Cn	63.7473	11	1.23435	0.37217
	Width_Cn	93.45	11	2.382	0.718
Pair 3	GP_1P	57.9418	11	1.47668	0.44524
	Width_1P	65.91	11	1.973	0.595
Pair 4	GP_2P	40.8636	11	1.22297	0.36874
	Width_2P	43.73	11	1.954	0.589
Pair 5	GP_1M	27.1109	11	1.21149	0.36528
	Width_1M	49.64	11	3.355	1.012
Pair 6	GP_2M	30.7745	11	2.07996	0.62713
	Width_2M	11.73	11	2.494	0.752

* All the values are in pixels (X)

Paired Samples Test

		Paired Differences		t	df	Sig. (2-tailed)
		95% Confidence Interval of the Difference				
		Lower	Upper			
Pair 1	GP_LI - Width_LI	-7.28248	-4.1248	-8.049	10	0.000
Pair 2	GP_Cn - Width_Cn	-31.12917	-28.28538	-46.552	10	0.000
Pair 3	GP_1P - Width_1P	-9.37697	-6.55757	-12.593	10	0.000
Pair 4	GP_2P - Width_2P	-4.07283	-1.65444	-5.277	10	0.000
Pair 5	GP_1M - Width_1M	-24.51445	-20.53645	-25.234	10	0.000
Pair 6	GP_2M - Width_2M	17.81515	20.2794	34.445	10	0.000

4. Paired t test for DENTSPLY – Small Mould

Paired Samples Statistics*

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	GP_LI	72.3145	11	1.08359	0.32671
	Width_LI	86.91	11	0.944	0.285
Pair 2	GP_Cn	53.8836	11	0.58521	0.17645
	Width_Cn	83.36	11	2.838	0.856
Pair 3	GP_1P	51.6855	11	1.75959	0.53054
	Width_1P	46.91	11	1.814	0.547
Pair 4	GP_2P	29.0836	11	1.12473	0.33912
	Width_2P	39.45	11	1.864	0.562
Pair 5	GP_1M	24.4618	11	1.15539	0.34836
	Width_1M	37.91	11	1.7	0.513
Pair 6	GP_2M	23.5036	11	1.05417	0.31784
	Width_2M	22.09	11	1.814	0.547

* All the values are in pixels (X)

Paired Samples Test

		Paired Differences		t	df	Sig. (2-tailed)
		95% Confidence Interval of the Difference				
		Lower	Upper			
Pair 1	GP_LI - Width_LI	-15.5113	-13.67779	-35.471	10	0.000
Pair 2	GP_Cn - Width_Cn	-31.43587	-27.52413	-33.584	10	0.000
Pair 3	GP_1P - Width_1P	2.4932	7.05953	4.661	10	0.001
Pair 4	GP_2P - Width_2P	-12.02271	-8.71911	-13.989	10	0.000
Pair 5	GP_1M - Width_1M	-14.97355	-11.921	-19.631	10	0.000
Pair 6	GP_2M - Width_2M	-0.0724	2.89785	2.12	10	0.060

5. Paired t test for DENTSPLY - Medium Mould

Paired Samples Statistics*

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	GP_LI	104.9491	11	1.17933	0.35558
	Width_LI	113.91	11	2.625	0.791
Pair 2	GP_Cn	70.6236	11	1.62753	0.49072
	Width_Cn	110.09	11	2.982	0.899
Pair 3	GP_1P	68.2564	11	1.84869	0.5574
	Width_1P	77	11	3.493	1.053
Pair 4	GP_2P	47.74	11	2.16557	0.65294
	Width_2P	55.73	11	3.003	0.905
Pair 5	GP_1M	34.5509	11	1.86188	0.56138
	Width_1M	54.64	11	4.822	1.454
Pair 6	GP_2M	33.8745	11	2.98982	0.90147
	Width_2M	29.91	11	1.64	0.495

* All the values are in pixels (X)

Paired Samples Test

		Paired Differences		t	df	Sig. (2-tailed)
		95% Confidence Interval of the Difference				
		Lower	Upper			
Pair 1	GP_LI - Width_LI	-10.60777	-7.31223	-12.116	10	0.000
Pair 2	GP_Cn - Width_Cn	-42.03676	-36.89779	-34.224	10	0.000
Pair 3	GP_1P - Width_1P	-11.58195	-5.90532	-6.864	10	0.000
Pair 4	GP_2P - Width_2P	-9.87311	-6.10143	-9.437	10	0.000
Pair 5	GP_1M - Width_1M	-23.59899	-16.57193	-12.737	10	0.000
Pair 6	GP_2M - Width_2M	2.08546	5.84545	4.7	10	0.001

