EFFECT OF RIDGE SHAPE ON THE FIT OF DENTURE BASES

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To all who nurtured my intellectual curiosity, academic interests, and sense of scholarship, making this milestone possible
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# TABLE OF CONTENTS

ACKNOWLEDGMENTS .......................................................................................................................... 4

LIST OF FIGURES .................................................................................................................................. 6

ABSTRACT ........................................................................................................................................... 7

CHAPTER

1 INTRODUCTION AND LITERATURE REVIEW ........................................................................... 9

   Historical Overview of Materials Used to Replace Teeth ................................................................. 9
   Polymerization Shrinkage of Poly Methyl Methacrylate ................................................................. 11
   Techniques Used for Processing of Poly Methyl Methacrylate ....................................................... 12
   Processing Errors of Poly Methyl Methacrylate ............................................................................. 13
   Occlusal Disharmonies after Processing Heat Cured Poly Methyl Methacrylates ....................... 15
   Objective of Study ......................................................................................................................... 15

2 MATERIALS AND METHODS ..................................................................................................... 16

   Simulated Ridges ............................................................................................................................ 16
   Acrylic Base Manufacturing Process ............................................................................................... 17
   Measuring Approach ..................................................................................................................... 18

3 RESULTS AND DISCUSSION .................................................................................................. 23

   Results ........................................................................................................................................... 23
   Zero Displacement ......................................................................................................................... 23
   Horizontal Displacement ............................................................................................................... 23
   Discussion ..................................................................................................................................... 24
   Zero Displacement ......................................................................................................................... 24
   Horizontal Displacement ............................................................................................................... 25

4 SUMMARY AND CONCLUSIONS .............................................................................................. 34

LIST OF REFERENCES ...................................................................................................................... 35

BIOGRAPHICAL SKETCH .................................................................................................................. 39
### LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1</td>
<td>Aluminum ridge pairs.</td>
<td>21</td>
</tr>
<tr>
<td>2-2</td>
<td>Ridge pair secured to aluminum plate</td>
<td>21</td>
</tr>
<tr>
<td>2-3</td>
<td>Ridge pair mounted to plastic stand</td>
<td>22</td>
</tr>
<tr>
<td>3-1</td>
<td>Ridge pair 1, 5° convergence</td>
<td>28</td>
</tr>
<tr>
<td>3-2</td>
<td>Ridge pair 1, 10° convergence</td>
<td>28</td>
</tr>
<tr>
<td>3-3</td>
<td>Ridge pair 1, 15° convergence</td>
<td>29</td>
</tr>
<tr>
<td>3-4</td>
<td>Ridge pair 2, 5° convergence</td>
<td>29</td>
</tr>
<tr>
<td>3-5</td>
<td>Ridge pair 2, 10° convergence</td>
<td>30</td>
</tr>
<tr>
<td>3-6</td>
<td>Ridge pair 2, 15° convergence</td>
<td>30</td>
</tr>
<tr>
<td>3-7</td>
<td>Ridge pair 3, 5° convergence</td>
<td>31</td>
</tr>
<tr>
<td>3-8</td>
<td>Ridge pair 3, 10° convergence</td>
<td>31</td>
</tr>
<tr>
<td>3-9</td>
<td>Ridge pair 3, 15° convergence</td>
<td>32</td>
</tr>
<tr>
<td>3-10</td>
<td>Distance between the acrylic base plates and the metal palatal plate</td>
<td>33</td>
</tr>
</tbody>
</table>
The objective of this study was to determine the accuracy of heat cured acrylic base plates on simulated edentulous ridges with different configurations. Edentulous ridges of the maxillae were simulated by attaching parallel trapetsoidal rods simulating ridges to a flat plate simulating the palate. The slope of the palatal “ridges” was always 45°, while the outside slopes were either 85°, 75° or 60°. The sagital ridge convergencies were 5°, 10° or 15° for each ridge shape. No ridges were simulated in the anterior regions. Two micrometers were attached to the aluminum base that mounts the simulated ridges. One measured the space between the metal palate surface and the base plate, and the other displaced the base plates in sagital anterior direction. PVS impressions of the simulated ridges were made. They were poured in type IV stone. A total of 54 acrylic base plates with 1 mm thickness were fabricated (n=6 per experimental condition). The acrylic base plates were placed on matching ridge models and the palatal-base plate distances were measured at each 1.000mm as the base plates were displaced in an anterior direction. The x and y values were plotted showing the vertical palate-base plate distance (y) as a function of anterior displacement (x). All results followed third degree polynomials. In conclusion, the best fit at zero displacement was for ridges with an anterior
convergency of 15° and an outside slope 60°. Furthermore, it can be concluded from this study that the steeper the outer angles of the ridges, the worse the fit of the acrylic base at zero displacement. Also, the anterior displacement of a relatively well fitting acrylic base plate causes the fit to become poor because of the influence of the inner slopes of the simulated ridges.
CHAPTER 1
INTRODUCTION AND LITERATURE REVIEW

