Mitigating Distortion of Light-Polymerized Composite Trial Bases

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MITIGATING DISTORTION OF LIGHT-POLYMERIZED COMPOSITE TRIAL BASES

by

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ABSTRACT
MITIGATING DISTORTION OF LIGHT-POLYMERIZED COMPOSITE TRIAL BASES.

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Triad Visible Light Cure (VLC) Denture Base Material, a light-polymerizing resin material, is commonly used by clinicians to make trial bases during the fabrication of dentures and in planning the prosthetic and surgical rehabilitation of edentulous patients. A well-known drawback to this material, however, is its tendency to distort during the light-polymerization process. This distortion tends to occur most often towards the posterior aspect of the palate, and can negatively impact the bases ability to be retained through suction to the edentulous arch. The purpose of this study was to evaluate whether an experimental polymerization protocol can mitigate distortion during the polymerization process to allow for a trial base with improved fit and retention.

Forty maxillary record bases were created, with one base fabricated on each cast. Twenty casts were used to fabricate trial bases per manufacturer recommendations, another 20 trial bases were fabricated according to the experimental protocol. These subgroups divided into 2 groups of 10, in which one-half of the trial bases made by a given protocol were evaluated for distortion at 1 hour, and the other half was evaluated at 7 days.

Statistical analysis was completed for the data collected. From this study, the following conclusions were made:

1. The experimental protocol for fabricating a trial base from Triad VLC material does not experience distortion up to 7 days after being polymerized that is statistically significant when compared to the distortion at 1 hour, but the manufacturer's protocol does experience distortion that is statistically significant.
2. The experimental protocol for fabricating a trial base from Trial VLC material experienced far less distortion than the manufacturer protocol.
3. The experimental protocol might allow for a trial base that fits and retains better than one made using the manufacturer’s protocol.

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CHAPTER 1

INTRODUCTION

Creating a retentive trial base is a critical step in the fabrication of complete dentures. This goal is often made more difficult due to the fact that compromises must be made when constructing a trial base. Though there are several materials a clinician can select from when making a trial base, there are inherent shortcomings associated with each one. While some classic materials offer ease of use, such as shellac or auto-polymerizing resin, deformation and poor adaptation to the edentulous ridge can complicate the record making process. Conversely, trial bases can be made from better-adapting materials such as cast metal or heat-polymerizing acrylic. Selection for these materials commit the clinician to a labor intensive process of trial base fabrication.

Another complicating factor in the construction of trial bases is the importance of preserving the definitive cast throughout the denture making process. When the trial base is made with a material that is ultimately not intended to be introduced into the final prosthesis during processing, a reliable definitive cast is necessary to reproduce the edentulous arch architecture that has been recorded in the final impression. Defects present in the definitive cast in the form of scratches and chips will be reproduced in the final prosthesis in the form of positive errors that will apply undue sharpness and pressure against the mucosa. These defects ultimately require time-consuming adjustment of the intaglio surface of the prosthesis, which results in a tissue-contacting area that is not truly representative of the adjacent edentulous anatomy. If a significant portion of the definitive cast is lost prior to processing as the result of trial base fabrication, it can result in the necessity for a new final impression appointment.

As a compromise between accuracy and ease of use, many clinicians have adopted the use of light-polymerized resin composites in order to fabricate trial bases. Light-polymerized resin composite trial base materials tend to be safer to handle than auto-polymerizing and heat-polymerizing resins, which expose clinicians and patients to resin monomer materials which may impose serious health risks, including skin and eye irritation, organ lesions, neuropathy, fertility disturbances, and others (Isfahan, 2010). In terms of ease of use, few materials offer easier handling than light-polymerizing resins, which typically come in individually packaged sheets of material that conform to the desired thickness for the base. Light-polymerized resin composite base materials are also available in an array of colors that mimic the general shade of gingiva. This helps to promote patient comfort and acceptance of the trial base during its repeated intraoral use during the denture fabrication process. Because the trial base mimics the gingiva, the clinician and patient are better able to evaluate tooth arrangements set into the base. If the shade of the base is inappropriate, it can become a distraction during esthetic evaluation. Finally, light-polymerizing resin materials have a more pleasant taste when compared with other temporary base materials. For example, shellac is often improved with zinc oxide paste and auto-polymerizing resins often leach excess monomer material. Light-polymerizing resins do not suffer from these shortcomings.

Despite the advantages that light-polymerizing resins offer the clinician, these materials do possess a shortcoming that can compromise the quality of a trial base. This shortcoming results from phenomenon that occurs during the light-polymerization process called 'resin uplift' phenomenon (Huh et al., 2010). During the polymerization process, light-polymerized resin composite materials tend to polymerize first at the point closest to the light source. Triad Visible Light Cure material (Triad, Dentsply Intl., York, Pa.), the most commonly used variety of light-polymerized resin composite, uses a proprietary polymerization machine that directs a light source at the trial base material from above a rotating platform on which the definitive cast sits.

As a result, the VLC material tends to polymerize first at the height of the residual ridge, typically the closest point to the light source. The un-polymerized resin composite material then contracts toward the initially polymerized material present at the ridge crest. The area affected the greatest by 'resin uplift' is typically the palatal region of the trial base, which contains material the greatest distance from the polymerizing light source. The unfortunate result is that polymerization shrinkage is greatest at the postpalatal seal region of the trial base.

Since light-polymerizing resin composite custom tray materials came into vogue in the 1990s, several articles have been published on protocols that help to mitigate distortion of the material during the polymerization process. Though reported to be effective, many of these protocols tend to involve a significant increase in complexity and intricacy of the custom tray fabrication process, while others require the use of additional expensive materials. As such, the question of how to improve the process of fabricating a custom tray out of light-polymerizing resin composite material has only been partly addressed. It is through this master's thesis that the question of how to more conveniently and accurately fabricate a trial base with light-polymerizing resin composite material is addressed.

CHAPTER 2

REVIEW OF THE LITERATURE

Trial bases, also known as base plates, are an important tool for construction of dentures. They act as a recording device, but also provide invaluable information to the practitioner about the patient's mental and physical capability to manage a removable appliance (Martone, 1963). Trial bases are made using a definitive cast of the maxillary or mandibular arch. The definitive cast accurately duplicates the soft and hard tissue anatomy of the arch using dental stone as a medium. Using the definitive cast, the clinician can carefully evaluate the patient's specific anatomic form, and create a trial base that adapts closely to the tissue surface and extends to appropriate anatomic borders. Regarding maxillary trial bases, it is important for the base to remain well-adapted to the patient's arch. Only a well-adapted trial base will allow for adequate retention through a 'suction cup' effect, otherwise gravity and the weight of the trial base will lead to its displacement. Designed as an analogue for the eventual complete denture prosthesis, it is important for trial bases to abide by the same principles that predict the success of the final prosthesis they aid in the construction of. These principles are first described by Pierre Fauchard in 1728 regarding the successful retention of complete dentures. Complete dentures should allow for negative atmospheric pressure and adhesion to aid in its retention, and the adaptation of the denture base should permit proper action of facial muscles (Swenson, 1947). This philosophy was further elaborated on by Fish in the early 20th century where he insisted a faithful reproduction of the bearing surface was a necessity, in addition, he felt the shape and form was vital for success (Fish, 1927).

In 1983, John Jones offered 16 attributes that a trial base should ideally possess (Jones, 1983). He stated that it is important for the trial base to be worn by the patient comfortably. The trial base should be well adapted to the patient's edentulous arch, and offers an overall good 'fit' to

the patient. From both a clinician and patient standpoint, the trial bases should be relatively inexpensive to fabricate. The material used should be readily adaptable to the cast so that the fabrication of the trial base is made easy. Rigidity is an important part of the trial base, as the records made using it require it to possess this quality. In order to offer comfort, the trial base must be thin enough that it is analogous to the final prosthesis, which means that it must have strength in thin areas. Because stability and retention are key, Jones states that resistance to breakage and dimensional strength are important attributes of trial bases. Good color and taste are considerations that must be made in addition. If the patient finds the trial base distasteful to look at, it can influence their perception of the cleanliness or safety associated with wearing the trial base in their mouths. Besides bad taste being in itself unpleasant, it could prevent the patient from being able to perform naturally during the record making procedures. From the practitioner's standpoint, a trial base material that does not require an extensive armamentarium during the fabrication process is of huge benefit. Temperature stability is an important consideration as well, as the trial base is exposed to rapid variations in temperature. During the record making procedures, and the ultimate denture processing appointment if it is to be incorporated, the trial base is run under cold water and is exposed to heat during waxing and potential denture processing. In order to appropriately evaluate the desired tissue support, comfort, and clearance for soft and hard tissues to be incorporated in the final prosthesis, it is important that the contours and thickness of the trial base are synonymous with the desired prosthesis. Another important attribute for a trial base material to possess is the ability to set teeth onto the trial base, either directly into the material, or indirectly onto the material using wax or another medium. Ideally, a trial base material should be able to take advantage of desirable undercuts for improved retention and stability. The clinician should have the ability to remove the trial base from the cast without causing abrasion or damage to the cast, and should similarly be able to replace the trial base onto the cast. Lastly, Jones proposed that a trial base should have the ability to be readapted in the event contours of the patient's edentulous arch are not accurately

recorded in the trial base. If the trial base possesses the aforementioned attributes, the clinical is able to perform the necessary record-making procedures.

With a well-fitting maxillary trial base, wax rims can be placed onto the base giving the clinician an opportunity to evaluate the proposed location for missing anatomical structures, including soft tissues and tooth structure. During this evaluation, it is important for the patient to perform a series of movements and expressions without displacement of the trial base. Only through the act of smiling, speaking, and other activities that place potential dislodging forces onto the trial base can the correct information be gathered. Once the location and orientation of the future prosthetic tooth and soft tissues has been determined, trial bases and their associated wax rims are used to record a reproducible relationship between a patient's maxillary and mandibular arches. This record is referred to as a maxillomandibular relationship record, and is necessary to articulate the patient's definitive casts and subsequently allow the clinician to arrange prosthetic teeth in a harmonious occlusion (Academy of Prosthodontics, 2005). Just as the successful evaluation of wax rims is highly reliant on proper retention of the maxillary trial base, so too is the maxillomandibular relationship record. Without a properly retained trial base, it is difficult if not impossible to create a reproducible record, potentially forcing the clinician to reset their denture arrangement.

