Comparing the Vertical Misfit of Casts Produced By Two Verification Jigs

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COMPARING THE VERTICAL MISFIT OF CASTS PRODUCED BY TWO VERFICATION JIGS

by

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A Thesis submitted to the Faculty of the Graduate School,
Marquette University,
In Partial Fulfillment of the Requirements for
the Degree of Master of Science

Milwaukee, Wisconsin

August 2014

ABSTRACT
COMPARING THEVERTICAL MISFIT OF CASTS PRODUCED BY TWO VERFICATION JIGS

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Marquette University, 2014

Purpose: To compare the dimensional accuracy between master casts fabricated with verification jigs made of acrylic resin and light cure Triad.

Materials and Methods: 10 GC Pattern resin Pattern verifications jigs and 10 Triad gel verification jigs fabricated of a master cast of a mandibular model of 4 internal hex implants. A stone base was fabricated for each verification jig. One screw test was used to evaluate the vertical gap at the terminal abutment using a digital micrometer with an accuracy of 1μm to record the vertical gap for each sample.

Results: Triad Gel group has the lowest average distortion value which is 27.8 μm and GC Pattern Resin group has an average value of 29.71 μm. There was no statistical significance difference between the two groups (p=.42)

Conclusions: The Triad gel jigs did not produce superior fit compared to GC Pattern resin pattern in a master cast with four implants and with an internal connection.

ACKNOWLEDGEMENTS

Abdulaziz Alqahtani, B.D.S.

I would like to express my very great appreciation to Dr. Geoffrey Thompson, my thesis director and director of the Graduate Prosthodontics program for his valuable and constructive suggestion during planning and execution of this research work and I am most of all grateful and thankful for his mentorship during my residency.

I would also like to extend my appreciation to my committee members: Dr. Daniel Domagala, Dr. Gerald Ziebert for their help and advice.

I would like to thank Nobel Biocare for providing me with implant analog needed for this research and my thanks is extended to Mr. Jason Schroeder.

I would also like to thank my faculty, my fellow residents and supporting staff at the Graduate Prosthodontics program.

Finally my special thanks go for my wife Reem for her encouragement, support and understanding during this project. Also I extend this special thanks to my parents, my brothers and sisters for the continuous support they have been showing me throughout my life.

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CHAPTER I

INTRODUCTION

The importance of creating passively fitting implant framework has been emphasized since the introduction of osseointegrated implants in dentistry. All the definitions of passive fit are empirical and not based on scientific evidence. However framework misfit will cause stresses in implant components and in the surrounding bone which may give concerns as to how this may affect the long term osseointegration. Mechanical complications such as gold screw loosening or fracture, abutment screw fracture, and framework or veneering material fracture have been attributed to poor fit. It has been noted that achieving an ideal fit is not possible and a scientifically proven definition of clinically acceptable level of fit should be identified. It is always easier to evaluate the fit of the framework in the master cast than to evaluate it in the patient mouth. It is important to make a cast that accurately reproduces the dimensional position of implants intraoraly since a framework that fits that cast will fit in the patient mouth. Use of verification jigs has been suggested for the purposes of producing accurate master models and to verify the implant position. This study was designed to compare the accuracy of verification jigs made using two different materials.

CHAPTER II

LITERATURE REVIEW

I. Fit of the Framework:

The need for passive fit:

Osseointegrated implants have significantly different clinical mobility as compared to natural teeth. It was found that the mobility range for osseointegrated implant 17 to 58 µm labially and 17 to 66 µm lingually with loads of 2.0 kg which is caused by bone deformation. This is in contrast with natural teeth where mobility ranges from 100 to 200 µm [1].

Due to the rigid connection between dental implants and bone, stresses caused by framework misfit will not dissipate over time. Some publications have stressed the importance of achieving a passive fit of implant frameworks because of this rigid connection [2].

Passive fit definition:

Passive fit is assumed to be one of the important prerequisites to maintain bone level around the implants. Theoretically, passive fit is defined as simultaneous and even contact between the whole inner surface of all retainers with all abutments without inducing any strain on the supporting implant components and surrounding bone structure in the absence of occlusal loads. Despite advancements in dental technology, passive fit as defined previously has not yet been achieved [3].

Many authors have defined acceptable passive fit but these definitions are hypothetical and are not based on scientific evidence. Branemark was the first one to define passive fit. He suggested that it should be at the level of 10 µm to allow bone maturation and remodeling under occlusal loads [2]. Jemt suggested that the framework is considered to have a passive fit when the gap between framework and abutment is less than 150 µm. He also stated that when more than a half turn is needed to completely seat the screw after initial resistance was felt, the framework is considered to have poor fit [4]. Patterson defined passive fit as the absence of gap between framework and abutment and absence of unfavorable strain after torqueing the screws [5]. Karel et al. defined passive fit as an absolute lack of strain development after placement of framework [6]. Klineberg and Murray used precision metal shims of 30 µm thickness to evaluate the fit of the framework. They considered frameworks with a gap greater than 30 µm over 10 % of the circumference of the interface as unacceptable [7].

Outcomes of framework misfit

Due to the rigidity of the connection between osseointegrated implants and surrounding bone, any stress caused by framework misfit will be transmitted to implant components and implant bone interface [3].

A finite element study showed that the presence of 111 µm vertical gap had a significant impact on stress distribution in implant components and surrounding bone. The presence of a cantilever or excessive force increased the effect of the misfit. When passive fit is achieved a lower peak stress is produced in each component due to widely

distributed stresss in all components. Also, when the prosthesis has a misfit, the gold screw and the abutment screw bore more stress than when a passive fit is present [8].

When the concept of implant osseointegration was established it was thought that having poor fit will have a detrimental effect on established osseointegrated implants [2]. In an animal study done by Carr et al., they found no difference in bone response between screw retained prostheses with two levels of misfits; 38 µm and 345 µm in the absence of occlusal loading [9]. In a retrospective study done by Kallus et al., they examined 236 patients who were wearing an implant supported prosthesis for at least 5 years. It was found that gold screw loosening was related to framework misfit. There were no clinical or radiographic findings that would indicate framework misfit will cause bone loss around implants [10]. Jemt and Book measured *in vivo* framework misfit in two groups of patients. One group was prospectively followed for one year, and the second group was followed retrospectively for five years. They found no statistical correlation between marginal bone loss and framework misfit with an average gap of 111 µm for one year group and 91 µm for the five year group and with a maximal discrepancy of 275 µm for both groups [11].

Previous studies have indicated the presence of bone tolerance around implants. However, no studies have scientifically measured or quantified the amount of this tolerance [12]. Several publications suggest that poor implant framework fit may cause mechanical complications such as gold screw loosening or fracture, abutment screw fracture, and framework or veneering material fracture [10, 13, 14]. When the framework misfit is excessive large external stresses will be introduced in screws and implant abutments which may lead to loosening or fracture of screws or fracture of the framework

if it does not possess enough bulk. The loosening of the screws is attributed to inadequate counteracting torque to the bending of an ill-fitting framework when tightened to the implant abutment [3].