Historical Overview of Materials Used to Replace Teeth

History reveals evidence of human struggle to replace missing teeth as far back as 3000 BC. Evidence was found that proves the Egyptians bounded teeth together with gold wires. In 700-500 B.C., the Etruscans became experts in restorative dentistry using gold bonded bridge work. It is speculated that the Mayas were the first to perform tooth transplantation 200-900 B.C. Pfaff proposed softened wax techniques to make impressions of teeth sometime between 1746 and 1755. This was a major breakthrough because it was the first time it became possible to use the indirect technique to fabricate dentures. As time passed by, loss of teeth was both expected and accepted by the poor and wealthy. George Washington had several dentures throughout the years, some were made out of gold, lead alloy, hippopotamus tusk and human teeth. As time progressed, wealthy people had dentures made of silver, gold, mother of pearl or agate. In the 1700’s entire dentures were made of porcelain. The porcelain dentures were appealing because unlike their predecessors, they would not rot. Porcelain teeth were then developed and moved to the United States in the 1800’s and were marketed on a large scale. In the 19th century, vulcanized rubber was the next discovery that caused a breakthrough in denture fabrication. Following vulcanized rubber, polymers such as polystyrene, vinyl acrylates, nylon and polycarbonate were used for fabricating dentures.

Today, the most commonly used material for denture bases is methyl methacrylate. It was first discovered in 1927, when Bauer, working with Otto Rohm, of Darmstadt, Germany, developed a synthesis making possible the production of small quantities of methyl ester of acrylic acid. Products of polymerization of acrylic acid and its derivatives are known as acrylic resins. It is worth mentioning that German researchers were the first leaders of the
field of acrylic discovery. The fundamental research of acrylic resins for use in dentistry was performed by German researchers and confirmed by researchers in the USA.

A progress report on denture base materials of that time was published by Sweeney et al. In 1936, The House of Delegates of the American Dental Association requested a study of denture materials from the research committee of the National Bureau of Standards. The research was started with the objective of developing a set of tests, and test methods, which would satisfactorily establish the suitability of denture base materials. The report dealt with tests of denture base materials prior to PMMA mentioned earlier.

In 1937 acrylic resin was introduced to the United States from Germany and has since then remained the material of choice in fabricating dentures. In 1939, Sweeney et al. published an article that compared the widely used denture base rubber and other materials with the relatively newly discovered PMMA resin. He performed physical and chemical tests on both materials and found PMMA to be superior to the hard rubber, which was the most used and most satisfactory of denture bases at that time. The ninth report on organic denture base materials from the laboratories of the National Bureau of Standards was published in 1942. It also compared PMMA resins with the denture base materials of that time and found PMMA and acrylic-vinyl resin to be the most satisfactory for denture bases. The significance of this article is that any new plastic from that time forward should first be tested as described in this paper before marketed to be used as a denture base material. Peyton et al. recognized the potential of using acrylics in denture bases and restorative procedures but warns of failures in the latter if not properly processed or placed. In 1942, Tylman et al. recognized the potential of PMMA for use as denture bases but warned of their use as restorative materials due to water absorption.
of the material, which causes expansion. Acrylic resin was gaining in popularity due to its excellent esthetic properties, adequate strength, resiliency, ease of processing and finishing.20

**Polymerization Shrinkage of Poly Methyl Methacrylate**

Acrylic resin did show a high degree of accuracy compared with the previous materials but did not come without some shortcomings. The combined effects of polymerization contraction of the PMMA acrylic, its thermal contraction, and strain induced during deflasking result in poor adaptation of the denture base to the edentulous arch.21 The magnitude of this problem is easily understood when one realizes that the volumetric shrinkage of the monomer is as high as 21 vol-%

The denture base is required to intimately contact the supporting tissue in order for it to be successful. The shrinkage of the acrylic denture negatively affects the intimate contact between the acrylic denture and the supporting tissue. If the denture contracts away from certain areas in the edentulous arch, then it will tend to apply pressure in other areas and could cause a change in occlusion. Several authors stated that the shrinkage of PMMA was a 3-dimensional process in several planes and was not linear.22,23 Polychronakis et al.24 agreed that maxillary dentures did exhibit dimensional changes but the dimensional changes were considered clinically acceptable.

Several authors used different techniques in to measure the effect of polymerization shrinkage on the adaptation of the denture base.15,25 Anthony et al.26 observed that nearly all maxillary dentures, after they are processed and then placed back on the master casts, will appear to contact the model in the flange regions and be deficient at the buccal borders. He also observed that the dentures showed the greatest discrepancies across the central portion of the posterior border.26 Sykora et al.27 measured the opening distance at the posterior palatal seal at 5 mm intervals across the posterior palatal border. Takamata et al.28 flowed low viscosity addition polymerizing PVS material between the processed denture and the master die and then
weighed the PVS on an accurate scale. Consani et al.29 placed processed resin bases on the master casts with an adhesive resin and then sectioned them laterally to measure the distance between the resin and the master cast at different anterior-posterior segments.