Another record made through the use of trial bases is the facebow record. This record allows the practitioner to properly orient the maxillary definitive cast onto the articulator. During this procedure, a facebow fork is generally attached to the maxillary trial base and wax rim, which is in turn attached to an apparatus that is oriented to predetermined positions on the patient's head and face. This particular record requires a static relationship between the aforementioned extraoral positions and the intraoral position of the trial base and occlusal rim. As a result, a well-retained trial base is crucial for this step. In the event the relationship is improperly recorded, the inaccuracy will be translated to the definitive casts as they are

transferred to the articulator. This error can ultimately lead to a significant esthetic failure in which the teeth are set at a cant, either as individual teeth, or as an entire arch. Additionally, properly programming the articulator to reproduce the patient's condylar anatomy and function is made impossible if an inaccurate facebow record has been made. The resulting error will prevent the practitioner from incorporating occlusal balancing, as dynamic tooth relationships cannot be properly included into the tooth arrangement.

In addition to serving a technical purpose during the process of construction a complete denture, a retentive trial base is highly important for both the dentist and the patient from a psychological standpoint (Burnett, 1968). Without a well-retained maxillary trial base, the clinician is left uncertain as to the reliability of the records made, taking focus away from the intricate task at hand. The result of an un-retentive trial base can also create concern and stress for a practitioner if incorrect information is gathered, and appointments are lengthened or even repeated. This can lead to significant expense to the practitioner in terms of time and the financial cost due to lost chair time. Perhaps more damaging is the psychological impact an ill-fitting trial base can have on the patient. Designed to be analogous to the final prosthesis in both form and fit, an ill-fitting maxillary trial base can lead the patient to lose confidence in the final result. Without patient confidence in the denture construction process and the dentist performing the associated procedures, it is difficult for the patient to maintain a positive outlook. This can ultimately lead to a failure of the prosthesis if the patient becomes discouraged with the whole process.

As a well-fitting trial base is important to the success of the denture construction process, several protocols and materials have been advocated as a means of improving success. An important consideration that must be made during the fabrication of a trial base is the necessity to preserve the definitive cast. As a result, a balance must be struck where the trial base remains well-adapted to the tissue bearing surface of the definitive cast, but does not become locked into

undercuts that are naturally occurring in edentulous ridge anatomy. This process typically begins by placing a thin separating medium onto the cast as a means to protect it during the process of separating it from the trial base. Materials used for this process include tin foil, petroleum jelly, and proprietary separating mediums. In order to appropriately block undercuts too large to allow for safe separation of the trial base from the definitive cast, wax is generally used. Some authors have also recommended the use of a softer flexible material like Coe-Soft (GC America) denture reline material (Burnett, 1968; Coffield, 1987; Heartwell and Rahn, 1975). This allows the trial base to better adapt to undercuts present in the patient's anatomy. After adequate block out has been applied to undercuts on the definitive cast, the process of making the trial base begins.

There are many materials and protocols that have been used to create trial bases. These materials include auto-polymerizing resins (Browning et al., 1963), heat-polymerizing resins (Brewer, 1963; Jones, 1983), swaged metal, cast metal (Craddock, 1951), Vulcanite (Payne, 1953), CAD/CAM milled (Goodacre et al., 2012), and light-polymerizing resin material (Tan et al., 1989). Formerly, shellac was a commonly used material in trial bases. Though an inexpensive material that was readily adapted to the definitive cast, shellac suffered from a tendency to distort and break. These factors were further complicated by the fact that shellac possesses poor fit and adaptation to the definitive cast, and suffers from significant shortcomings when considering accuracy (Jones, 1983). While zinc oxide eugenol paste has been used as a means of improving the fit of shellac bases, it introduced an objectionable taste for most patients.

In another protocol, a trial base is waxed directly onto the cast. The waxed pattern is designed so that it includes the idealized thickness and proportions of the final denture base. The wax pattern and definitive cast is then invested in hydrocolloid, and the wax pattern is removed after separating the cast and investment, leaving a void between the cast and investment once they are joined back together. After this process has been completed, liquid acrylic resin is placed into the investment and both the investment and definitive cast are placed into warm water and

pressure pot to complete polymerization. Once polymerized, the trial base is intended to be used during the record making process, and is eventually incorporated into the final prosthesis (Browning, 1973). This process allows for increased accuracy during the record making process, and aids in increasing dimensional accuracy during the final processing by decreasing the bulk of acrylic needed. The disadvantage to this protocol, however, would be risky in situations where large undercuts exist in the patient's anatomy. Additionally, the question arises as to how auto-polymerizing resin would react during the heat-polymerization process after the final arrangement has been invested.

Another protocol using auto-polymerizing resin is often referred to as the 'sprinkle-on technique' in classic prosthodontic literature (McCracken, 1953). Fabrication of a trial base using this technique is accomplished by first applying a separating medium to the definitive cast. Auto-polymerizing resin polymer powder is then 'sprinkled' onto the cast in addition to liquid monomer. Once the auto-polymerizing resin has been placed in adequate thickness and location, the trial base is polymerized under pressure in tepid water. This technique has been shown to offer the benefit of accuracy and rigidity when compared to other classic techniques for trial base fabrication (Jones, 1983). Modifications to the technique further increase the accuracy, including the incorporation of soft reline material around undercuts (Burnett, 1968). The disadvantage with this technique results from the difficulty of working with a liquid resin material. Because the material flows and is unrestricted, achieving uniform and appropriate thickness can prove challenging. With the uneven topography inherent in the maxillary arch, the material tends to settle in the palate and other low-lying areas, and thin-out on the ridge crest (Hamada, 1986). One proposed method involves the fabrication of a mold by which the trial base is formed, allowing for better control over the thickness of the material (Assadzadeh and Yarmand, 1975). In this technique, wax block out is placed in areas where large undercuts are present. The blocked out definitive cast is then impressed and duplicated in buff stone. Wax block out is

placed over the cast surface where the intended trial base will extend, and a second indexed cast is poured over the second cast and wax up. After separating the casts, the wax spacer is removed. Auto-polymerizing resin is then mixed and placed between the two casts under pressure and is polymerized. Another means of handling the unpolymerized resin is building the trial base in sequential parts (Hope et al., 1971). By approaching trial base construction in parts, the clinician is able to focus on the thickness around specific anatomic landmarks. To increase the ease of the process, the use of an old perfume spray bottle as a means of carefully controlling the amount of monomer applied to the cast in hopes of decreasing the fluidity of the un-polymerized resin has even been recommended (Hamada, 1986). Though this helps to improve the technical difficulty associated with this method of trial base fabrication, it still requires much care to employ successfully. In addition to controlling the amount of monomer being used with a perfume bottle, gauze has been implemented as a means by which the flow of auto-polymerizing acrylic is managed (Bolouri and McCarthy, 1998). By placing a sheet of gauze over a lubricated cast, the gauze acts as a kind of scaffold for the acrylic material. In their technique article, it is recommended that the gauze is wetted with monomer prior to beginning the 'sprinkle-on' technique of resin application described in the previous literature. Auto-polymerizing resin is applied to the ridge crest initially, and is subsequently placed to the remainder of the desired surface of the cast. Once polymerization has occurred, Bolouri and McCarthy recommend removing the tray by pulling upward on the gauze threads that remain exposed on the periphery of the tray. While there are several techniques that help to control the flow of auto-polymerizing acrylic resin, another disadvantage to auto-polymerizing resin as a trial base material is its tendency to shrink and distort during the polymerization process. If the amount of distortion during polymerization becomes too great, proper retention and stability of the trial base will not be achieved.

Several research articles have been published regarding the distortion inherent to auto-polymerizing resins. Because the process of polymerization occurs without significant pressure and heat, un-polymerized material typically remains long after the initial polymerization process occurs. As a result, deformation of the material continues for several hours after monomer and polymer has been combined. By mixing four auto-polymerizing resin materials in a standardized fashion and using a mold in order to create test samples of a known diameter, their dimensional change over time could be evaluated (Pagniono et al., 1982). Over the course of 24 hours it was discovered that distortion and shrinkage continued to progress. Though the degree of polymerization shrinkage varied among samples, the minimum amount of shrinkage noted was 0.16 +/- 0.02 mm of distortion, all the way up to 0.38 +/- 0.22 mm. While this process eventually slows significantly after approximately 9 hours, it can lead to a cumulative error of misfit by the time it ceases. While the distortion with impression trays can be compensated for by waiting until 9 hours of polymerization has concluded, and since the impression material ultimately captures the desired anatomic structures, the same cannot be said for trial bases. With distortion of the trial base's intaglio surface comes a lack of intimate fit to the definitive cast, and in turn the patient's edentulous arch.

It has been proposed that providing anchorage between the trial base and the definitive cast during the polymerization process can aid in preventing distortion that can lead to poor adaptation between the two (McElroy and Canada, 1984). In order to create anchorage, McElroy and Canada recommend drilling holes into the definitive cast distal to the posterior palatal seal. Auto-polymerizing resin material is then applied to the cast after lubricating, making sure to properly extend the material into the holes. After polymerization has completed, the trial base can be removed from the definitive cast and trimmed to appropriate extensions.

While some authors have approached the problem of misfit by attempting to limit auto-polymerizing resin polymerization shrinkage, others have sought to simply correct it after the

fact. In order to improve the fit of auto-polymerizing trial bases, various techniques have been offered in the literature. One such recommendation has been to adjust the intaglio surface of the trial base with the aid of pressure indicating paste and seating the base onto the patient's edentulous arch (Jordan et al., 1989). Jordan also suggests locating the postpalatal seal in the patient's mouth, and transferring its location to the cast. After the transfer has been made, the post dam is carved into the cast, and lubricant is applied to the surface of the cast. The adjusted trial base is then seated back onto the cast after warm bees wax is placed into the carved post dam, and it is thus joined to the trial base. Some authors have taken a more extreme approach to compensating for the distortion present in auto-polymerizing resin trial bases by relining the entire base (White et al., 1990).

White et al. described a process by which wax is placed over the definitive cast to act as a spacer. Tin foil is then placed over the wax with care to ensure a smooth surface is present. A clear auto-polymerizing acrylic resin is then mixed and applied over the blocked out surface, which the author recommends controlling with a finger wetted with monomer to spread the material evenly. After the acrylic has polymerized the trial base is removed from the cast, as is the wax and tin foil spacer. A lubricant is applied to the definitive cast surface, and soft reline material is then mixed and applied to both the cast and to the intaglio surface of the trial base, which is seated back onto the definitive cast. The resulting trial base is then trimmed of excess material, and is ready for associated record making appointments.