II. Measurement of the Framework Misfit

1. Clinical Assessment

Different methods have been proposed to evaluate the fit of the framework. Clinically there are different methods to evaluate the fit of the framework; however, none of these methods is accepted as the standard test. The accuracy of these methods can be affected by implant distribution and number, margin location, framework rigidity, eyesight, lighting, angle of vision, and experience of the dentist [12].

The alternate finger pressure technique is a simple technique to detect a gross misfit by applying pressure in an apical direction alternatively at each end of the framework to detect the presence of any fulcrum [15]. Adell et al. suggested that the observation of saliva movement at the framework-abutment junction increases the accuracy of this technique [16]. Direct vision and tactile sensation, with the use of an explorer is another technique that can be improved by the use of ample lighting and magnification [14, 15, 17]. Sensitivity of this method is affected by the size of the explorer tip, location of margin, and the dentist's visual acuity. Christensen showed that clinicians would accept a subgingival margin with an opening up to 119µm, while supragingival with a 26µm opening were rejected [18]. Dental explorers are more efficient in detecting horizontal gaps compared to vertical ones [19].

Periapical radiographs are another method to evaluate framework fit especially when connections are subgingival. The radiographic film should be perpendicular to the long axis of the implant-abutment junction [20].

The one screw test was suggested by Jemt for evaluation of framework fit. [4] In this test, one screw is tightened at one terminal abutment and any discrepancy is observed at the other abutments [21, 22]. It is effective for long span frameworks. It is used in conjunction with direct vision and an explorer when the margins are supragingival or with radiograph for subgingival margins. One of its drawbacks is that it cannot detect discrepancies in three dimensions and often distortion is masked if it is occurs in a horizontal plane [21, 22]. Another screw test introduced by Jemt is based upon a vertical misfit of 150µm or less. In this test, every gold screw is tightened individually until initial finger resistance is achieved. If more than a half turn is needed to torque the gold screw from 10 to15 N-cm then it is a misfit [23, 24].

Disclosing materials, such as wax, elastomeric material, and pressure indicating paste have been used to evaluate framework fit [17, 25]. They can be used with both supragingival and subgingival margins. Materials of measurable thickness like unwaxed floss (12 µm) and shim stock (10-12 µm) can also be used to assess the fit of the framework [12].

2. Laboratory Assessment

When the framework is fabricated, the lab technician should check the fit on the cast before the dentist tries it in the patient's mouth. A framework that does not fit the master cast will not fit in the mouth. Several different methods may be used to assess the

fit of framework in the laboratory. Few of them are practical and cannot be used in a commercial laboratory.

One screw test: if no detectable gap exists between the implant analogs and the framework when one screw in the distal abutment is completely tightened we can say the framework has an acceptable fit. The presence or absence of the gap can be assessed by explorer, direct vision, micrometer, or magnification [26].

Microscope measurements: microscopes of different magnifying powers can be used to measure inter-implant distances or to measure vertical gaps in conjunction with one screw test. To use this method effectively reference points should be used to standardize measurement [27].

Photogrammetric technique: it was introduced by Lie and Jemt to analyze the fit of implant frameworks. This technique measures the three dimensional orientation of the abutment cylinders on the implant analogs. It involves the use of a small standard camera with a wide angle lens modified by placing a glass plate with cross mark in the film plane and two parallel mirrors in the front of the lens. This modification will result in the production of 3 images of every object from one exposure. The images produced by this camera will be measured by an analytic plotter under stereoscopic vision and with the aid of computer software. This technique can provide an accurate three dimensional measurement that can measure a gap as small as 30 μm. It is a technique sensitive procedure that requires standardization of the position of the camera [23].

Coordinate measuring machine: this machine consists of a probe which can travel in the x,y,z axes and record the dimension of the framework or inter-implant analogue distances and height when it touches a surface. The distances that the probe travels is

calculated by computer software and transformed into measurable data. When using this machine to measure framework misfit it is important to have a verifiable datum and a coordinate reference system before any comparison between different measurement sets [28]. Although this machine has high accuracy, it is not feasible to use this machine due to its high cost which make its use limited to dedicated metrology oriented research laboratories [26].

Strain gauge analysis: strain gauges consist of fine wires or foils arranged in a grid pattern which are attached to the framework. These gauges are sensitive to strains caused by inaccuracy of framework misfits. One of the drawbacks of this method is that strain values are measured only where the gauges are attached, which make detection of strain dependent on where the gauges are attached and not where the highest strain is. They are also sensitive to temperature [29].

Finite element analysis (FEA): is a computer-based technique for calculating strength and behavior of structures [30]. It is a good tool to evaluate the behavior of peri-implant structure and stresses affecting screws and implant bone interface caused by framework fitting and occlusal loading. The clinical significance of the information provided by the FEA is dependent on the assumptions and boundary conditions in the hypothesized model [26].

III. Factors affecting the framework fit accuracy

Each step for framework fabrication has an effect on the final fit of the framework starting from impression making. Clinical factors include impression material and

impression technique, while laboratory factors include die material, die fabrication technique, and materials and techniques used to fabricate the framework.

1. Impression material:

Impression materials are used to record a negative form of the intraoral structure for the fabrication of stone casts that replicate the intraoral structure where the prosthesis is fabricated. The accuracy of the impression is very important for the construction and the fit of the implant-supported prosthesis. Ideal dental implant impression should produce an accurate impression, resist tearing without traumatic removal, has enough working time, sets within a reasonable time, biocompatible, pleasant order, taste and acceptable color, easy to use, easily wets oral tissue, dimensionally stable, compatible with die materials, and have enough rigidity to prevent displacement or rotation of impression coping [31].

Alginate impression material are hydrophilic in nature and has the ability to work in wet environments with blood or saliva with good accuracy. It can reproduce good surface details as it has a low wetting angle. It can be easily removed from the patient's mouth. Due to its lack of rigidity, alginate impressions must be supported by rigid trays. Alginate can be considered as the most flexible impression material which makes it not useful for dental implant impression. It is relatively low in cost compared to other impression materials. Alginate impression materials are dimensionally unstable, asimbibition or desication can occur therefore alginate must be poured no more than 10-12 minutes after impression making and it can only be poured once. It has relatively a low tear strength therefore it can tear easily[31].

Polyether impression materials are moderately hydrophilic, have low wetting angle, accurate, dimensionally stable, and can be poured after 1-2 weeks after impression making and allows multiple pours. Polyethers have the highest tear strength therefore it does not tear easily and can be used in subgingival areas. Polyethers are rigid materials therefore difficult to remove from the patient's mouth; however, "soft" polyethers can be removed more easily. It has a short working time (4-5 minutes) and setting is not altered by latex. Polyethers taste bad; however its bitter taste can be masked by flavors [31].