Kawara et al.30 and Kimoto et al.31 used strain gauges and thermo-couples that were imbedded in the resin at time of resin packing to quantitatively determine the degree of distortion of heat cured PMMA resins while being processed. Kawara et al.30 and Kimoto et al.31 studies differed from other studies by studying the shrinkage in a dynamic manner compared to others that studied the distortion after the denture base had been processed and remained stationary.

Techniques Used for Processing of Poly Methyl Methacrylate

Several techniques for processing PMMA dentures have been described in the literature.28 The traditional and most common technique of processing dentures has been in a brass denture flask for compression molding of the heat cure acrylic while in its doughy stage.28 Several authors studied different processing techniques on the outcome of denture adaptation. Sykora et al.27 compared the traditional heat cured compression molding technique to the injection molding technique. Their results showed that the injection molding technique showed greater dimensional stability compared to the compression molding technique. Goodkind et al.32 compared pour technique of processing dentures versus cold cure packing and found that bases processed with pour technique shrunk more than those processed from the cold cure technique. Peyton et al.33 compared self-curing and heat curing denture resins. He found that the dimensional stability of the self-curing acrylic is generally equal or superior to heat-cured acrylic. Dukes et al.34 compared compression molding to the pour technique and discovered that compression molding resulted in a smaller increase in vertical dimension of occlusion compared to the pour resin technique. Several other authors studied different variations in denture processing techniques but keeping the shape of the master model constant. In contrast,
some other authors chose to vary the shape of the master model. Sykora et al.27 compared a continuous-injection technique to the trial pack technique but varied the palatal vault shape by either being flat or high. They stated that the injection-technique showed better adaptability and that the results were influenced by palatal shape. Pow et al.35 studied the effect of relining and rebasing on 22 different maxillary and mandibular complete dentures. They found that relining and rebasing procedures exhibited shrinkage of 0.3% despite different shapes of maxillary and mandibular dentures.

Hedge et al.10 compared V-shaped, U-shaped and flat-shaped palatal vaults using the heat cured press pack technique. They concluded that the V shaped palatal vault exhibited the highest dimensional change in the frontal and vertical planes. Körber studied the effect of ridge size and ridge shape and found that as the ridge size increased and the outer surfaces became more parallel, the larger the palatal discrepancy became.36 Mandibular denture dimensional changes were measured by Lechner et al.37. They found that linear shrinkage occurred in all dimensions with the greatest shrinkage in the anterior-posterior direction along the lingual flanges. Vast amount of literature is available that compares the processing techniques of complete dentures against each other. Some of the for-mentioned articles add limited geometrical analysis of the edentulous arch to the comparison. The geometry usually includes the palatal vault shape and does not focus on other areas of the edentulous arch such as the outer slope of the buccal plates or the overall taper of the jaw when viewed occlusally.

**Processing Errors of Poly Methyl Methacrylate**

Fabricating heat cured PMMA dentures requires multiple steps with special attention to details in each step. Several articles are available that address the different steps in fabricating dentures and suggest methods to reduce polymerization shrinkage.38 Chen et al.39 found that thicker dentures exhibited less molar to molar linear shrinkage but higher gaps in the posterior
palate compared with thinner dentures. Woelfel et al.40 agreed with Chen et al. in that thick upper and lower dentures changed dimensionally less than thin ones. Sykora et al.41 investigated the type of stone used in flaking dentures. They found that the use of high expansion stone yielded dentures with less gap at the posterior palate compared to dentures fabricated with type III stone. Becker et al.42 found no difference between all gypsum processing technique compared to silicone gypsum processing technique.

Skinner et al.43 studied the effect of varying the powder-liquid ratio of the resin on shrinkage and water sorption. They found that it had little effect as far as dimensional changes occurring during and after processing. Jerolimov et al.44 varied polymer/monomer mixing ratios from 1.5:1 to 4.5:1 vol/vol to determine the effect on dimensional accuracy and impact resistance of PMMA resin. The wide variation in powder-liquid ratio used by Kawara et al.30 revealed that a long, low-temperature processing technique was needed for the heat-activated PMMA to reduce polymerization shrinkage and prevent boiling of the monomer. Yeung et al.45 findings disagreed with those findings of Kawara et al.30 because their results concluded that temperature differential had been excluded as a reason for the warpage of dentures. Kobayashi et al.46 suggested a gradual cooling course for 12 h or more after processing the heat-activated acrylic denture to effectively lessen the denture deformation. Kimoto et al.31 concur with these findings. Komiyama et al.47 on the other hand suggested bench cooling the flask for a minimum of 1 d before deflasking. After processing and retrieval of the denture, Sykora et al.27 and Anderson et al.48 agreed that immersion of the denture in water results in no statistically significant change in dimensions. Cal et al.45 and Cheng et al.50 recommend adding glass fibers to the denture base polymer to reduce dimensional changes in dentures. Collard et al.51 found
that the addition of montmorillonite to denture base resins reduced the linear shrinkage and impact strength, while increased the roughness of the denture resin.