6. Paired t test for DENTSPLY - Large Mould

Paired Samples Statistics*

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	GP_LI	86.0109	11	1.27337	0.38394
	Width_LI	97.73	11	2.687	0.81
Pair 2	GP_Cn	60.5909	11	1.66573	0.50224
	Width_Cn	86.45	11	2.115	0.638
Pair 3	GP_1P	53.6018	11	1.31123	0.39535
	Width_1P	67.18	11	1.834	0.553
Pair 4	GP_2P	41.6527	11	1.13709	0.34285
	Width_2P	50.82	11	2.892	0.872
Pair 5	GP_1M	31.5073	11	1.79304	0.54062
	Width_1M	47.45	11	1.968	0.593
Pair 6	GP_2M	29.4218	11	1.22011	0.36788
	Width_2M	32	11	2.449	0.739

* All the values are in pixels (X)

Paired Samples Test

		Paired Differences		t	df	Sig. (2-tailed)
		95% Confidence Interval of the Difference				
		Lower	Upper			
Pair 1	GP_LI - Width_LI	-13.53511	-9.89762	-14.354	10	0.000
Pair 2	GP_Cn - Width_Cn	-27.20361	-24.52367	-43.007	10	0.000
Pair 3	GP_1P - Width_1P	-14.99745	-12.16255	-21.347	10	0.000
Pair 4	GP_2P - Width_2P	-11.06556	-7.26535	-10.748	10	0.000
Pair 5	GP_1M - Width_1M	-17.44813	-14.44642	-23.675	10	0.000
Pair 6	GP_2M - Width_2M	-4.20677	-0.94959	-3.527	10	0.005

7. Mann-Whitney U Test

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
Proportion CI/LI	66	1.4459	.07367	1.31	1.59	1.3901	1.4574	1.5115
Proportion LI/Cn	66	1.0854	.05688	.96	1.22	1.0440	1.0811	1.1280
Proportion Cn/1P	66	1.4468	.18816	1.16	1.98	1.3168	1.4135	1.5308
Proportion 1P/2P	66	1.3050	.13671	1.02	1.61	1.1891	1.2891	1.4052
Proportion 2P/1M	66	1.0412	.10744	.81	1.26	.9755	1.0430	1.1310
Proportion 1M/2M	66	2.0676	1.08991	1.18	5.63	1.4815	1.6530	1.9000
Brand Type	66	1.50	.504	1	2	1.00	1.50	2.00

Mann-Whitney Test Ranks

	Brand Type	N	Mean Rank	Sum of Ranks
Proportion CI/LI	1	33	41.59	1372.50
	2	33	25.41	838.50
	Total	66		
Proportion LI/Cn	1	33	38.52	1271.00
	2	33	28.48	940.00
	Total	66		
Proportion Cn/1P	1	33	30.15	995.00
	2	33	36.85	1216.00
	Total	66		
Proportion 1P/2P	1	33	32.82	1083.00
	2	33	34.18	1128.00
	Total	66		
Proportion 2P/1M	1	33	33.61	1109.00
	2	33	33.39	1102.00
	Total	66		
Proportion 1M/2M	1	33	33.36	1101.00
	2	33	33.64	1110.00
	Total	66		

Test Statistics[a]

	Proportion *CI*/LI	Proportion LI/Cn	Proportion Cn/1P	Proportion 1P/2P	Proportion 2P/1M	Proportion 1M/2M
Mann-Whitney U	277.500	379.000	434.000	522.000	541.000	540.000
Z	-3.424	-2.123	-1.417	-.289	-.045	-.058
Asymp. Sig. (2-tailed)	.001	.034	.156	.773	.964	.954