Polyvinyl siloxanes are hydrophobic in nature therefore less accurate in the presence of moisture; a surfactant might be needed to reduce the high wetting angle. They are dimensionally stable allowing for multiple pours and can be poured weeks after impression making, but require a wait of at least 30 minutes before pouring to allow the setting reaction to be completed to avoid porosity. They are rigid with high tear strength but not more than polyether; however, they can be removed more easily than polyethers. It is thermally sensitive, sets slower upon cooling and faster upon heating. Polyvinyl siloxanes can be contaminated by sulfur or sulfur compounds from latex gloves and rubber dams and from the oxygen inhibited layer found after curing resins [31].

Polysulfide impression materials are low to moderately hydrophilic, have low wetting angle with excellent details, fair dimensional stability can allow multiple pours only with the presence of acceptable thickness of the material, not rigid and can be removed easily without tearing therefore can reproduce the subgingival margin accurately. It is inexpensive, not affected by latex, has bitter taste and it cannot adhere to itself therefore cannot be used in border molding [31].

Impression plasters contains calcium sulfate hemihydrate as the main component. This material is rigid and cannot bend, and must be stored in an air tight container to prevent it from absorbing water from air. Impression plasters are rarely used nowadays; however, it is used as "wash" material in edentulous impressions[32].

Polyether and vinylpolysiloxane (VPS) are the preferred impression material for implant impressions [33-37]. Wee et al., evaluated torque resistance of different impression materials and found that (medium consistency) polyether has the highest torque value followed by VPS addition silicone (high consistency) and then polysulfide (medium consistency). Additionally, he reported that implant casts made from polyether and addition silicone impression materials were more accurate than polysulfide impression material [33]. Assunaco et al. evaluated four dental impression materials using three different impression techniques with different implant angulation for model with four implants. They found that condensation silicone has the least accuracy among materials tested and he suggested that the use of condensation silicone is contraindicated with dental implants. They also found that polyether and high viscosity addition silicone were the most accurate. Polysulfide had an intermediate accuracy [38].

Several other studies compared the accuracy of polyether and VPS impression materials and found no difference [33-36, 38-40].

2. Custom tray vs. stock tray:

Multiple publications showed that custom trays consistently produced accurate impression compared with stock trays in prepared teeth. In dental implant impression Burns et al found that rigid custom trays for pick up impressions produced more accurate

impressions compared with flexible stock tray. It was possible to have accurate impression with stock tray but its accuracy was not consistent compared to custom tray [41, 42].

3. Impression technique:

There are two implant impressions techniques used with most implant systems. The closed-tray technique uses tapered impression coping. The coping are connected to the implants and after making the impression the copings are removed from the mouth, connected to an implant analogue and then reinserted into the impression before pouring the final cast. The open-tray technique uses square and screw-retained impression copings. The openings in the tray allow access to the impression coping screws so that the coping can be removed along with the impression.

Liou et al. evaluated the accuracy of replacing three tapered impression copings in a transfer impression technique made from Impregum F and Extrude impression materials. It was found that none of the copings were replaced accurately and consistently by all five participating dentists [34]. Daoudi et al. found significant difference in implant position in the horizontal plane, implant inclination and rotation in casts produced by senior dentist, postgraduate student and dental technicians after they repositioned tapered impression copings into elastomeric closed-tray impressions [37].

Del Acqua et al. reported in his study that both splinted and unsplinted open-tray impressions are more accurate compared with closed-tray impression. When there are three or less implants, most studies showed no difference between closed-tray and open tray impression techniques [43]. However, when there are four or more implants several

studies have shown that open-tray impressions were more accurate [40]. Kim et al. compared the accuracy of implant impression in-vitro and found that the non-splinted technique showed less three dimensional linear displacements than the splinted technique during impression making while the splinted technique showed less three dimensional linear displacement than the non-splinted group during cast fabrication [44]. One study evaluated the accuracy of pick-up impressions made with an acrylic resin splint and without on a model with four internal connection implants using polyether impression material. It was found that splinting impression copings with acrylic resin produced more accurate casts [45].

Assunaco et al. evaluated accuracy of transfer impressions for osseointegrated implants at various angulations. They evaluated four dental impression materials using three different impression techniques with different implant angulation situations for model with four implants. It was found that open tray impressions with splinted impression coping produced better results compared with open tray without splinting and closed tray impression [38]. More recent studies reported implant impression with splinted coping were more accurate than impressions made with non-splinted copings [38, 40, 46].

4. Die Materials:

A definitive cast is the positive reproduction of the intraoral structure recorded by the impression material. Desirable qualities of die materials are accuracy, dimensional stability, ability to reproduce fine details, strength, resistance to abrasion, ease of adaptation to the impression material, color for contrast, and safety [31].

Gypsum is the most commonly used cast and die material. It is produced by calcining calcium sulfate dihydrate. The dihydrate is ground and heated to temperature of 110º C to 120º C (230º F to 250º F) to drive off some of the water of crystallization and convert them to calcium sulfate hemihydrate. Depending upon heating conditions, different forms of calcium sulfate hemihydrate are produced [47].

According to the American Dental Association specification number 25 dental gypsum products are available in five types:

I Plaster Impression.

II Plaster Model.

III Dental Stone, Model.

IV Dental Stone, Die, High Strength, Low Expansion.

V Dental Stone, Die, High Strength, High Expansion.

The criteria used to classify types of gypsum products are setting expansion and compressive strength. All of these five types are made of the same chemical (calcium sulfate hemihydrate); however, the difference is in the amount of water remaining within the crystal. Water decreases as the temperature increases during the process of calcination.[48]

After initial setting all gypsum products show measurable linear expansion this expansion could alter the positional relationship of implant replicas within the die material. American Dental Association Specification Number 25 defines setting expansion as percentage linear growth of the die material measured at two hours after initial mixing [48]. Heshmati et al. measured the linear setting expansion of six type IV and type V dental stones up to 120 hours. He found that for most of die materials, setting

expansion was complete at 96 hours and most of the expansion happened after 2 hours (22% to 71% of the total expansion). Die keen exhibited the highest total expansion [49].

One of the disadvantages of gypsum is poor resistance to abrasion. To compensate for this disadvantage attempts were made to improve gypsum by including hardener in the gypsum products. Resin strengthened gypsum products such as Resin Rock is an example of attempt to strengthen the gypsum products [50].