**Occlusal Disharmonies after Processing Heat Cured Poly Methyl Methacrylates**

Occlusal disharmonies after processing complete dentures are very common. A laboratory remounting procedure is performed and the distortion usually causes a rise in the incisal pin of an articulator an average of 0.127 mm. Wesley et al. found a definite shift of tooth contacts to the most posterior teeth after processing. Villa et al. reported that shrinkage of an acrylic resin during processing was the cause of occlusal discrepancies.

Basso et al. compared the increase in vertical dimension of occlusion between dentures with teeth arranged in lingualized occlusion and conventional balanced occlusion after heat-processing. They found that both teeth arrangements exhibited similar vertical dimension of occlusion increase but the lingualized occlusion was easier to adjust. Lingualized occlusion was advocated as an effective occlusal scheme for maintaining balanced occlusion easily on one hand and is esthetically pleasing on the other hand. Also, lingualized occlusion ease of adjustability may counteract the harmful tendency for teeth to shift due to polymerization distortion of the heat cured PMMA dentures.

**Objective of Study**

The objective of this study was to determine the accuracy of heat cured acrylic base plates on simulated edentulous ridges with different geometric configurations. The hypothesis to be tested was that the more parallel the outer ridges are, the larger the palatal discrepancy would be, and the more parallel the ridges are in sagital direction, the more the base needs to be displaced in anterior direction until optimal palatal adaptation is reached.
CHAPTER 2
MATERIALS AND METHODS

Simulated Ridges

Simulated ridges and sections of maxillary edentulous arches were made in aluminum by attaching machined ridge sections to aluminum plates. The palatal slope of the aluminum ridges was constant at a 45 degree angle. The outer slope of the ridges varied. One pair had an outer slope of 85 degrees (pair number 1), the second pair had a slope of 75 degrees (pair number two) and the third pair had a slope of 60 degrees (pair number 3). The right height of the three different shapes was kept constant at 10 mm (Figure 2-1).

In addition to the ridge shape variable, a second variable was the angle of convergence between each of the paired simulated edentulous ridges when viewed from the anterior-sagital direction. These angles were 5 degrees, 10 degrees and 15 degrees. For each ridge shape pair, three aluminum plates were fabricated so the anterior-sagital conditions for each ridge shape criteria could be met. The aluminum ridges were mounted on the plates by means of threaded screws that precisely fit the aluminum ridges from the bottom. Thus, a total of nine simulated ridge conditions were made (Figure 2-2).

After mounting the ridge pair on the respective aluminum plate, the partly simulated aluminum maxilla was fitted to a four-legged plastic table that would suspend the aluminum plate and ridges approximately 254 mm high (Figure 2-3). As seen from Figure 2-3, the aluminum ridges lacked anterior segments representing the premaxillae. This segment was left out intentionally. The reason the premaxillae was omitted from the design was due to the method used to collect fitness data as the base was displaced in anterior direction.
**Acrylic Base Manufacturing Process**

A polyvinylsiloxane (PVS) duplicating material (PolyPour, batch #060321, GC Lab Technologies, Alsip, IL, USA) was used to replicate each aluminum ridge pair. The area of impression making was standardized by boxing the area of the ridges by using an aluminum cylinder (inner diameter of 120 mm and 80 mm high) that fit all the plates accurately. After boxing the aluminum ridges, the PVS catalyst and base were mixed. Equal quantity of the PVS duplicating material was mixed (60 mL of each component) for 15 s until a homogenous color was achieved then the mixture was slowly poured over the aluminum ridges. With this approach one PVS mold per ridge condition was made. The impressions were poured in dental stone (Microstone, batch# 027040705, Whip Mix, Louisville, KY, USA). The stone came in individualized packages of 140 g. Each package was mixed with 40 mL water and hand mixed for 15 s, whereupon the stone was mixed under vacuum (Vac-u-vester, Serial # 0179003, Whip Mix, Louisville, KY, USA) for another 25 s. The stone was then poured in each of the PVS impressions and retrieved one hour after pouring. Each PVS mold was poured six times to yield a total of 9 x 6 (54 stone models).

On each of the made gypsum casts, one layer of base plate wax (Henry Schien, Pink Medium Wax, batch# 062542, Melville, NY, USA) was heated uniformly and fitted over each model. The edges of the base plate wax were cut to fit the outer slopes of the model, the inner slopes and the palate.