a. Grouping Variable: Brand Type

12. APPENDIX 3: RAW DATA

N	Brand	Type	Proportion CI/LI	Proportion LI/Cn	Proportion Cn/1P	Proportion 1P/2P	Proportion 2P/1M	Proportion 1M/2M
1	Ivoclar	SMALL	1.51	1.02	1.45	1.15	1.02	1.65
2	Ivoclar	SMALL	1.52	1.01	1.58	1.18	1.07	1.75
3	Ivoclar	SMALL	1.52	1.06	1.61	1.13	1.15	1.63
4	Ivoclar	SMALL	1.48	1.09	1.46	1.23	1.16	1.58
5	Ivoclar	SMALL	1.51	1.04	1.50	1.15	1.18	1.54
6	Ivoclar	SMALL	1.48	1.06	1.54	1.13	1.15	1.48
7	Ivoclar	SMALL	1.51	1.09	1.40	1.14	1.16	1.65
8	Ivoclar	SMALL	1.45	1.07	1.53	1.10	1.17	1.71
9	Ivoclar	SMALL	1.51	1.07	1.55	1.18	1.13	1.48
10	Ivoclar	SMALL	1.53	1.01	1.46	1.30	0.98	1.33
11	Ivoclar	SMALL	1.53	1.08	1.45	1.25	1.02	1.43
12	Ivoclar	MEDIUM	1.36	1.12	1.34	1.21	1.04	1.53
13	Ivoclar	MEDIUM	1.52	1.07	1.17	1.37	0.98	1.52
14	Ivoclar	MEDIUM	1.41	1.15	1.32	1.14	1.20	1.32
15	Ivoclar	MEDIUM	1.40	1.17	1.24	1.16	1.22	1.46
16	Ivoclar	MEDIUM	1.44	1.14	1.16	1.36	1.12	1.50
17	Ivoclar	MEDIUM	1.42	1.09	1.35	1.16	1.07	1.44
18	Ivoclar	MEDIUM	1.40	1.22	1.21	1.33	1.05	1.71
19	Ivoclar	MEDIUM	1.37	1.18	1.30	1.27	1.13	1.18
20	Ivoclar	MEDIUM	1.35	1.22	1.20	1.22	1.26	1.30
21	Ivoclar	MEDIUM	1.40	1.08	1.27	1.19	1.16	1.32
22	Ivoclar	MEDIUM	1.31	1.20	1.25	1.24	1.04	1.42
23	Ivoclar	LARGE	1.59	1.07	1.40	1.49	0.94	3.43
24	Ivoclar	LARGE	1.50	1.08	1.49	1.48	0.88	3.85
25	Ivoclar	LARGE	1.52	1.14	1.49	1.49	0.91	5.63
26	Ivoclar	LARGE	1.46	1.10	1.45	1.43	0.85	3.24
27	Ivoclar	LARGE	1.52	1.11	1.37	1.60	0.81	4.33
28	Ivoclar	LARGE	1.54	1.09	1.45	1.42	0.92	4.45
29	Ivoclar	LARGE	1.50	1.10	1.40	1.49	0.98	4.18
30	Ivoclar	LARGE	1.56	1.08	1.37	1.55	0.86	4.64
31	Ivoclar	LARGE	1.53	1.10	1.41	1.57	0.81	5.20
32	Ivoclar	LARGE	1.52	1.16	1.35	1.61	0.91	5.00
33	Ivoclar	LARGE	1.51	1.08	1.42	1.49	0.85	4.08
34	Denstply	SMALL	1.32	1.02	1.77	1.33	0.97	1.48
35	Denstply	SMALL	1.31	1.00	1.98	1.10	0.98	1.86
36	Denstply	SMALL	1.35	1.05	1.71	1.26	0.97	1.86
37	Denstply	SMALL	1.33	1.03	1.87	1.18	0.98	1.82
38	Denstply	SMALL	1.31	1.13	1.56	1.25	1.14	1.59
39	Denstply	SMALL	1.36	1.02	1.83	1.21	1.00	1.65
40	Denstply	SMALL	1.37	1.04	1.75	1.17	1.08	1.52
41	Denstply	SMALL	1.37	1.06	1.72	1.21	1.03	1.90
42	Denstply	SMALL	1.34	1.06	1.71	1.17	1.11	1.85
43	Denstply	SMALL	1.37	1.07	1.72	1.21	1.03	1.90
44	Denstply	SMALL	1.34	0.99	1.98	1.02	1.19	1.57
45	Denstply	MEDIUM	1.46	1.03	1.45	1.35	0.90	2.10
46	Denstply	MEDIUM	1.49	1.02	1.45	1.54	0.81	2.00
47	Denstply	MEDIUM	1.46	1.06	1.36	1.45	1.04	1.69
48	Denstply	MEDIUM	1.44	1.08	1.33	1.34	1.09	1.90
49	Denstply	MEDIUM	1.51	0.97	1.47	1.42	1.10	1.85
50	Denstply	MEDIUM	1.46	1.10	1.31	1.45	1.06	1.68
51	Denstply	MEDIUM	1.53	0.96	1.58	1.31	1.15	1.66
52	Denstply	MEDIUM	1.49	1.05	1.46	1.28	1.09	1.71
53	Denstply	MEDIUM	1.48	1.03	1.51	1.36	1.04	1.70
54	Denstply	MEDIUM	1.50	1.06	1.39	1.35	1.08	1.96
55	Denstply	MEDIUM	1.54	1.03	1.43	1.38	0.95	1.87
56	Denstply	LARGE	1.40	1.16	1.21	1.27	1.12	1.53
57	Denstply	LARGE	1.50	1.08	1.30	1.34	1.09	1.59
58	Denstply	LARGE	1.41	1.15	1.25	1.39	1.14	1.34
59	Denstply	LARGE	1.44	1.13	1.25	1.41	1.02	1.66
60	Denstply	LARGE	1.47	1.12	1.27	1.25	1.15	1.48
61	Denstply	LARGE	1.42	1.13	1.33	1.33	1.00	1.60
62	Denstply	LARGE	1.40	1.09	1.35	1.24	1.10	1.39
63	Denstply	LARGE	1.35	1.16	1.32	1.40	1.00	1.38
64	Denstply	LARGE	1.41	1.15	1.34	1.20	1.15	1.38
65	Denstply	LARGE	1.40	1.16	1.26	1.38	1.02	1.40
66	Denstply	LARGE	1.43	1.10	1.28	1.37	1.00	1.63

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