An alternative material to gypsum products are epoxy resin and electroplated dies. Epoxy resin die materials are used to overcome the low strength and poor abrasion resistance of die stone material. They exhibit polymerization shrinkage with values ranging from 0.1% to 0.3%. It has better detail reproduction compared with gypsum [50]. Electroplated die involves the deposition of a coat of pure silver or copper on the impression and then the coat is supported with type IV stone or resin. This technique has many disadvantages, it is time consuming to produce a cast with this technique as it may take up to eight hours to pour the cast, special equipment is necessary, it is incompatible with many impression materials and when silver plating is used, and health safety is a concern because of the cyanide solution [50].

Wee et al. measured the dimensional changes of implant casts fabricated with Vel-Mix, Die Keen, Resin Rock and a low fusing alloy. He also measured the amount of strain produced in implant framework which was secured to different experimental stone casts. Resin rock produced the least mean absolute strain on the implant framework and it also produced the least dimensional change among other die stone materials [51].

Duke et al. compared the physical properties of two resin modified type IV gypsum die stone material (Resin Rock and Milstone), two conventional type IV gypsum

die materials (Silky Rock and Diestone) and an epoxy resin die material (Epoxy-Die). Epoxy die had a superior abrasion resistance, better detail reproduction, the highest transverse strength and the highest dimensional change. There was no significance difference between the properties of resin modified gypsum die materials and those of conventional die materials [52].

Kenyon et al. compared the linear dimensional accuracy of seven die materials: type IV gypsum die (Vel-Mix), type V gypsum die (Hard Rock), resin reinforced type IV gypsum die (Resin Rock), epoxy resin (Die Epoxy), polyurethane resin (Model Tech), bis-acryl composite material (Integrity) and copper-plated supported with resin reinforced type IV gypsum die. All measurements were done 96 hours after separation from the impression. Resin reinforced type IV gypsum die and copper plated dies were more dimensionally accurate than all others. Epoxy resin material shrank the same as gypsum expanded. Polyurethane dies showed combination shrinkage and expansion which prevents it from being recommended as a die material [53].

Linear expansion will affect the accuracy of the cast and hence the accuracy of the framework fit. All die material will exhibit some dimensional changes after setting. It is important that dentists and laboratory technicians select a die material with minimal dimensional changes for implant restorations.

5. Implant framework fabrication technique:

Conventional casting:

The fit of a cast implant framework is affected by pattern fabrication material, investment material, investing technique and casting [54]. Noble metal alloys produce

implant frameworks with better fit compared to base metals. Frameworks cast using a gold alloy has the most accurate fit among alloys, but the high cost of gold limits it use. Silver-palladium alloy is an economical alternative to gold and it has superior fit compared with base metal [55]. Noble alloys have a high density and low solidus temperature compared to base alloys which make them more easily castable. In addition, cast-to abutments can be only used with noble alloys. Cast-to abutments have a prefabricated machined surface that fits more accurately compared to burn out plastic sleeves used with base metals [56].

Base metal alloys such as cobalt-chrome (Co– Cr) and nickel-chrome (Ni-Cr) are less expensive compared with noble alloys and have superior physical properties. However, they are difficult to cast, finish, and polish. For base metal casting accuracy, titanium (Ti) alloy casting is more accurate than Ni-Cr and Co-Cr alloys, and Co-Cr alloy casting is worse than Ni-Cr. Single base alloy casting are not acceptable for implant frameworks and additional refinements to improve their fit are needed before they can be inserted [55].

Sectioning and soldering is one way to improve the fit of cast frameworks, especially for noble alloys. The framework may be cast in multiple segments and then soldered together with the use of intraoral index [57]. The cast-to procedure is a modification of soldering technique where instead of using low fusing solder to connect the framework segments a similar framework alloy is used to connect the segments together. The cast-to method can be superior to the normal soldering technique [58].

Laser welding is another technique to connect framework segments. It is an efficient method to improve the fit of base metal alloy frameworks. It doesn't require the

use of additional materials to connect the framework thus in theory it should not reduce the strength of the welded structure. However a 15 years retrospective study reported more fractures in laser welded frameworks compared to gold framework and all fractures happened in the laser welded joint [59].

Spark erosion also known as electric discharge machining is a process that uses electric discharge to precisely contour metal or alloy by erosion [57]. Spark erosion can provide superior fit compared to sectioning and soldering gold alloy frameworks. It improves the fit of base metal alloy frameworks more than it improves the ones with noble alloy. It can be used on the framework even after porcelain application; however, it requires a special machine and training and it is an expensive procedure which hindered its universal use in commercial labs [55].

Computer aided design and computer aided manufacture (CAD/CAM):

CAD/CAM involves three steps, 1) scanning to record the 3D geometry of the dental cast and construct a virtual model; 2) CAD modeling by virtually design the 3D contours of implant framework, and 3) CAM production by milling the actual framework according to the virtual design [60]. Advantages of CAD/CAM fabrication process is it eliminates the use of wax patterns, investment and casting, and any inaccuracies that comes with these steps. In addition CAD/CAM titanium frameworks are milled from homogeneous blocks. They have better physical properties and the process is less labor intensive compared to conventional cast alloy [61]. CAD/CAM milled frameworks exhibit a superior and consistent fit compared with conventional cast frameworks even with sectioning and laser welding [55, 62]. Until now CAD/CAM milled frameworks

fabrication are the most accurate and consistent way to fabricate implant frameworks [55].

IV. Verifying the accuracy of the master cast:

Henry and Rasmussen described techniques to verify the accuracy of the master cast using a verification jig made of Duralay resin [15, 63]. Moreover, verification jigs can be used for fabrication of a corrected cast if the master cast was not accurate [15, 64], or it can be used to verify the fit of the metal framework [15, 65].

One in vitro study compared the accuracy of verification jigs to closed and open tray impression technique with elastomeric impression material. The model used in this study was of 3 parallel implants. It was found that there was no positive advantage for using a verification jig since the accuracy of verification jigs was not significantly superior to standard impression techniques [66].

In a retrospective study done by Ercoli et al; he evaluated if there was a difference in the passivity between metal frameworks fabricated with or without a verification jigs, it was found that when a verification jig was used all frameworks achieved passive fit on all patients. While in the other group, where the frameworks were fabricated without a verification jig, only 2 frameworks achieved passive fit while 12 did not [67].

Statement of the problem:

Accurate master casts are a prerequisite when fabricating a metal framework for implant restorations. Currently, all impression techniques may generate variable degree of inaccuracy of the master cast and final restoration which may lead to biological or mechanical failure. Several studies suggest the use of verification jigs to improve the accuracy of the master cast and hence the framework fitting.

Aim of the study:

To compare the dimensional accuracy of master casts fabricated with verification jigs made of acrylic resin and to master casts fabricated with verification jigs made of light polymerized Triad.

Null hypothesis (H_0):

There is no difference between the accuracy of casts fabricated with light cured Triad verification jigs and casts fabricated with GC Pattern resin pattern verification jigs.

Alternative hypothesis (H_1):

There is a significant difference between the accuracy of casts fabricated with light cured Triad verification jigs and casts fabricated with GC Pattern resin pattern verification jigs.