Flasking was done by placing the wax covered stone model in the base of the flask (Hanau Varsity, Hanau Eng. Co. Inc., Model# 66039, Buffalo, NY, USA) and pouring stone (Microstone, batch# 027040705, Whip Mix, Louisville, KY, USA) into the flask. The stone around the master model was smoothed even and any undercuts were removed. A plaster separator (Swan petroleum jelly, Cuberland Swan, Smyrna, TN, USA) was painted on the master
model and base stone. The upper half of the flask was then placed on the base securely and a second mix of stone (Microstone) was flowed in place while the flask was resting on a vibrator (Buffalo, No.2, Buffalo Dental Mfg Co., Inc., Syosset, NY, USA) at medium vibration. A plaster separating material (Swan petroleum jelly) was then painted over the second stage pour. A new mix of stone (Microstone) was then placed on the top half of the flask that was slightly overfilled. The lid of the flask was then gently tapped to allow excess stone to exit the holes in the flask edges and lid. The excess stone was cleaned off after it had set.

The acrylic base plates were processed in a similar manner described by Becker. After boil-out of the base plate wax and a brief cooling of 15 minutes, the monomer and polymer of the heat cured resin (Lucitone, batch# 061113, Dentsply Int., York, PA) were mixed according to the instructions supplied by the manufacturers liquid-powder ratio and allowed to gel in an air tight mixing jar for about three minutes. The room temperature was kept at 23.5°C. One trial pack of the resin was needed due to the small amount needed to fill the lost wax. Eleven hundred twenty N of pressure was used for the trial pack with two sheets of cellophane. Final closure was done at 20016 N of pressure. The flask was then transferred to a hand press. The long cure method was used for polymerization by immersing the flask in 71° C for 9 h. After 9 h in the water bath, the flask was bench-cooled for 12 h in compliance with Kobayashi. After separation from the flask; the acrylic base plates were recovered from the stone models and placed in an air tight plastic bag with water. Measurements were made approximately 24 h after recovery of the base plates.

**Measuring Approach**

To measure the fit of the acrylic bases to the original aluminum models, two micrometers (Fowler 0-6” 0.00005”, Fred V. Fowler Co., Inc, Newton, Massachusetts, USA) were attached to the aluminum plates to which the aluminum ridges had been mounted. The micrometers were
attached by means of screws that were machined in each of the aluminum plates in the exact same position (Figure 2-3). One micrometer was attached to the bottom of the aluminum plate in the center of the simulated jaw segment. At that location, a hole was drilled so the micrometer could read the distance between the aluminum plate and the palate of the acrylic base. This hole was located in the exact same position in relation to the pair of aluminum ridges regardless which plate they were mounted to. The other micrometer was attached at the edge of the aluminum plate touching the widest part of the acrylic base representing the posterior edge of the denture. This micrometer was used to displace the acrylic base anteriorly. Thus, by use of these two micrometers, it was possible to record the vertical distance between the palate part of the aluminum plate and the acrylic base plate as it was displaced in the horizontal direction. The reason the aluminum ridges lacked the anterior segment representing the premaxillae was to allow the recording of the acrylic base as it was displaced anteriorly without interfering with an anterior ridge segment.

Before a measurement procedure started, all sharp and uneven edges around the periphery of the acrylic denture base were smoothed to allow the seating of the acrylic base plate on the aluminum ridges more accurately. The edge of the denture base was aligned with a straight line connecting the posterior edges of the aluminum ridges. This position represented the horizontal location of the denture base before it had been displaced and was assigned the horizontal 0.000 mm position. The vertical micrometer was set in its zero position representing a position when its measuring rod was flush with the simulated palate of the aluminum plate. The vertical micrometers wheel was then turned until the rod touched the intaglio surface of the denture base. The reading of that distance was recorded as the vertical discrepancy at the horizontal “0” position. The denture base was then displaced horizontally in 1.000 mm steps by using the
horizontal micrometers rod and at each such step the distance between the palate and the intaglio of the denture base was read with the vertical micrometer at that position until no further displacement could be read because of interference between the two micrometers (Figure 2-3).

The interference between the two micrometers would coincide with a horizontal displacement of 14.000 mm in all 54 cases.

The measured distances between the acrylic base plates and the aluminum plates at all intervals were entered into Microsoft Excel (Microsoft, Redmond, WA, USA) and plotted using the XY scatter chart type. After the graphs were completed, Microsoft Excel was used to formulate a trend-line of the plotted data. The trend-line chosen was a polynomial of the third degree. In addition, the software was used to calculate the equation of the third degree polynomial and show it on the graph. By deriving the third degree polynomial, it was also possible to determine max and mean values that were found for some cases within the 0.000 to 14.000 mm displacement.
Figure 2-1. Aluminum ridge pairs. Pair number 1 is far left with outer wall slope of 85°. Pair number 2 in the middle with outer wall slope of 75° and pair number 3 with outer wall slope of 60° in the far right.