After fabricating a trial base, some authors have offered a means by which the soft tissue adaptation can be better improved, particularly in areas where larger undercuts exist. One such technique includes a process by which the maxillary trial base is perforated with a number 8 round bur, and a reline is performed on the cast with polyether impression material (Berman, 1981). Some authors have even advocated the use of the final impression itself as a trial base (Ortman and Edgerton, 1982). The final impression is made with a carefully fitted custom tray

using polysulfide or polyether impression material. The definitive cast is poured making sure not to lock the impression into the cast. Once the definitive cast has set, the impression is carefully separated and is trimmed for proper extensions and thickness. Ortman and Edgerton claim this technique allows for a stable and retentive trial base, but can only be used in certain circumstances that may preclude its efficacy in the maxillary arch. Because the final impression is trimmed, the authors state that impression compound cannot be used for the border molding portion of the impression. Furthermore, the intaglio of the impression cannot be modified to incorporate a post dam as described by Jordan. The resulting inability to modify the post dam would potentially lead to a lack of retention of the trial base.

Auto-polymerizing resins are commonly used by practitioners because of their relative ease of use and lack of expense, but correcting their ultimate shortcomings with regards to accuracy can necessitate the use of time consuming and complicated techniques. Alternatively, some practitioners advocate the use of heat-polymerizing resin bases due to the increased dimensional stability that they offer, though ultimately the benefit of doing so is up for debate. In 1967, Schoen and Stewart demonstrated that the difference in maxillomandibular relationship record between auto-polymerizing and heat-polymerizing trial bases were statistically insignificant. For their experiment, trial bases were made from both auto-polymerizing and heat-polymerizing resins, and the quality of their fit to the edentulous arches were evaluated by comparing their performance during the process of creating a maxillomandibular relationship record. Schoen and Stewart selected 6 patients who had demonstrated the ability to find a reproducible centric relation position, and fabricated a set of trial bases with both materials. A reference centric relation record was made to compare both trial base sets to, and the process of creating a maxillomandibular relationship record was repeated 6 times per patient in order to ensure consistency. When comparing the accuracy of the auto-polymerized trial bases to the heat-polymerizing final bases, there was a mean difference of 0.149 +/- 0.056 mm. Though this

difference was measurable, it was not found to have clinical impact on the ability to create an accurate record. A limitation with this study, however, are the small sample sizes and the influence of operator ability on the outcome. This study also fails to address other serious implications of misfit, including lack of retention and stability, which impacts several other components of denture fabrication. Additionally, Anselm Langer expanded on Schoen's experiment by evaluating the final occlusal accuracy after the final processing of auto-polymerizing trial bases and heat-polymerized final bases (Schoen, 1967). In order to evaluate the accuracy of the maxillomandibular relationship record made using auto-polymerizing and heat-polymerizing bases, 2 groups of 20 patients had complete dentures made in identical fashion with the only difference being the base utilized in each group. After the complete denture sets were processed, the occlusion was checked for discrepancies. The results showed a significantly greater incidence of incorrect occlusion in the group receiving complete dentures fabricated with the aid of auto-polymerizing trial bases when compared to dentures that incorporate a heat-polymerized final base. While only 5 of the 20 dentures had a correct occlusion in the auto-polymerizing group, 18 of the 20 heat-polymerized base dentures had an accurate occlusion after processing. Occlusal inaccuracies in interarch space present in the auto-polymerizing trial base group ranged from 0.1 mm to 0.7 mm. Langer explains Schoen's findings by arguing that though Schoen found no statistically significant difference in variation between the maxillomandibular relationship record in auto-polymerizing and heat-polymerized bases, this is due to the fact that only the horizontal discrepancy was evaluated. Langer argues that the greater dimension of inaccuracy takes place in the vertical plan as opposed to the horizontal.

While many techniques allow for the modification of the trial base after its fabrication to allow for a better adaptation to the labial aspects of the cast where undercuts are generally present, some recommendations have been given in the literature as a means of minimizing block out needed. A simple solution that has been offered is the use of a surveyor in the evaluation of

the definitive cast, prior to the fabrication of the trial base (Sherman, 1984). While clinicians have typically judged the amount and location of block out necessary for a given cast through visual evaluation, Sherman et al. points out the advantage of surveying the definitive cast. During this process, the height of contour of undercuts are marked with a carbon marker. The undercuts are then blocked out with the minimal amount of wax required, as defined during the survey. In order to minimize block out of large labial undercuts prior to the fabrication process of a maxillary trial base, which is commonly a necessity to avoid damage to the definitive cast and allow for a path of draw during the removal process, redirecting the location of block out to less critical areas on the definitive cast has been offered as a solution (Nishigawa et al., 2002). A technique that works regardless of the material selected, the definitive cast is placed onto a tilt table in order to survey it. The cast is tilted to an angle that allows for a path of draw coincident with the labial undercuts present. In order to allow this path of draw to function, the palate must too be surveyed, as it is the likely spot where a new undercut will exist. The undercut is outlined on the surveyor, and block out is applied as necessary. After block out has been placed on the palate, the trial base is fabricated with a path of draw that guides toward the anterior. Though some block out occurs on the palatal aspect of the definitive cast, it is generally much less than would be necessary on the labial aspect, and would have little effect on the retentive properties of the trial base.

In order to avoid the need for trial base fabrication on a definitive cast, and to combat the shrinkage that occurs during the polymerization process, Computer Aided Design/Computer Aided Manufacture (CAD/CAM) technology has been proposed as a solution. Currently, CAD/CAM trial bases are cost-prohibitive for a lot of practitioners, and requires expensive equipment or an outside lab to fabricate the trial base.

While techniques to fabricate trial bases continued to improve, the distortion shortcomings inherent to the materials were unavoidable. Light-polymerizing composite resin

materials were introduced in the 1990s and offered a potential means for offering increased safety and convenience to clinicians and patients (Dentsply, 1990). Available in individually packaged sheets, VLC allowed for easy and safe material handling during the trial base fabrication process. The material also limited free monomer exposure of the clinician and the patient. While light-polymerizing composite resins offers a solution to many of the problems posed by other trial base materials, distortion during the polymerization process remains a challenge. The distortion is the result of a phenomenon termed 'resin uplift' phenomenon (Huh et al., 2010), which affects light-polymerizing composite resin materials during the polymerization process. The phenomenon is thought to be due to the contraction of material upon polymerization at positions closest to the light source, which pulls on unpolymerized material further away from the light source. As a result, the material is 'uplifted' toward the light source, affecting a change in the pre-polymerized form and contour of the material. Resin uplift is particularly problematic during the fabrication of trial bases due to the large variation in surface topography present in the maxillary arch, and the large difference in distance between the edentulous ridge and the light source, and the palate and the light source. This leads to the greatest distortion in the distal aspect of the middle palate, an area which is crucial for proper atmospheric seal (Boberick and McCool, 1998).

In order to combat the distortion imparted on the light-polymerizing composite resin trial base during the polymerization process, solutions have been proposed that help to limit the effects of resin uplift. One such proposal recommends the use of tin foil in order to stage the exposure of the light-polymerizing material to the light source (Boberick and McCool, 1998). When comparing the distortion present in trial bases made using this staged approach to those made using the Dentsply manufacturer's procedure (Dentsply, 1990), a significant reduction in the distortion was found. The shortcoming with this recommended technique results from the firm adaptation of tin foil to the cameo surface of the trial base. The uneven surface of tin foil in conjunction with the heat generated during the light polymerization process result in a rough and

irregular surface on the finished trial base, requiring the clinician to spend extra time finishing and polishing the trial base.

Another recommended technique involves physically sectioning the palate from the crestal portion of the trial base, allowing the two segments to polymerize separately (Huh et al., 2010). After initial polymerization has taken place more Triad material is placed into the gap and polymerized, thus joining the 2 sections. This technique has been shown to decrease distortion during the polymerization process, but is plagued by the same shortcomings as Boberick's technique, leaving the trial base with a rough and irregular palatal surface later requiring extra time to finish and polish.

In order to avoid the shortcomings in the aforementioned techniques for light-polymerizing composite resin bases, it has been proposed that the correction of the distortion be made after the polymerization process has been completed. One such technique advocated for the post dam to be carved into the definitive cast after the trial base has been fabricated, and subsequently picking up the post-palatal seal in silicone bite registration material (Oh and May, 2011). This technique is similar to those proposed in classic literature to compensate for distortion in auto-polymerizing resins that utilize a soft reline material. The disadvantage with this technique is primarily related to the additional expense of the bite registration material.

Despite their limitations, prior research has shown that the distortion that affects light-polymerizing composite resin materials can be at least partly controlled. By providing clinicians a reliable protocol that addresses the resin uplift phenomenon, while doing so in a simple and cost-effective way that maintains a smooth comfortable surface finish, light-polymerizing composite resin can be made an even more effective material in dentistry. This study proposes such a protocol for polymerizing light-polymerizing composite resin trial bases, and compares the resulting distortion to that in trial bases fabricated using the manufacturer's protocol.