CHAPTER III

MATERIALS AND METHODS

Master Model:

A stone model of a mandible with four implants analogs (Nobel Replace RP, Nobel Biocare) was fabricated (Figure 1). From the stone model a CAD/CAM metal framework was fabricated to precisely fit the cast (Figure 2). This framework will be used later as a measuring reference for the sample casts.

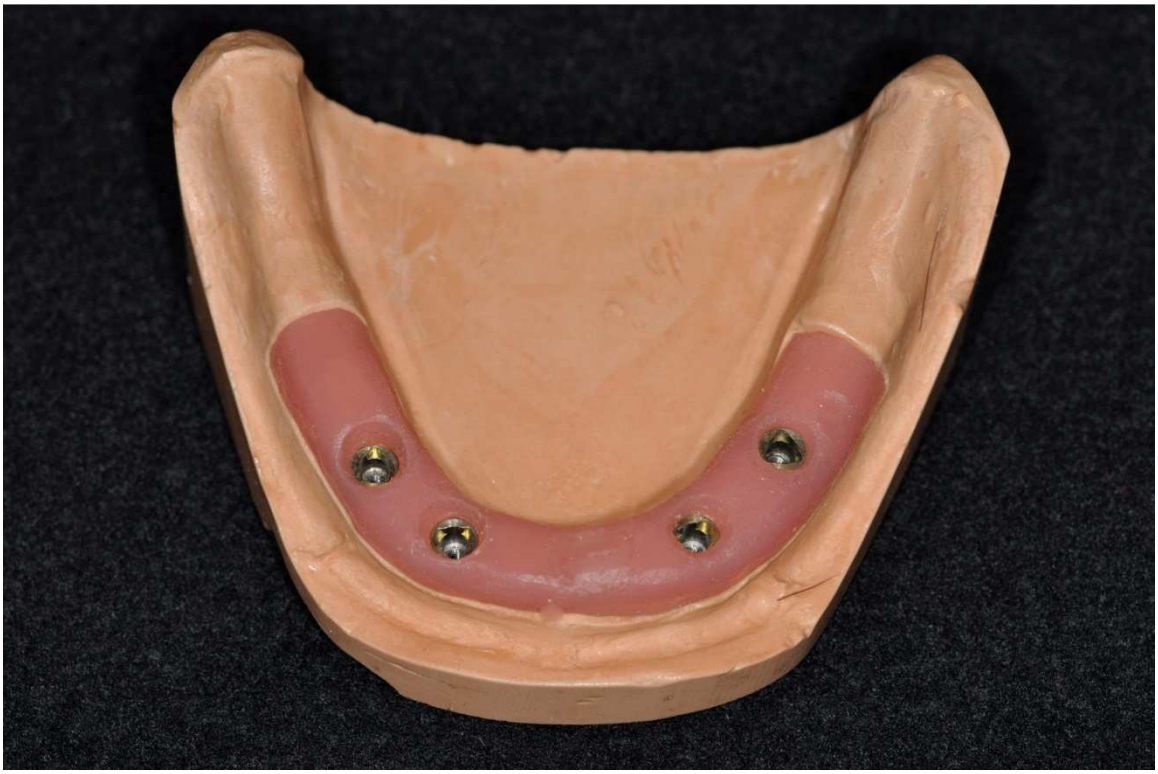

Figure 1: The master model.

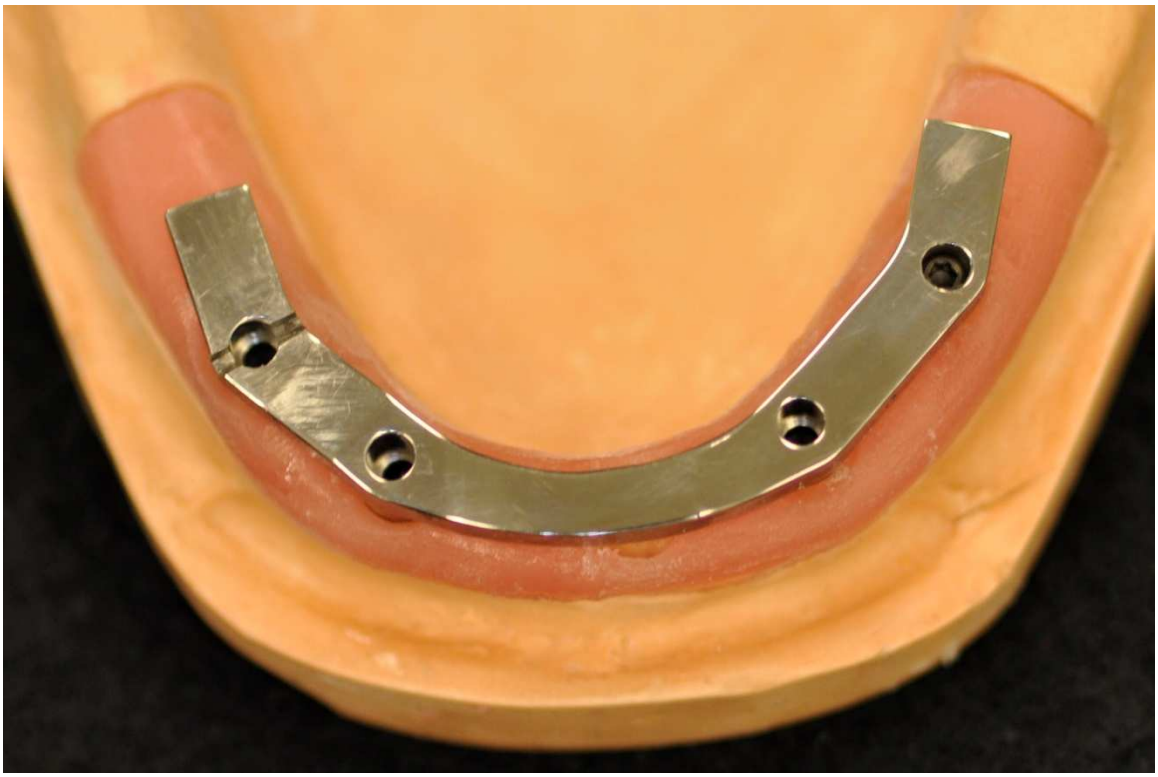

Figure 2: CAD/CAM Framework fabricated from the master cast.

Test Samples:

Twenty verification jigs were fabricated from the stone model to make twenty stone casts and were divided into two groups.