Figure 2-2. Ridge pair secured to aluminum plate. The sagittal ridge convergences were either 5°, 10° or 15° for each ridge pair. This was achieved by mounting the machined ridge pairs on aluminum plates by means of precisely placed screws. No ridges were simulated in the anterior region.
Figure 2-3. Ridge pair mounted to plastic stand. To measure the fit of the processed acrylic bases, two micrometers were attached to the aluminum plates. One measured any space between the intaglio surface of the base plate, and the other measured the displacement of the base plate in sagital/anterior direction.
CHAPTER 3
RESULTS AND DISCUSSION

Results

Zero Displacement

The results for the different ridges are presented in Figures 3-1 to 3-9. Figure 3-1 shows the graph for the ridge pair 1 with the 5 degrees convergence angle. At the zero mm displacement position, the average of the six samples yielded a spacing between the palatal part of the acrylic base and the metal plate of 2.290 mm. Figure 3-2 shows the value for the same ridge pair but with a sagital convergence angle of 10 degrees, while Figure 3-3 shows the displacement for the same ridge pair but with a convergence angle of 15 degrees. As seen from Figure 3-2, the zero mm displacement position was an average of 1.313 mm, while in Figure 3-3, the zero mm displacement position was an average of 0.564 mm. From these figures it is clear that at the zero mm position distance, the acrylic plate to metal plate distance decreased, suggesting that as the convergence angle between the aluminum ridge increased, the better the fit between the acrylic base plate and the aluminum ridges. A similar pattern was observed in the 10 and 15 degree convergence of the aluminum ridges with 75 and 85 degree outer slopes at zero displacement.

Horizontal Displacement

After performing the measurements at zero displacement, the acrylic plates were displaced anteriorly by 1.000 mm increments. For the ridges with anterior convergency, the gap between the aluminum plate and the acrylic base plates decreased as the base plates were displaced anteriorly. However, after the gap between the acrylic base plates and the aluminum plates reached a certain distance, the acrylic plates started rising again and the measurements become larger. An exception was the 15 degree convergence ridges which had a tendency to raise the
acrylic plate early in the displacement if not as soon as the displacement had begun. The inner
slope of the aluminum ridges, which formed a 45 degree angle with the metal plates, was found
to be the contributing factors to the rise of the acrylic plates. Even though all inner slopes were
constant at 45 degrees, they influence the fit by interfering with the intaglio surface of the more
converging ridges as the base plate was anteriorly displaced (Figure 3-10).

The x and y values of each ridge condition (Figures 3-1 to 3-9) followed third degree
polynomials quite well (see the R-values for the different curves). The y-values at x=0 were
analyzed using a two-way ANOVA to determine significant effects (p<0.05) of ridge slope and
ridge convergency. The same analysis was conducted for the y-values determined at the 14.000
mm displacement location in sagital direction.

The results revealed strong significant correlations between ridge slope and ridge
convergency (p<0.001) and a weaker but still strongly significant (p<0.001) interaction between
these two variables. The polynomials made it also possible to determine the location within the
measured range where the shortest y-value existed. The results recorded at x=0.000 and
x=14.000 as well as where the shortest y-value were detected between these two end points.

**Discussion**

**Zero Displacement**

As seen from Figure 3-10, the y-values at zero displacement (blue bars) revealed that the
fit of the processed record base on ridge pair 1 (85° outer walls) with 5°, 10° or 15° convergence
(1,5°), (1,10°) and (1,15°) is clearly worse than ridge pair 2 (75° outer wall) and ridge pair 3 (60°
outer wall) both with 5°,10° and 15° convergence. In other words, as the outer walls of the ridge
pairs became steeper, the worse the initial fit of the acrylic plates became apparent at zero mm
displacement. This can be attributed to the polymerization shrinkage of the acrylic base plates
resulting in a tighter contact on the outer wall of the steeper ridges (ridge pair 1 with 85° outer
walls) in comparison to the less steep outer walls of ridges 2 and 3 (with the 75° and 60° respectively).

Further along at zero mm displacement, ridge pair 1 with 5° convergence (1,5°) exhibits a poorer fit than the (1,10°) and (1,15°) convergency. When comparing all three ridge pairs (1, 2 and 3) with 5° convergence to same ridge pair with 10° and 15° convergence, it is clear that the fit of the acrylic base plates improves respectively as the sagital convergency increases.