The following research hypotheses were made:

1. Fabrication protocol will not affect the average gap size.

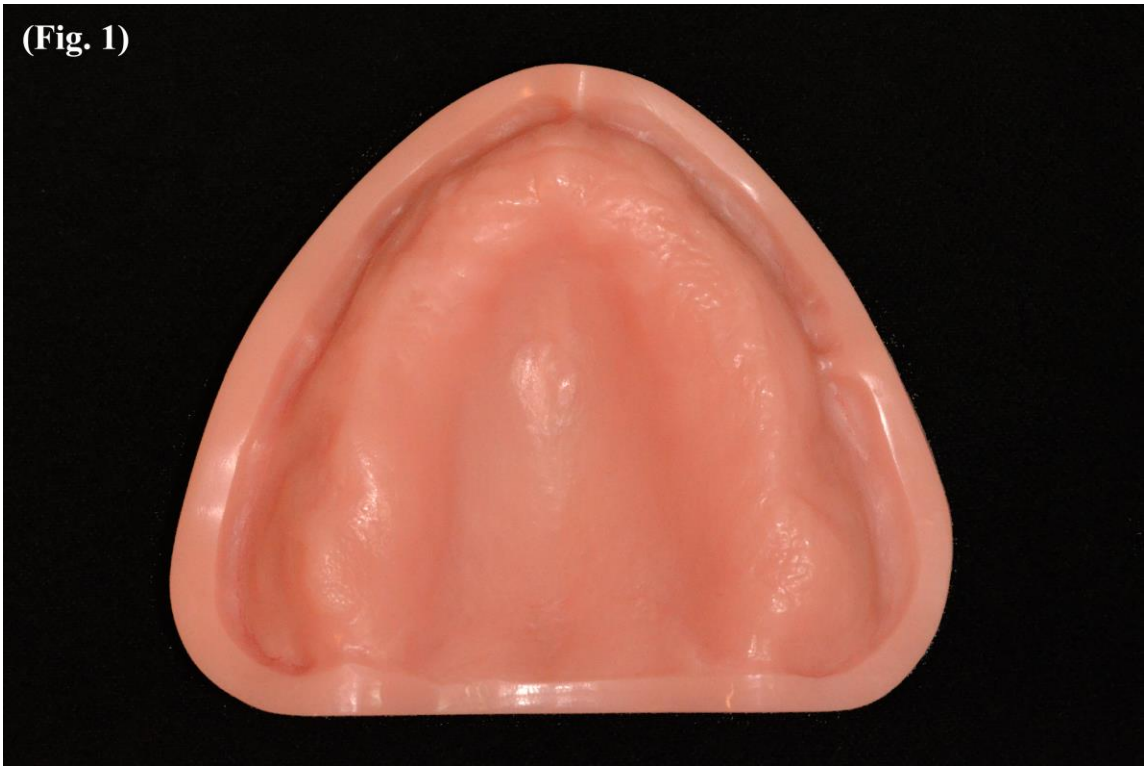
2. The amount of time post-polymerization will not affect the average gap size.

CHAPTER 3

MATERIALS AND METHODS

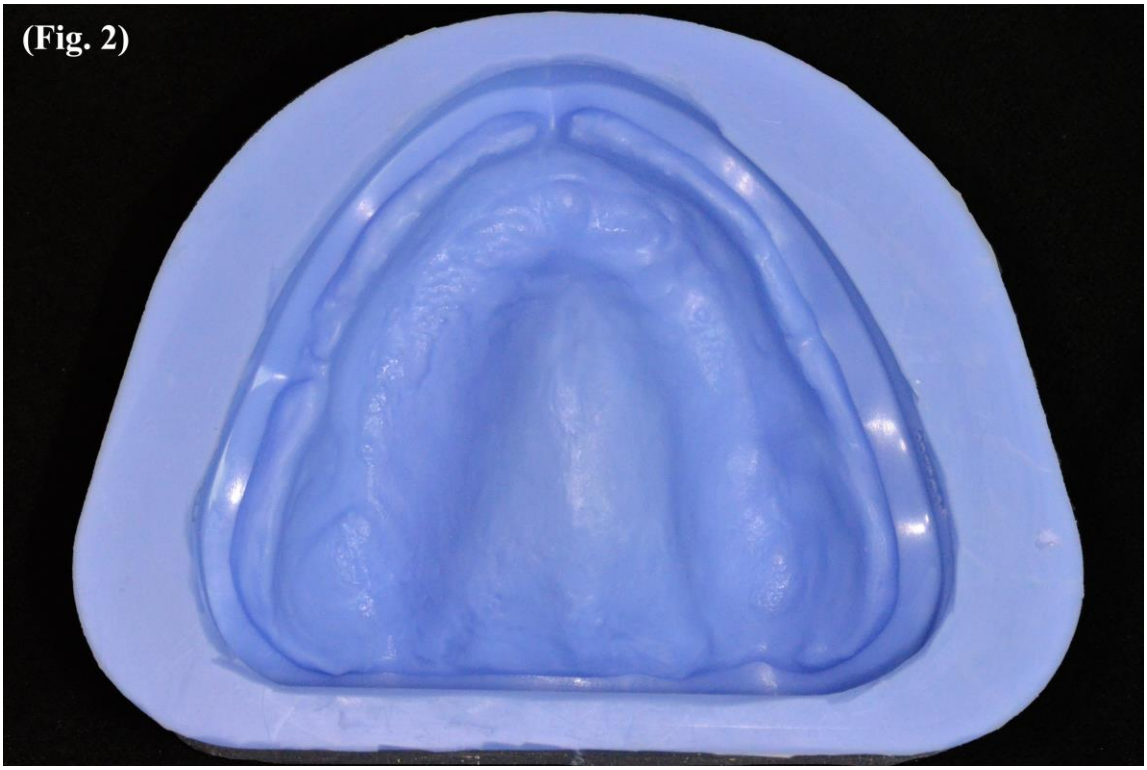
One B-3 series edentulous maxillary model (Farasco, Greenville, NC) was selected as a simulated patient template (Fig. 1). A line was scribed with a ¼ round bur to define a standardized margin to which all trial base flanges would be extended. The reference line was positioned approximately 2 mm above the depth of the vestibule and extended from the distal aspect of the hamular notches to form a circumferential border. A post-palatal seal was not carved into the model due to concerns it would complicate the measuring procedure and would alter the uniformity of the VLC thickness in that region.

Fig. 1 B-3 series edentulous maxillary model (Farasco, Greenville, NC).



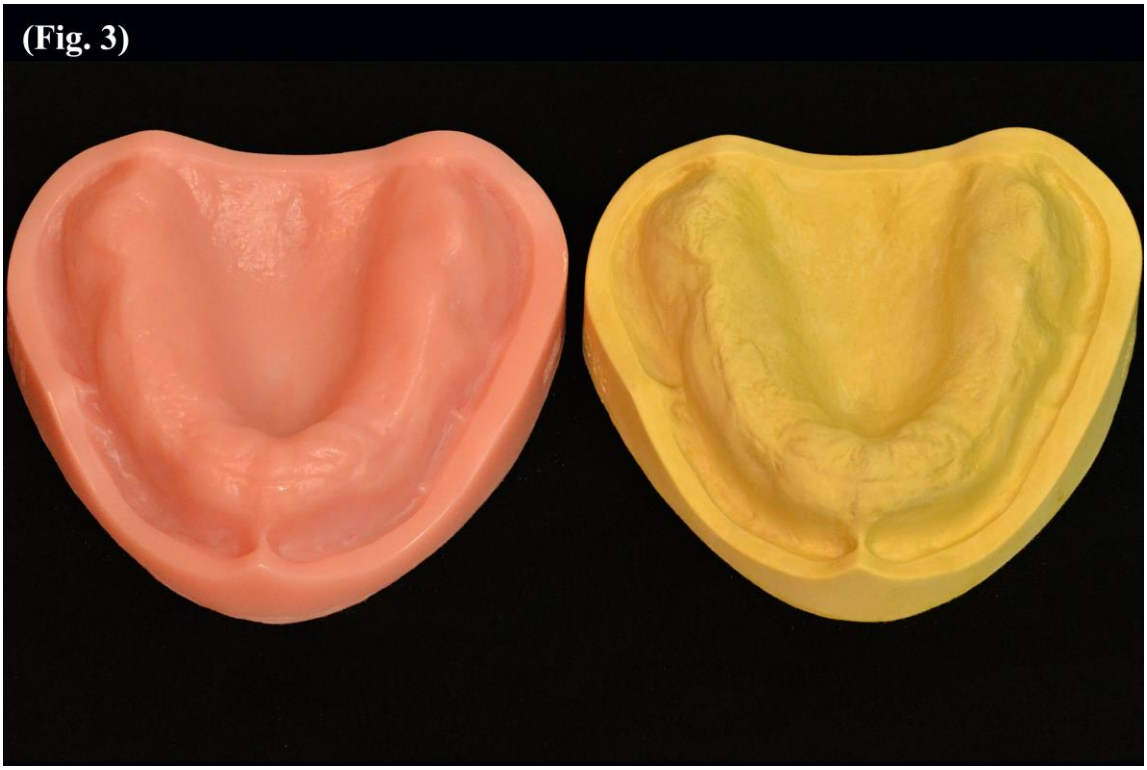
Four negative molds of the edentulous model were made using duplicating silicone (Wirosil, Bego, Lincoln, RI) (Fig. 2). The 4 molds were used to fabricate 10 stone casts each (N=40) using the same lot of Type 3 gypsum buff stone (Whipmix, Louisville, KY) and according to manufacturer recommendations (Fig 3). The casts set for 1 hour prior to removal from the mold, and were allowed to dry for 24 hours before two light coats of petroleum jelly (Vaseline, London, England) were applied. Again they were again allowed to dry. Just prior to the fabrication of trial bases, a third layer of petroleum jelly was applied.

Fig. 2 Negative molds of the edentulous model (Wirosil, Bego, Lincoln, RI).



Forty maxillary record bases were formed, with one base fabricated on each cast. Twenty of the casts were used to fabricate trial bases per manufacturer recommendations (MN), and another 20 trial bases were fabricated with an experimental protocol (EX). These groups were further divided into 2 groups of ten, in which one-half of the trial bases made by a given protocol were evaluated for distortion at 1 hour (HR), and the other half was evaluated at 7 days (WK).

Fig. 3 Stone casts made using Type 3 gypsum buff stone (Whipmix, Louisville, KY).