Group 1: 10 verification jigs were made with autopolymerizing resin (GC Pattern Resin, GC America) using open tray impression copings. Four impression copings were hand torqued onto the implant analogs and dental floss was used to connect them. Subsequently, the impression coping were splinted using GC Pattern resin (Figure 3). After the resin polymerized, the jigs were sectioned between each coping with a thin disc to release stresses caused by resin shrinkage (Figure 4). After 24h, the sectioned jig was connected with a small amount of GC Pattern resin individually at each gap in 17 minute intervals. After connecting all segments, a PVS index was made to help duplicate the

verification jig to ensure that every jig has the same dimensions (Figure 5). Then the jig was removed from the model and four implant analogs were connected to the impression copings and a stone model (Resin Rock; WhipMix Corp.) was poured using a base former(Figure 6).

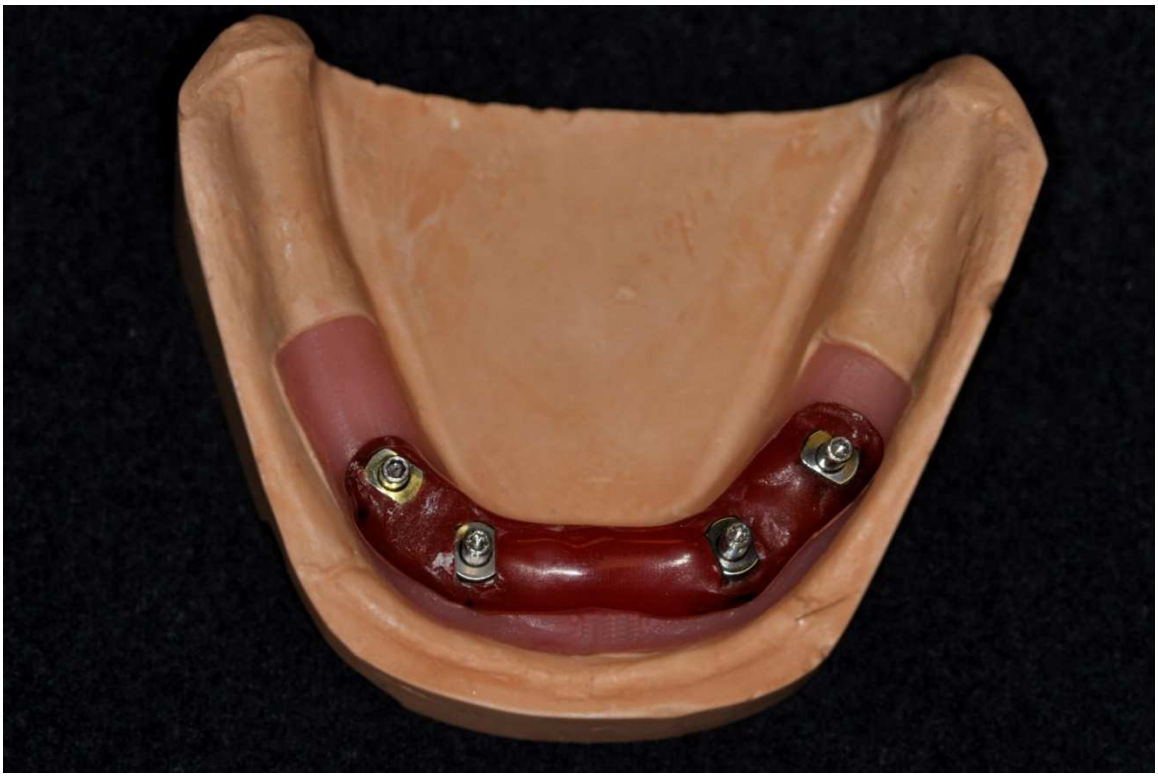

Figure 3: GC Pattern resin verification jig.

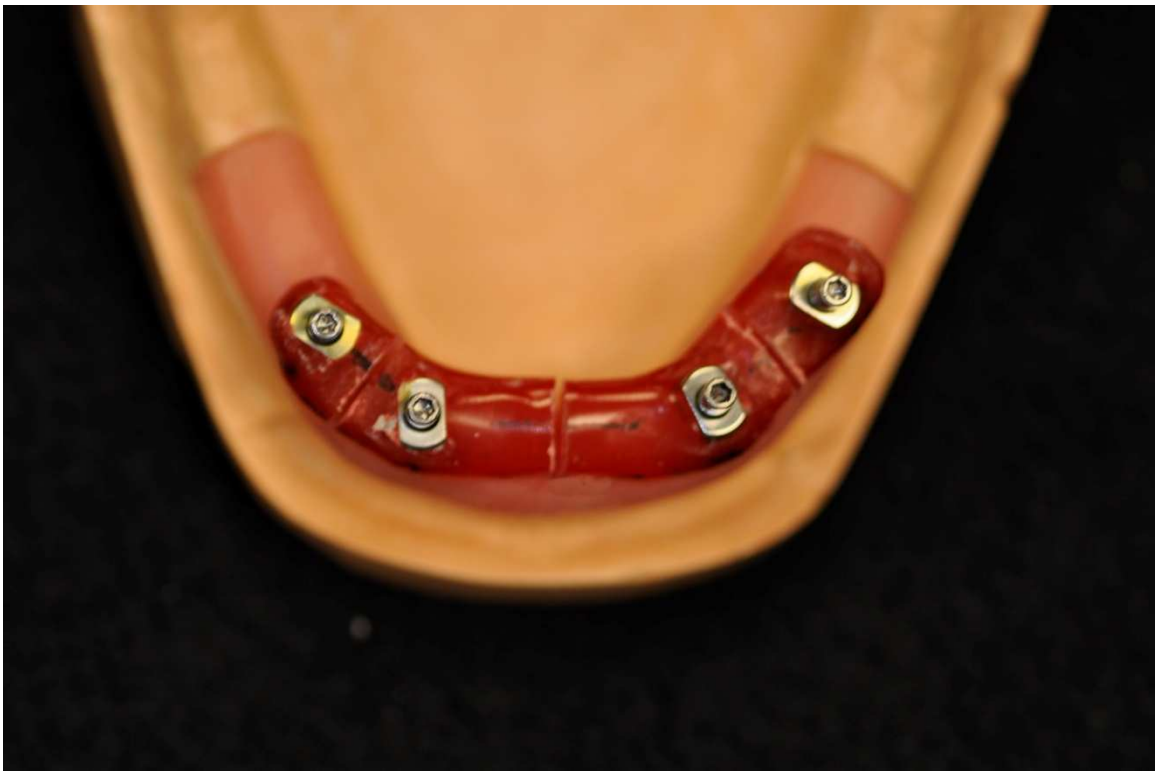

Figure 4: Sectioned verification jig.