Consequently, all ridge pairs with 5° convergency (smallest anterior convergency angle), adapts poorly in comparison to ridge pairs which converged more. On the other hand, it was noticed that the poor fit of the record base at (1,5°) was improved when the same convergence angle (5°) was tested on ridge pair 2 and 3 (75° and 60° respectively) at zero displacement (Figure 3-10). The same applies to all ridge pairs with 10° and 15° convergency at zero displacement (Figure 3-10). Thus, ridges with more sagital/anterior convergence had better adapting record bases at x=0. This allows us to postulate that edentulous maxilllas that are tapered when viewed occlusaly would have a better denture fit compared to an edentulous maxillae that is squared when viewed occlusaly. This result is in line with Körber’s clinical study. In addition, dentures fabricated for edentulous maxillary ridges with more resorption on the buccal plate would fit better than dentures made for parallel ridges.

**Horizontal Displacement**

At maximum displacement (x=14.00 mm, yellow bars in Figure 3-10), the fit of the processed base plate had an inversely related relationship with the fit of the acrylic base plate at zero displacement. This is especially evident if the initial fit is poor or good. It was noticed while performing the measurements that the inner slopes of the ridge pairs had a large influence on this phenomenon. When the initial fit of the record base was mediocre, it seemed to be a competition between the outside ridge slope and the palatal ridge slope as the base plate was
displaced in an anterior direction. That interaction explains why a minimum (red bar in Figure 3-10) in y-values existed between the extreme displacement locations \( x = 0.000 \text{ mm} \) and \( x = 14.000 \text{ mm} \). The reason behind the observations stated above is the degree of convergence of the ridge pairs. The more the ridge pairs converged anteriorly, the better the initial fit at zero displacement. However, the inner slope of the ridge pair influenced the base plate sooner in the displacement and worsens the fit of the base plate.

The results of this study can be applied to the edentulous arch when viewed transversely. The buccal plate of the edentulous maxillary arch resorbs medially as time passes. As suggested by the results of this investigation, the higher the degree of buccal resorption, the better the palatal adaptation will be. In cases where the edentulous arches are more parallel in sagittal direction, a clinician should expect more denture adjustments to be done on the buccal plate. Conversely, if the buccal plates of an edentulous arch seem highly resorbed, the clinician might predict an intimate adaptation of the denture.

The shapes of the edentulous arches when viewed occlusally is another factor that can help a clinician predict the fit of a denture. If the shape of the edentulous arch is tapered, one might argue that the patient will experience more sore spots around the inner slopes of the pre-maxillae area. This is extrapolated from the study because the higher the convergence seen between the edentulous arches, the sooner the interference exhibited by the inner slope of those edentulous arches. If the shape of the edentulous arches is square on the other hand, the clinician might find less sore spots around the inner slopes of the premaxillae because the inner slopes wouldn’t interfere with the seating of the denture as soon as a tapered shaped maxillary arch. In contrast, the sore spots might show more on the distal slope of the maxillary ridges close to the hamulus.
If a clinician could predict areas of soreness by studying the shape of an edentulous maxillary arch, he or she could relieve those areas on the master cast before the denture is processed or delivered. Possible ways to achieve such relief could be to use tin foils in order to relief the critical areas. For example, if a patient presented with a tapered maxillary arch, the dentist could use tin foil and burnish it on the premaxillae and the inner slopes of the edentulous arches close to the premaxillae to alleviate future soreness in this area resulting from the tendency of these areas to lift the acrylic base. However, the relief of the compressed regions could also have negative effects on denture retention. It is well-known that upper dentures are very well retained initially, but after a few weeks in service their retention decrease. That decrease is most likely a result of tissue adaptation to an initially poorly fit denture. Thus, by using tin foils to relief pressure sites. The relief could result in a denture that the patient would perceive as a poorly retained denture, which could have negative effects as well. Therefore, to determine whether predicted pressure sites should be relieved or not, it is important to perform systematic clinical studies in an attempt to find the best way to optimize the performance of a complete denture.

Further analysis could be performed to describe the fit of the acrylic base plate by use of a third degree polynomial \( y = Dx^3 + Cx^2 + Bx + A \). From our study we know that A in that polynomial describes the starting gap between the base plate and the palate. More analysis should be performed to study the variables B, C and D which could be linked to the shrinkage of the acrylic base plate and the two angle variables (outer slopes and sagital convergency).
Figure 3-1. Ridge pair 1, 5° convergence. Changes in base plate/palatal displacement as base plate is displaced in an anterior direction. Diamond shapes represent mean values (n=6) and adjacent vertical lines their standard deviations. The polynomial for this curve was \( y = 0.0006x^3 - 0.0094x^2 - 0.081x + 2.3074 \) and the \( R^2 = 0.9861 \).