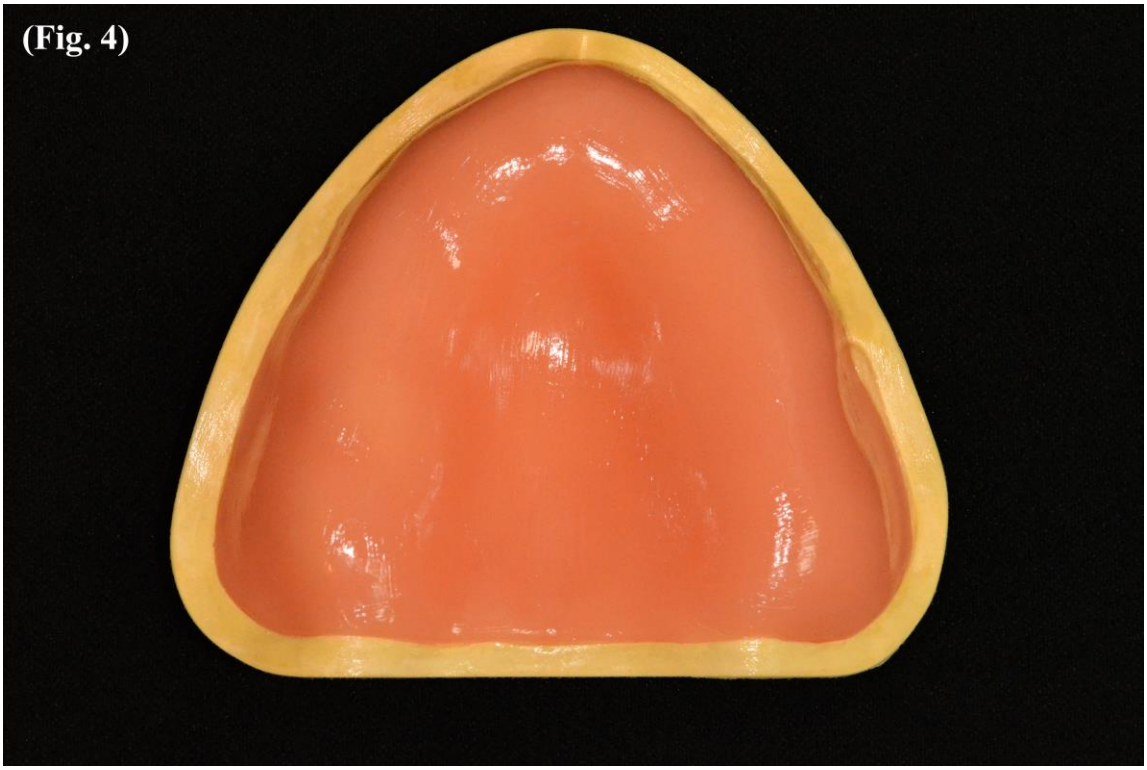


Initial fabrication steps for all trial bases included taking 1 sheet of pink Triad (VLC) record base material, and applying to each cast immediately following its removal from the light protective packaging. The Triad was adapted with care to avoid air pocketing and thinning. Excess material was trimmed to the reference line that had been scribed on the edentulous model. A thin layer of petroleum jelly was applied to the trial base material (Fig. 4).

Continued procedure for fabrication of record bases:

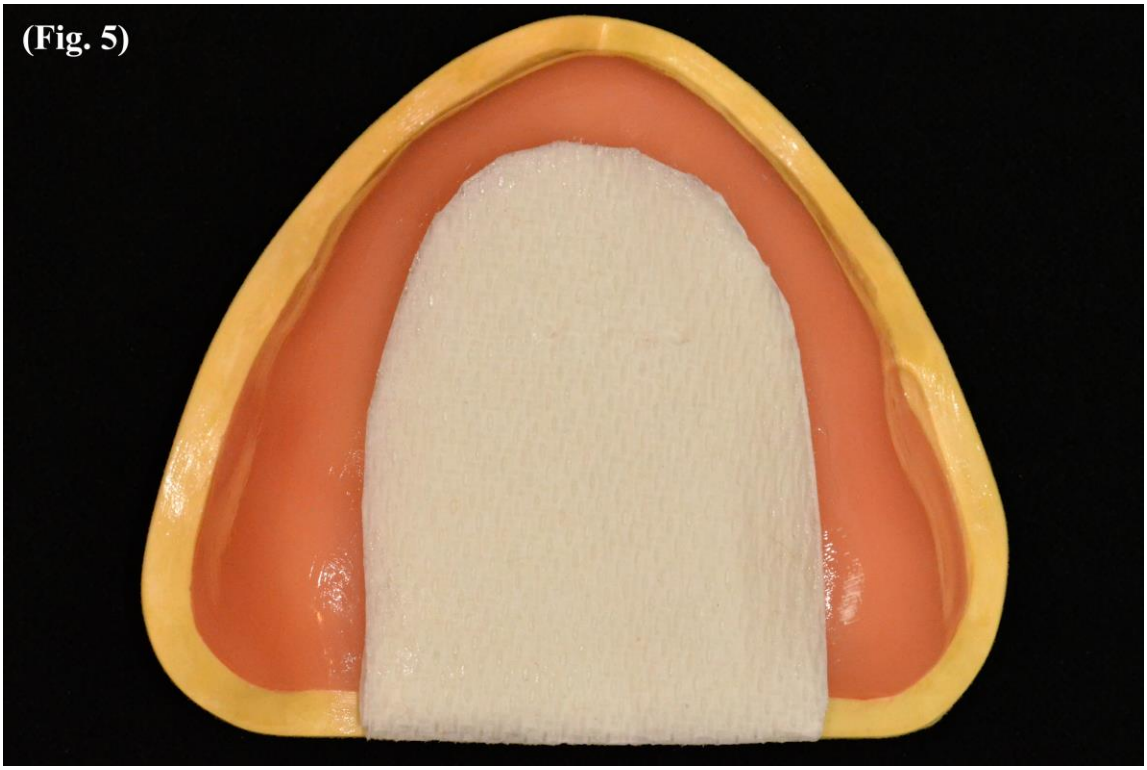
Manufacturer Protocol. The assembly was polymerized in a Dentsply Triad 2000 Light Curing System for 2 minutes. After the record base was separated from the cast, a thin coating of petroleum jelly was applied over all surfaces of the record base and processed, tissue side up, for an additional 6 minutes. Total polymerization time was 8 minutes.

Fig. 4 Triad VLC adapted to cast.



Experimental Protocol. After having adapted the Triad material as previously described, a paper towel (Georgia-Pacific, Atlanta, GA) is folded so that it is 8 layers thick. The paper towel is cut into the shape of the palate, and a small amount of petroleum jelly is applied to adhere layers to one another. The paper towel is then gently placed onto palatal space without applying pressure (Fig. 5). The trial base and cast are then placed in the Triad 2000 for 1 minute for an initial polymerization. The paper towel is then removed, and the base is polymerized uncovered for 1 more minute. While allowing the trial base to cool on the cast, the cameo surface of trial base is cleaned with soap and toothbrush. The trial bases were gently removed with a buffalo knife once cool. The intaglio surface of trial base is polymerized for 1 minute, making the total polymerization time 3 minutes. Lastly, the trial base is placed back onto the cast and allowed to cool.

Fig. 5 Paper towel gently placed onto palatal space.



Testing adaptation of record base to cast:

Half of the samples from each group were tested 1 hour after fabrication and the remaining samples were tested after 7 days.

The space between the cast and the record base was measured to the nearest 0.01 mm with digital calipers (Mitutoyo) accurate to 0.01 mm. Measurements were made at three points A, B, and C, which represented the right ridge crest, the midpalatal region, and left ridge crest, respectively (Fig. 6). Each point was measured 3 times, and the mean was calculated for each given measurement. Additional measurements were taken at 5 mm increments after reduction of the posterior border with a model trimmer (Renfert MT) (Fig. 7). All measurements were made by the same examiner.

Fig. 6 Space between the cast and the record base measured to the nearest 0.01 mm.

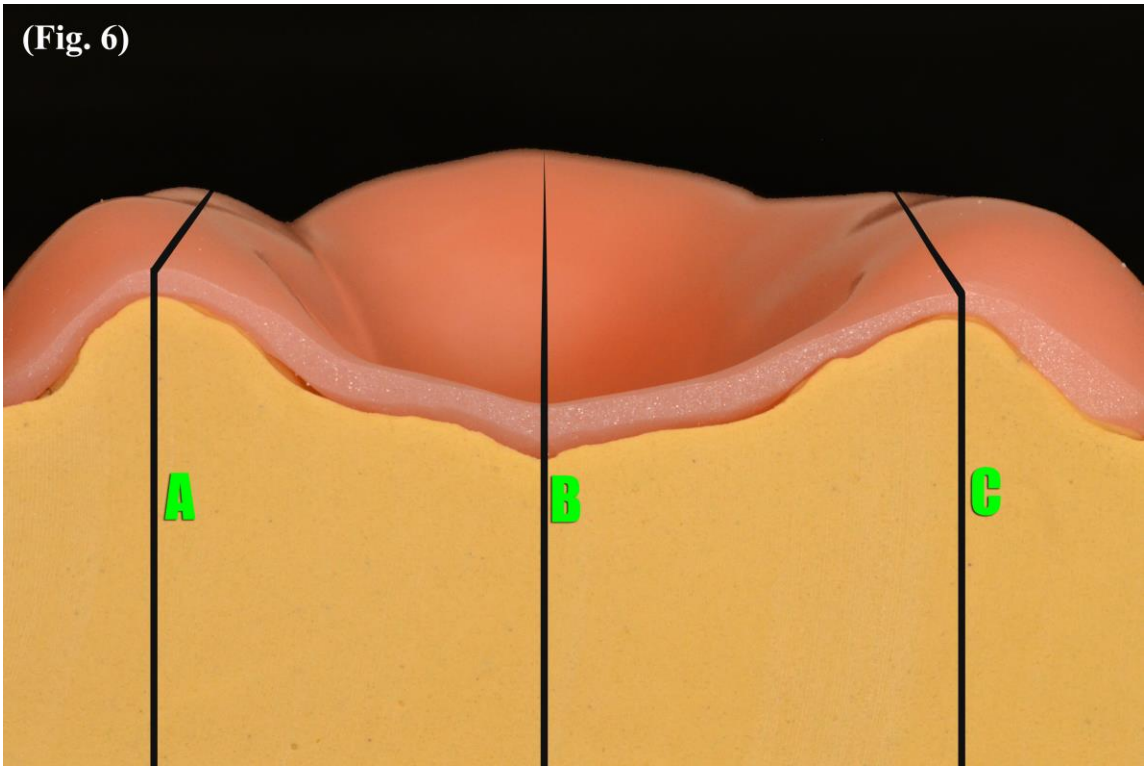
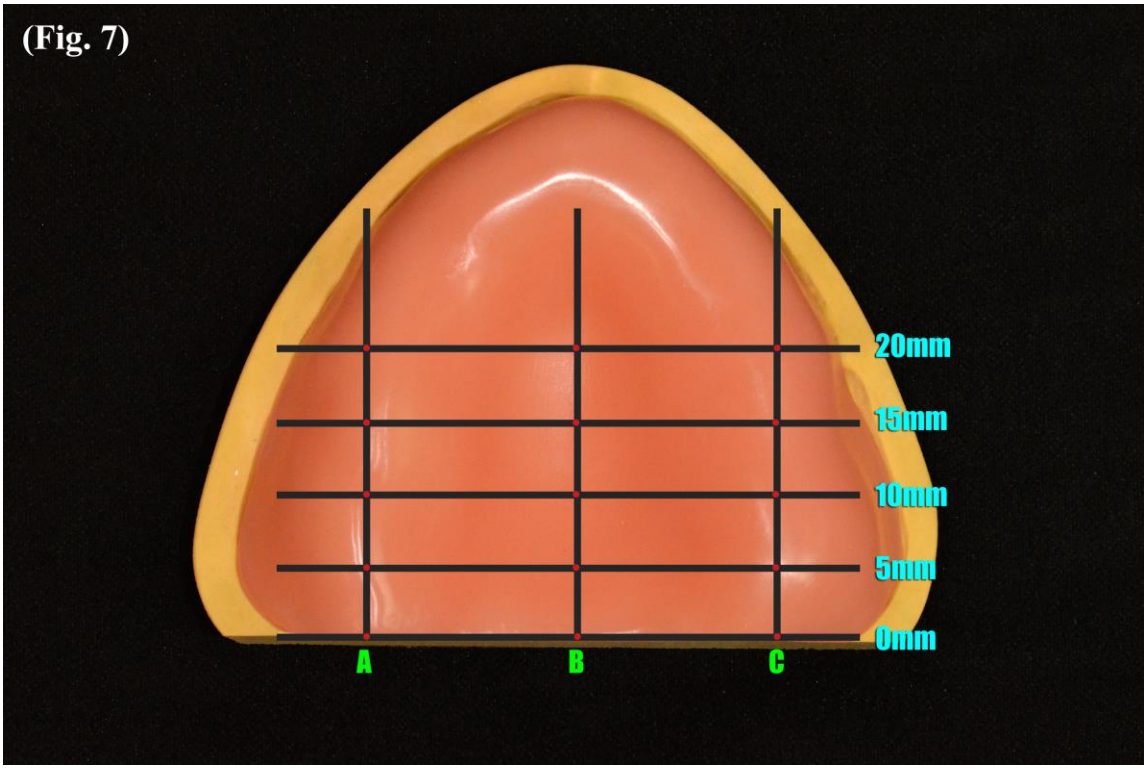