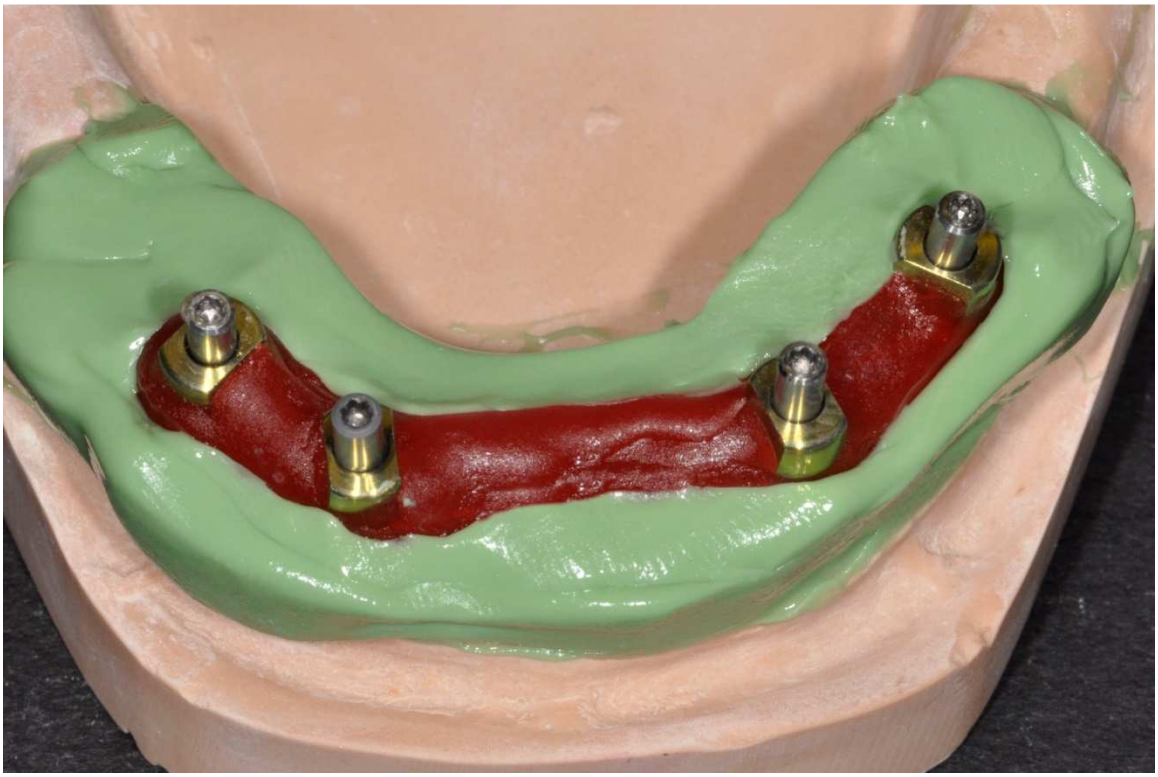

Figure 5: A PVS index was made to help duplicate the verification jigs.

Figure 6: Verification cast

Group 2: Group 1: 10 verification jigs were made with light cured resin (Triad gel, Dentsply International, Inc.) using open tray impression copings. The PVS index Triad was connected to 4 impression copings that were torqued onto implant analogs. After the resin was polymerized for a 1 minute light cure cycle, the jig was sectioned between each coping with a thin disc to release stresses caused by resin shrinkage (Figure 7). After that, the sectioned jig was connected with a small amount of Triad gel between each gap. The gaps were connected individually and light polymerized for 1 minute. After connecting all segments, the jig was removed from the model and four implant analogs were connected to the impression copings and a stone model (Resin Rock; WhipMix Corp.) was poured using a base former.

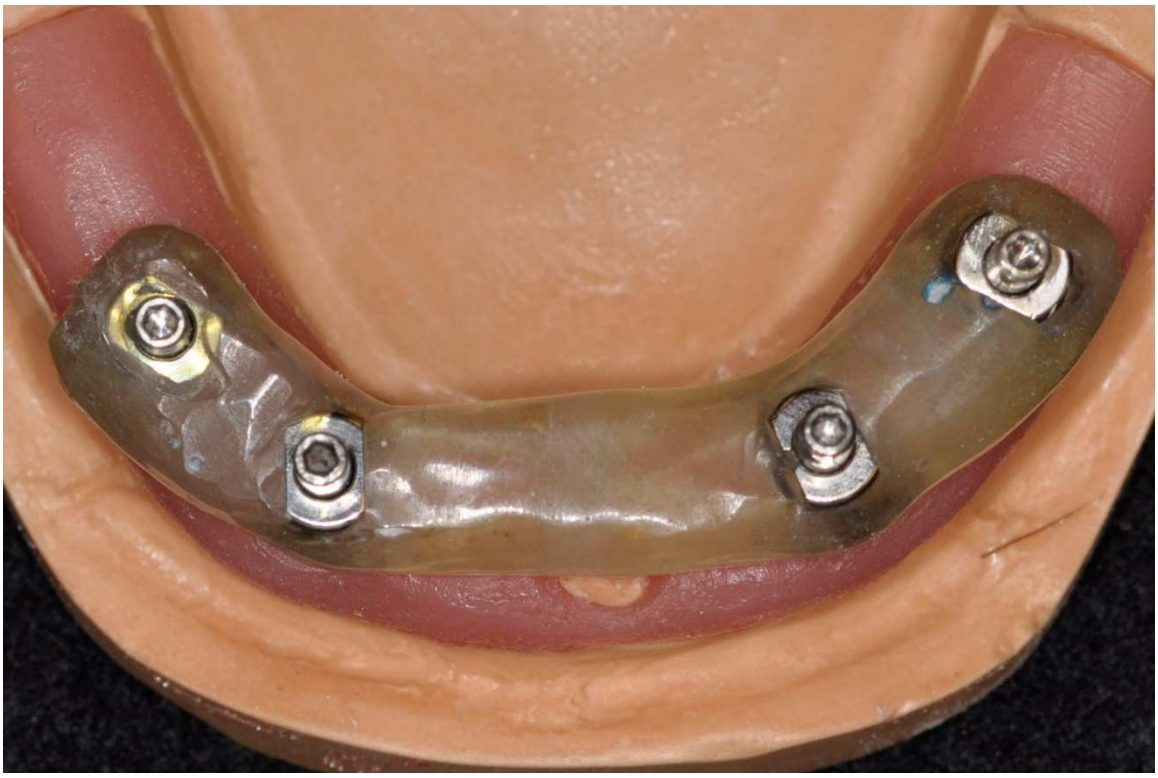

Figure 7: Triad Gel verification jig.

The right distal implant analogue used in every stone base, including the master cast, was modified by machining a dimple in its apical part for use as a reference point (Figure 11). This dimple allowed consistent positioning of the digital micrometer.

A slot was cut with a carborundum disc (Red Flash Disc; Keystone Industries) on the superior surface of the framework, and at the right distal abutment to allow consistent positioning of the blade of the digital micrometer (Figure 12).