Figure 3-2. Ridge pair 1, 10° convergence. Changes in base plate/palatal displacement as base plate is displaced in an anterior direction. Diamond shapes represent mean values (n=6) and adjacent vertical lines their standard deviations. The polynomial for this curve was \( y = 0.0003x^3 + 0.0049x^2 - 0.1489x + 1.3415 \) and the \( R^2 = 0.9665 \).
Figure 3-3. Ridge pair 1, 15° convergence. Changes in base plate/palatal displacement as base plate is displaced in an anterior direction. Diamond shapes represent mean values (n=6) and adjacent vertical lines their standard deviations. The polynomial for this curve was $y= -0.0004x^3 + 0.0111x^2 + 0.0183x + 0.535$ and the $R^2 = 0.999$

Figure 3-4. Ridge pair 2, 5° convergence. Changes in base plate/palatal displacement as base plate is displaced in an anterior direction. Diamond shapes represent mean values (n=6) and adjacent vertical lines their standard deviations. The polynomial for this curve was $y= -0.0005x^3 + 0.0158x^2 - 0.1314x + 0.8272$ and the $R^2 = 0.9088$
Figure 3-5. Ridge pair 2, 10° convergence. Changes in base plate/palatal displacement as base plate is displaced in an anterior direction. Diamond shapes represent mean values (n=6) and adjacent vertical lines their standard deviations. The polynomial for this curve was $y= -0.0006x^3 + 0.0179x^2 - 0.087x + 0.5298$ and the $R^2 = 0.9586$

Figure 3-6. Ridge pair 2, 15° convergence. Changes in base plate/palatal displacement as base plate is displaced in an anterior direction. Diamond shapes represent mean values (n=6) and adjacent vertical lines their standard deviations. The polynomial for this curve was $y= -0.0012x^3 + 0.027x^2 - 0.0527x + 0.2574$ and the $R^2 = 0.9773$
Figure 3-7. Ridge pair 3, 5° convergence. Changes in base plate/palatal displacement as base plate is displaced in an anterior direction. Diamond shapes represent mean values (n=6) and adjacent vertical lines their standard deviations. The polynomial for this curve was $y = -2E-05x^3 + 0.0034x^2 - 0.044x + 0.5539$ and the $R^2 = 0.9429$

Figure 3-8. Ridge pair 3, 10° convergence. Changes in base plate/palatal displacement as base plate is displaced in an anterior direction. Diamond shapes represent mean values (n=6) and adjacent vertical lines their standard deviations. The polynomial for this curve was $y = -0.0005x^3 + 0.0148x^2 - 0.0501x + 0.3924$ and the $R^2 = 0.9991$
Figure 3-9. Ridge pair 3, 15° convergence. Changes in base plate/palatal displacement as base plate is displaced in an anterior direction. Diamond shapes represent mean values (n=6) and adjacent vertical lines their standard deviations. The polynomial for this curve was $y = 0.0001x^3 - 0.0031x^2 + 0.1362x + 0.2738$ and the $R^2 = 0.9981$. 
Fig. 3-10. Distance between the acrylic base plates and the metal palatal plate. [At zero displacement (blue bars) and after 14 mm anterior displacement (yellow bars)]. In some cases a lower displacement was identified between the start and end positions. These minimum distances are shown as the red bars in the graph.
CHAPTER 4
SUMMARY AND CONCLUSIONS

Three configurations of edentulous arches with three options of anterior-sagital convergences (per pair) were tested. Heat cured acrylic base plates were fabricated to measure degree of adaptability of these base plates to the original simulated edentulous arches. The adaptability was measured by means of micrometers attached to the bottom and side of the base plates to be measured. The distance between the intaglio of the base plates and the palate was measured by the vertical micrometer while the horizontal displacement was performed by the horizontal micrometer in 1.000 mm increments. The measurements were plotted and equations of the graphs were determined.

It can be concluded from this study that the steeper the outer angles of the ridges, the worse the fit of the acrylic base at zero displacement. If the initial fit of the record base is poor (parallel outer slopes or parallel convergence), anterior displacement causes it to improve. On the other hand, if the initial fit of the record base is good (converged outer slopes or converged ridges), the anterior displacement causes the fit to become poor because of the influence of the inner slopes of the simulated ridges. These findings support our formulated hypothesis.
LIST OF REFERENCES


BIOGRAPHICAL SKETCH

I was born in 1976 and grew up in Kuwait City, Kuwait. I graduated from Sabah Elsalim High School in Kuwait City in 1994. In 1994, I enrolled at the University of Missouri Kansas City as a dental student where I joined the six year combined program of Bachelors of Arts and Science and Dentistry. At the University of Missouri Kansas City I met my wife Rana, whom I married to in 2002. Together we worked for the public health system of Kuwait from 2002 to 2004 before we decided to go back to the USA to specialize. I enrolled in the Graduate Prosthodontics program at The University of Florida and she enrolled at the Graduate Periodontic program at the University of Florida also. In 2004, Rana and I were blessed with our first born Jawan and in 2005 we were blessed with our son Yousef. After graduation as a specialist in Prosthodontics from the University of Florida in August of 2007, I will continue teaching there until 2008 when my wife graduates. After both of us have graduated, we plan to go back to Kuwait and work for the public health system for the betterment of the dental service of our beloved country. This is the beginning of the rest of our lives.