Fig 7. Measurements taken at 5 mm increments.



Statistical Analysis

The mean gap size for each group was calculated in millimeters for each of the corresponding sites A_0-C_{20}. The normality of distribution for variables B_0 and average of A_0, B_0, C_0 in each group was tested with Kolmogorov-Smirnov's test. The homogeneity of variances among the groups was tested with the Levene test.

Linear discriminant analysis was performed to visualize the difference of the overall gap size between the trial base and the cast among the different groups. For the discriminant analysis, a stepwise procedure was used to select only those locations where a significant difference exists (p<0.05). Locations with p-value >0.20 were considered insignificant, and were removed from further consideration in the stepwise procedure.

For sites A_0, B_0, C_0 cluster analysis was performed using nearest neighbor analysis. Clusterization was evaluated using the different combinations of method-time as targets. Additionally one-way ANOVA was used to find differences in the average gap size between the posterior palatal aspect (A_0,B_0,C_0) and the posterior midpalatal region (B_0) among the groups with "method*time" as the dependent variable. This was followed by post-hoc tests (Tukey's HSD) to locate the differences. All analyses were performed with a statistical software (SPSS v23.0; IBM Corp). Sample size was calculated with 80% power to detect differences among groups at α=.05 and effect size f=0.65 (G*Power 3.1.9.2; Erdfelder, Faul & Buchner).

For each of the 15 combinations of position (A, B, and C) and location (posterior, 5, 10, 15, and 20), the data, when classified by method and time, form a two-way array with 10 replicated values in each cell.

CHAPTER 4

RESULTS

For the discriminant analysis, the stepwise procedure selected the following significant locations: B0, C0, B10, A15, B15, and C20 ($p<0.05$). Table 1 shows the contribution of each of function variable to the discriminant function. Table 2 shows the coefficients of linear discriminant function for each one of the groups at the significant locations. Figure 8 describes the discrimination based on the best two discriminant functions. These two discriminant functions are the best linear combinations of the gap sizes (after stepwise selection of B0, C0, B10, A15, B15, and C20) that describe the best discrimination between the four groups. The plot shows that group centroids EXHR and EXWK are different from MNHR and MNWK. Additionally group centroid MNHR is different from MNWK.

Table 1. Wilk's Lamda test for discriminant analysis

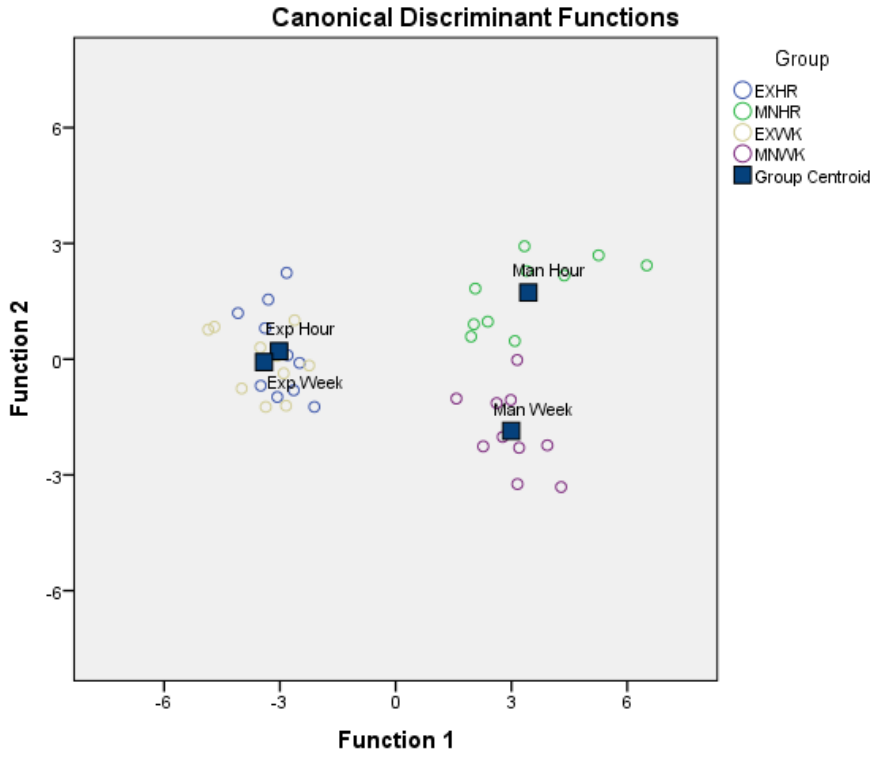
Test of Function(s)	Wilks' Lambda	*P*
1 through 3	.02	.00
2 through 3	.27	.00
3	.75	.04

Table 2: Fisher's linear discriminant functions - Classification Function Coefficients

	Group			
	EXHR	MNHR	EXWK	MNWK
B0	15.90	40.51	20.04	41.85
C0	8.68	30.31	5.75	14.21
B10	4.68	5.93	-0.60	-8.84
A15	12.67	16.61	6.18	20.24
B15	9.34	14.01	7.40	30.05
C20	1.19	11.76	2.72	22.85

(Constant)	-14.46	-66.76	-11.43	-59.91

Fig. 8 Discriminant function plot after stepwise selection.



For the posterior palatal region (A_0, B_0,C_0) the mean (SD) gap for group EXHR was 0.43 mm (0.06), for group EXWK it was 0.42 mm (0.06) (Table 3), for group MNHR it was 1.22 mm (0.14), and for group MNWK it was 1.07 mm (0.09) (Table 4). Cluster analysis of the same region resulted in 100% correct clustering when the target was "method" (Fig 9). However, significant false clustering was observed when the target was "time" (Fig. 10). One-way ANOVA showed statistically significant differences among the groups [$F(3,36)=201.476$, $P<.001$]. Post-hoc tests showed that groups EXHR and EXWK were not statistically different from each other, but both were statistically different from either

groups MNHR and MNWK. Group MNHR was significantly different from MNWK (Table 5).

Table 3. Descriptive Statistics for EXHR and EXWK

Gap size (mm)	EXHR				EXWK			
	A_0	B_0	C_0	Average A_0,B_0,C_0	A_0	B_0	C_0	Average A_0,B_0,C_0
Mean	0.23	0.74	0.32	0.43	0.23	0.76	0.26	0.42
Standard Deviation	0.09	0.09	0.09	0.06	0.06	0.12	0.10	0.06
Minimum	0.13	0.58	0.16	0.36	0.11	0.58	0.12	0.35
Maximum	0.38	0.90	0.48	0.53	0.34	0.95	0.45	0.51
Kolmogorov-Smirnov[a]		*P*=.20		*P*=.17		*P*=.20		*P*=.20
Levene[b]		*P*=.53		*P*=.20		*P*=.53		*P*=.20
Group Size	10				10			

[a]Normal distribution in every group was verified with Kolmogorov-Smirnov test (*P*>.05).
[b]Homogeneity of variances among groups was verified with Levene test (*P*>.05).

Table 4. Descriptive Statistics for MNHR and MNWK

Gap size (mm)	MNHR				MNWK			
	A_0	B_0	C_0	Average A_0,B_0,C_0	A_0	B_0	C_0	Average A_0,B_0,C_0
Mean	1.03	1.69	0.95	1.22	0.95	1.56	0.70	1.07
Standard Deviation	0.24	0.11	0.25	0.14	0.22	0.12	0.07	0.09
Minimum	0.76	1.49	0.61	1.11	0.72	1.38	0.62	0.92
Maximum	1.58	1.81	1.32	1.57	1.36	1.76	0.82	1.20
Kolmogorov-Smirnov[a]		*P*=.20		*P*=.18		*P*=.20		*P*=.20
Levene[b]		*P*=.53		*P*=.20		*P*=.53		*P*=.20
Group Size	10				10			

[a]Normal distribution in every group was verified with Kolmogorov-Smirnov test (*P*>.05).
[b]Homogeneity of variances among groups was verified with Levene test (*P*>.05).

Fig. 9 Clustering of experimental vs manufacturer's methods for sites A_0, B_0, C_0 after combining "time".

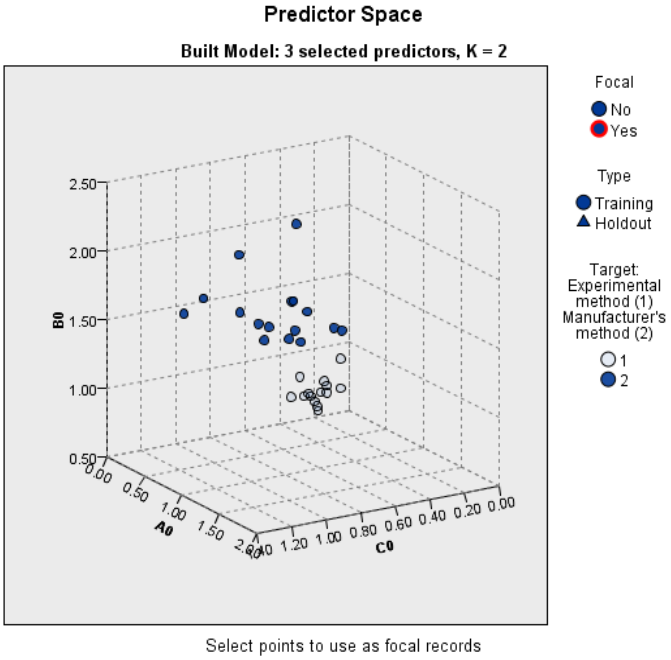


Fig.10 Separation of 1 hour vs. 1 week groups for sites A_0, B_0, C_0 after combining "method".

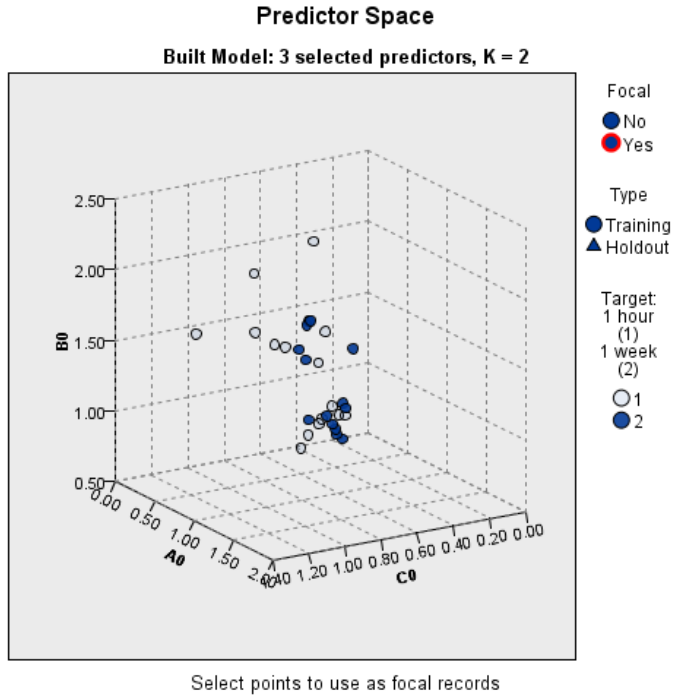


Table 5. Inferential statistical results for comparison at posterior palatal region (A_0, B_0, C_0)					
ANOVA	Sum of Squares	*df*	Mean Square	F	*P*
Between groups	5.267	3	1.756	201.476	<.001
Within groups	0.314	36	0.009		
Total	5.581	39			
Tukey's HSD	Group			Mean	
	EXHR			0.43[a]	
	EXWK			0.42[a]	
	MNHR			1.22[b]	
	MNWK			1.07[c]	
[a,b,c] Differences between mean values with different superscript were significantly different ($P \leq .05$).					

For the posterior midpalatal region (B_0) the mean (SD) gap for group EXHR was 0.74 mm (0.09), for group EXWK it was 0.76 mm (0.12), for group MNHR it was 1.69 mm (0.11), and for group MNWK it was 1.56 mm (0.12) (Table 6). One-way ANOVA showed statistically significant differences among the groups [$F(3,36)=204.945$, $P<.001$]. Post-hoc tests showed that groups EXHR and EXWK were not statistically different from each other, but both were statistically different from either groups MNHR and MNWK. Group MNHR was not significantly different from MNWK (Table 6).

Table 6. Inferential statistical results for comparison at posterior midpalatal region (B_0)					
ANOVA	Sum of Squares	*df*	Mean Square	F	*P*
Between groups	7.666	3	2.555	204.945	<.001
Within groups	0.449	36	0.012		
Total	8.115	39			
Tukey's HSD	Group			Mean	
	EXHR			0.74[a]	
	EXWK			0.76[a]	
	MNHR			1.69[b]	
	MNWK			1.56[b]	
[a,b] Differences between mean values with different superscript were significantly different ($P \leq .05$).					

CHAPTER 5

DISCUSSION

After completing the experiment and the subsequent statistical analysis of the data, it was determined that the first null hypothesis which states there is no significant effect of protocol on the average gap size was rejected. Instead, it was found that a significant difference in average gap size occurred between the experimental protocol and the manufacturer's protocol.

Similar studies have demonstrated that by segmenting the polymerization process, polymerization shrinkage and distortion can be mitigated. When evaluating research that has been done specifically pertaining to VLC, a number of techniques have been successful. One of the earliest documented modifications to the polymerization process established that shielding portions of the tray from the visible light source allowed for a decrease in distortion (Boberick and McCool, 1998). The idea behind this was that the palate was left malleable after polymerizing the bulk of the VLC material. This allowed for the material to be re-adapted to the palate prior to the final cure, which positioned the material in the closest proximity possible to the cast, and decreased the total volume of material being polymerized. Later literature offers the idea of physically sectioning the unpolymerized VLC so that the total volumetric shrinkage can better be managed, and subsequently joining the sections with a smaller volume of VLC in a second polymerization exercise (Oh and May, 2008). The initial case study that demonstrated sectioning VLC was later expanded upon in a more formal randomized control trial (Huh et al., 2010). In this study, the mechanism for the distortion in VLC was termed the 'resin uplift' phenomenon.

Understanding the 'resin uplift' phenomenon has allowed clinicians to better identify the specific factors of the VLC polymerization shrinkage that lead to distortion. During the process

of light-polymerization, VLC polymerizes first at the point closest to the light source, and later at sites further away. As polymerization occurs, so does volumetric shrinkage. As the material shrinks, the material contracts toward the light source where the initial polymerization occurs. Because of the relative height of the edentulous ridge to the rest of the arch, initial polymerization tends to occur on the maxillary arch, and lastly at depth of the palate where VLC is furthest away from the light source. As a result, the greatest distortion tends to occur at the depth of the palate, in particular at the periphery of that deepest portion (point B0). This has been confirmed by the data presented in this paper, and is coincident with early research on VLC distortion (Boberick and McCool, 1998).

When evaluating the second null hypothesis that there is no significant effect of time on the average gap size, it was only partially rejected. While there was no significant effect of time on the average gap size when evaluating the experimental protocol at one hour and at one week, there was a significant difference when comparing the manufacturer's protocol at one hour and at one week.

After all trial bases had been fabricated, they were placed in case pans that were kept away from light sources. In those case pans, trial bases using both the manufacturer's recommended protocol and the experimental protocol were intermixed. As such, it is unlikely that storage conditions contributed to the increased distortion between the manufacturer groups, since it would be expected that a similar change would have occurred in the experimental group as well. It also seems unlikely that further polymerization would have taken place in the MNWK during the 7-day period, since those trial bases were allowed to be polymerized for 6 minutes longer. This increased polymerization time would generally lead to greater dimensional stability, but that was not the case. Though the increased distortion between MNHR and MNWK cannot be readily explained, it is coincident with experiments that have been performed using a similar material and methods (Boberick and McCool, 1998). Though the distortion was found to be

statistically significant between MNHR and MNWK, the difference is likely clinically insignificant.

Ultimately, it was found that the experimental protocol allowed for superior control over VLC distortion during the polymerization process. This is likely due to the fact that by using the experimental protocol, the 'resin uplift' phenomenon is accounted for by segmenting the polymerization process. By covering the palate, the remainder of the trial base is allowed to polymerize, and the unpolymerized VLC in the palatal region is left pliable and well-adapted to the cast. Secondly, the period of time to which the VLC material is exposed to polymerizing light source is limited to only the amount of time necessary to fabricate a dimensionally stable base. It has been demonstrated in this paper that the anecdotal polymerization time of three minutes is adequate to polymerize a VLC trial base, and to remain dimensionally stable for a week's time. It can be assumed that given this trend, a trial base fabricated using the experimental protocol would remain stable longer than that period of time. By exposing VLC to the polymerizing light source for eight minutes as recommended by manufacturer (Dentsply, 1990), it has been demonstrated that distortion is greater than the experimental protocol, and that dimensional stability is worse than the experimental protocol over the course of the first week. It is possible that the increased distortion is the result of a higher percentage of VLC polymerization resulting from longer exposure to the polymerizing light source, and thus there is a greater sum shrinkage in the trial base. Another possibility could be warpage of the trial base occurring from the longer exposure to the polymerizing light source, as the bulb and the polymerization unit as a whole become quite warm after the final 6-minute polymerization cycle.

Trial bases are an important tool in denture construction, and allow the clinician to evaluate both physical and emotional ability of the patient to tolerate the final treatment. Trial bases also help to guide the clinician to create a denture with the proper dimensions and form, facilitating the best treatment outcome. As such, it is crucial for trial bases to adapt well to the

patients edentulous ridge in order to aid in retention and stability (Fish, 1927). Despite having been a tool used in dentistry for over a century, the creation of a practical and well-adapted trial base remains problematic for clinicians. Classic prosthodontic literature is rife with techniques and protocols aimed at creating more accurately fitting trial bases. While a number has not been agreed upon regarding the amount of distortion allowable in a trial base, the main goal during fabrication of that base should always be to minimize that distortion. This paper offers a means by which that distortion can be decreased. In addition to decreasing the distortion inherent to VLC proceeding the polymerization process, the experimental protocol is easy and cheap to employ. Unlike other protocols offered in the literature, the experimental protocol does not require the use of additional materials other than a paper towel or napkin. This is in contrast to aforementioned protocols that require the use of reline material or impression material. Additionally, the protocol does not impart roughness to the cameo surface of the trial base as well-adapted tin foil would. The surface and thickness of the trial base is also kept unadulterated because it is not sectioned and rejoined in later steps. Finally, the experimental protocol requires very little competency with lab techniques, and can be readily employed by any clinician with ease.

While every attempt was made to control the experiment, there are limitations inherent. Care was taken to apply VLC material uniformly onto each cast, and to equate all peripheral tray extensions. This goal was not achieved to perfection, but great effort was made to insure all samples as close to identical as possible. In order to help compensate for any variation in the samples, trial bases were randomly assigned to one of the four groups just before the polymerization process occurred. Due to practical considerations, several samples were polymerized at given periods of time. As a result, it is possible that the ambient temperature inside of the Triad 2000 was not identical, which could potentially cause a change in distortion of the trial base. This variable was again mitigated by randomizing the order in which samples from

all four groups were polymerized. Given the relatively small amount of distortion that occurred between the trial bases and their respective casts, it was important to confirm proper measurements in order to accurately record the data. In order to keep measurements as accurate and objective as possible, all measurements were made by one researcher (J.I.), recorded measurements were based on the mean of three measurements with the caliper started at 0.00 mm, and the group to which a given sample belonged to was not revealed to the examiner until the measurements had been completed.

Finally, further research on this topic is needed. While it was demonstrated in this experiment that the distortion that occurs in light-polymerizing composite resin materials can be mitigated, they cannot be entirely counteracted using the proposed experimental protocol. It is likely that the accuracy with which a trial base is fabricated can be further improved by continued modification of the polymerization protocol. The resin uplift phenomenon may also only partially explain the distortion that occurs in VLC trial bases. It would be beneficial to study the amount of heat generated by the Triad 2000, and then to evaluate the effects of that heat on polymerized VLC trial bases. Additionally, with advances in material science, it can be assumed that improved materials will become available to clinicians to use in the construction of trial bases. While ready access CAD/CAM technology is currently out of practical reach for many clinicians, the cost and complexity of the technology will likely make it less prohibitive in years to come. Even then, there are few technologies or materials that offer clinicians the ideal solution to a problem, and further advances in procedural modification will be needed. Those solutions will likely be based on similar solutions presented in the classic literature, just as the experimental procedure in this paper was. As such, it is important that advances in accurate measurement of distortion be utilized in future research when possible. By using 3-dimensional scanning technology, the ability for a researching to accurately evaluate the distortion present is greatly improved.

CHAPTER 6

CONCLUSIONS

VLC trial base material offers clinicians several advantages during the trial base manufacturing process, including increased material safety and ease of use. While the literature offers several examples of material distortion due to 'resin uplift' during the polymerization process, there have been successful attempts made to improve the accuracy of the material by relining it, and even modifying the polymerization process. It was unknown, however, if the simple protocol offered in this experiment would offer a means of combating the distortion.

From this study, the following conclusions can be made:

1. The experimental protocol for fabricating a trial base from VLC material did not experience distortion up to 7 days after being polymerized that is statistically significant, while the manufacturer's protocol did.
2. Less distortion between the trial base and the cast occurs as distance from the posterior aspect of the base increases toward the center of the trial base regardless of time or protocol.
3. The greatest distortion between the trial base and the cast occurs toward the mid-palatal aspect of the trial base toward the posterior palatal seal regardless of time or protocol.
4. The experimental protocol for fabricating a trial base from Trial VLC material experienced far less distortion than the manufacturer's protocol.
5. The experimental protocol might allow for a trial base that fits and retains better than one made using the manufacturer’s protocol.

CHAPTER 7

APPENDIX A

Table 7. Mean measurements for EXHR

Sample	A0	B0	C0	A5	B5	C5	A10	B10	C10	A15	B15	C15	A20	B20	C20
1	0.18	0.81	0.28	0.11	1.24	0.18	0.42	0.46	0.43	0.52	0.39	0.23	0.05	0.16	0.05
2	0.21	0.74	0.22	0.09	0.91	0.16	0.51	0.41	0.39	0.57	0.33	0.09	0.18	0.28	0.05
3	0.14	0.72	0.32	0.05	1.03	0.18	0.43	0.95	0.20	0.29	0.44	0.16	0.00	0.26	0.05
4	0.38	0.78	0.44	0.10	1.21	0.19	0.17	0.99	0.45	0.31	0.42	0.26	0.00	0.28	0.05
5	0.15	0.63	0.40	0.05	1.25	0.00	0.00	0.52	0.00	0.45	0.26	0.00	0.05	0.31	0.05
6	0.26	0.77	0.16	0.00	0.93	0.05	0.48	0.42	0.38	0.45	0.28	0.32	0.00	0.25	0.00
7	0.32	0.78	0.36	0.17	0.98	0.05	0.54	0.41	0.45	0.63	0.24	0.20	0.00	0.05	0.00
8	0.24	0.58	0.48	0.05	0.62	0.05	0.05	0.51	0.32	0.60	0.67	0.12	0.00	0.22	0.14
9	0.31	0.90	0.30	0.27	1.09	0.05	0.35	0.62	0.48	0.22	0.32	0.28	0.15	0.32	0.23
10	0.13	0.72	0.22	0.00	0.71	0.10	0.15	0.78	0.18	0.05	0.36	0.10	0.00	0.26	0.00

Table 8. Mean measurements for MNHR

Sample	A0	B0	C0	A5	B5	C5	A10	B10	C10	A15	B15	C15	A20	B20	C20
11	0.76	1.81	1.17	0.32	1.66	0.21	1.22	0.87	0.18	0.32	0.72	0.15	0.21	0.48	0.09
12	0.85	1.58	0.89	0.97	1.32	0.57	1.08	1.02	0.38	0.37	0.62	0.24	0.16	0.53	0.25
13	1.11	1.49	0.76	0.52	1.51	0.49	1.01	1.04	0.29	0.57	0.79	0.32	0.28	0.41	0.21
14	0.82	1.75	1.31	0.38	1.44	0.32	0.52	0.78	0.55	0.94	0.61	0.20	0.21	0.41	0.16
15	1.58	2.39	1.32	0.90	1.98	0.37	0.49	1.12	0.46	0.47	0.72	0.41	0.31	0.54	0.34
16	0.90	1.71	1.02	0.59	1.91	0.54	0.38	1.46	0.41	0.39	0.75	0.61	0.32	0.45	0.42
17	1.12	2.36	0.79	0.81	1.96	0.41	1.19	2.03	0.28	0.45	1.08	0.29	0.49	0.72	0.27
18	1.08	1.69	0.71	0.43	2.03	0.35	0.79	1.27	0.23	0.59	0.65	0.80	0.31	0.62	0.60
19	1.12	1.62	0.61	0.66	1.65	0.39	0.41	1.10	0.34	0.91	0.51	0.62	0.31	0.48	0.25
20	0.94	1.58	0.87	0.75	1.79	0.61	0.99	0.89	0.33	0.48	0.54	0.77	0.29	0.56	0.39

Table 9. Mean measurements for EXWK

Sample	A0	B0	C0	A5	B5	C5	A10	B10	C10	A15	B15	C15	A20	B20	C20
21	0.20	0.89	0.37	0.15	1.22	0.11	0.17	0.59	0.21	0.45	0.15	0.18	0.14	0.34	0.12
22	0.34	0.81	0.38	0.05	0.88	0.16	0.05	0.42	0.05	0.12	0.38	0.16	0.00	0.15	0.00
23	0.27	0.78	0.45	0.14	0.66	0.10	0.40	0.62	0.18	0.22	0.53	0.19	0.16	0.42	0.18
24	0.22	0.58	0.24	0.05	0.76	0.11	0.18	0.33	0.05	0.05	0.05	0.00	0.05	0.05	0.05
25	0.20	0.65	0.27	0.05	0.74	0.05	0.10	0.28	0.14	0.00	0.05	0.00	0.00	0.05	0.00
26	0.17	0.95	0.12	0.12	0.90	0.10	0.22	0.56	0.17	0.23	0.46	0.10	0.05	0.30	0.05
27	0.21	0.62	0.27	0.14	0.70	0.05	0.10	0.20	0.11	0.05	0.16	0.18	0.05	0.28	0.21
28	0.28	0.72	0.32	0.12	0.92	0.19	0.24	0.49	0.27	0.48	0.35	0.29	0.05	0.15	0.10
29	0.26	0.81	0.24	0.05	0.85	0.18	0.24	0.51	0.17	0.22	0.23	0.00	0.10	0.14	0.05
30	0.11	0.79	0.19	0.10	1.03	0.05	0.12	0.40	0.10	0.12	0.44	0.14	0.05	0.15	0.05

Table 10. Mean measurements for MNWK

Sample	A0	B0	C0	A5	B5	C5	A10	B10	C10	A15	B15	C15	A20	B20	C20
31	0.72	1.38	0.66	0.51	1.62	0.22	0.80	0.75	0.51	0.63	0.87	0.70	0.53	0.37	0.46
32	0.87	1.68	0.72	0.81	1.21	1.04	0.71	0.65	1.02	0.80	0.66	0.50	0.47	0.51	0.87
33	0.76	1.42	0.82	0.48	1.32	0.34	0.59	0.74	0.61	0.73	0.96	0.41	0.58	0.72	0.49
34	1.23	1.59	0.62	0.55	1.50	0.32	0.57	0.85	0.31	0.56	0.81	0.05	0.23	0.53	0.51
35	0.78	1.67	0.67	0.54	1.71	0.35	0.32	0.80	0.47	0.98	0.64	0.55	0.41	0.69	0.31
36	0.79	1.49	0.73	0.49	1.33	0.43	0.48	0.82	0.43	0.77	0.74	0.76	0.32	0.49	0.41
37	0.85	1.48	0.68	0.36	1.25	0.37	0.31	0.64	0.30	0.52	0.79	0.27	0.05	0.29	0.10
38	1.36	1.61	0.63	0.55	1.49	0.34	0.79	0.66	0.48	0.35	0.76	0.32	0.40	0.72	0.77
39	1.01	1.76	0.76	0.41	1.33	0.11	0.77	0.92	0.22	0.66	0.59	0.53	0.37	0.47	0.41
40	1.12	1.52	0.77	0.78	1.77	0.68	0.83	0.89	0.32	0.98	0.78	0.75	0.42	0.55	0.74

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