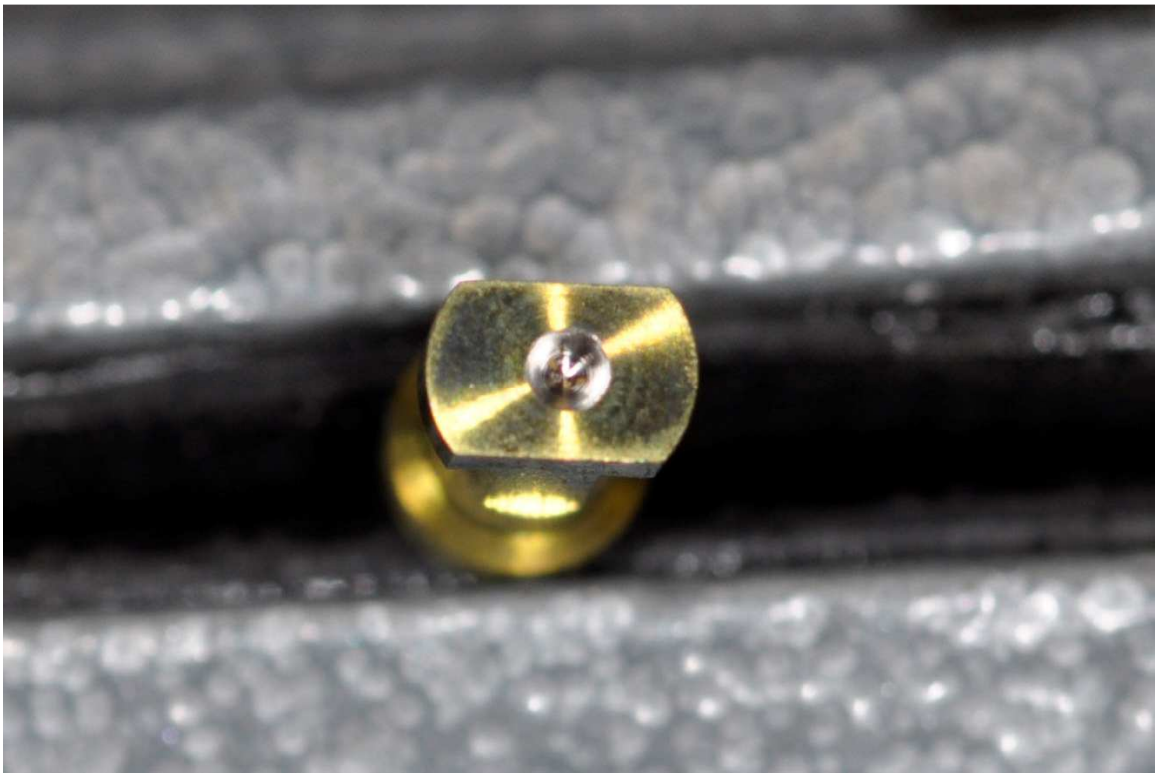

Figure 8: Machined dimple.

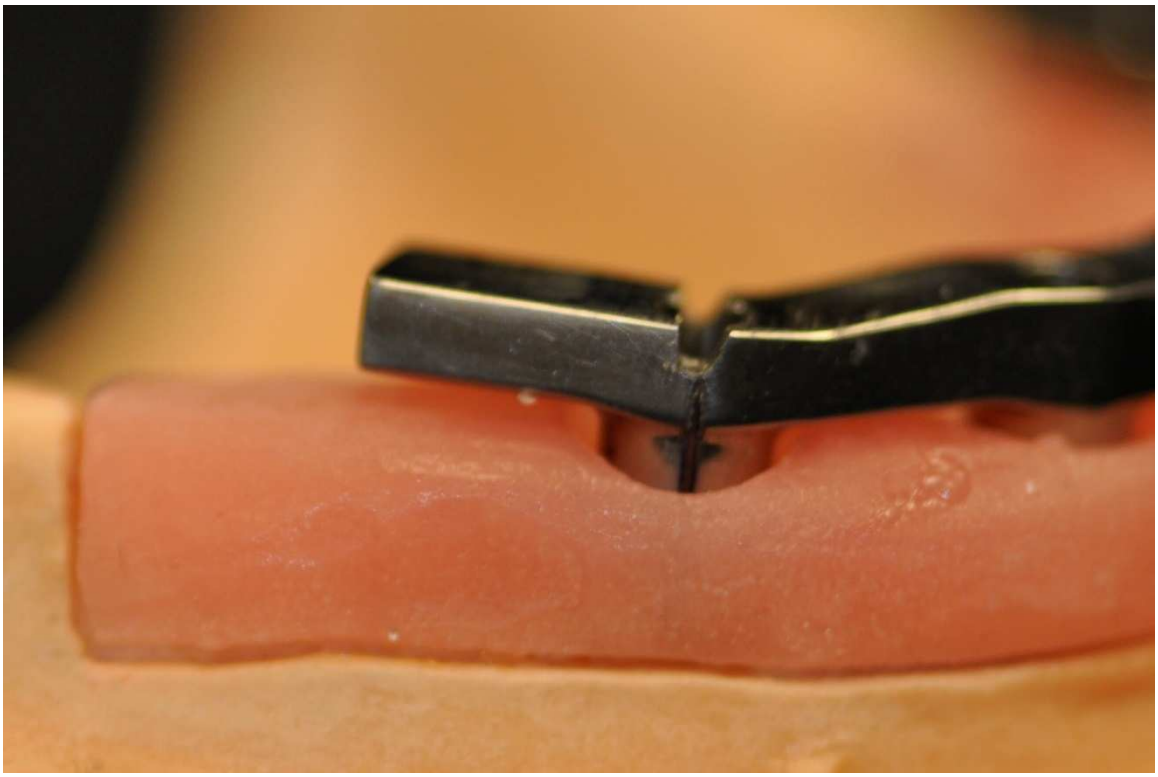

Figure 9: Groove was cut into the framework for measurement reference.

Measurements:

All measurements are made with a digital micrometer with an accuracy of ±1 μm (No. 342-271; Mitutoyo Corp.). The lengths of each implant analog were measured three times and mean values were calculated (Figure 13). The framework was secured on each stone model specimen by torqueing one screw on left distal implant analog to 35 N-cm. A light cured tray resin material (Triad, TruTray, Dentsply International Inc.) were placed between the right framework cantilever and stone model specimen and cured for one minute to prevent downward movement of framework when micrometer measurements were done (Figure 14).

Vertical measurements were made with the digital micrometer. The blade end of the micrometer was placed at the framework slot and the anvil end was placed at the

dimple on the implant analog. Measurements were taken three times and mean values were calculated (Figure 15). The vertical misfit gap was calculated by measuring the overall vertical dimension of framework and the implant analog and subtracting the length of each implant analog. Vertical misfit measurements were subtracted from the measurement made on the master model to obtain a distortion value in each sample.

Figure 10: Measuring implant analog length.

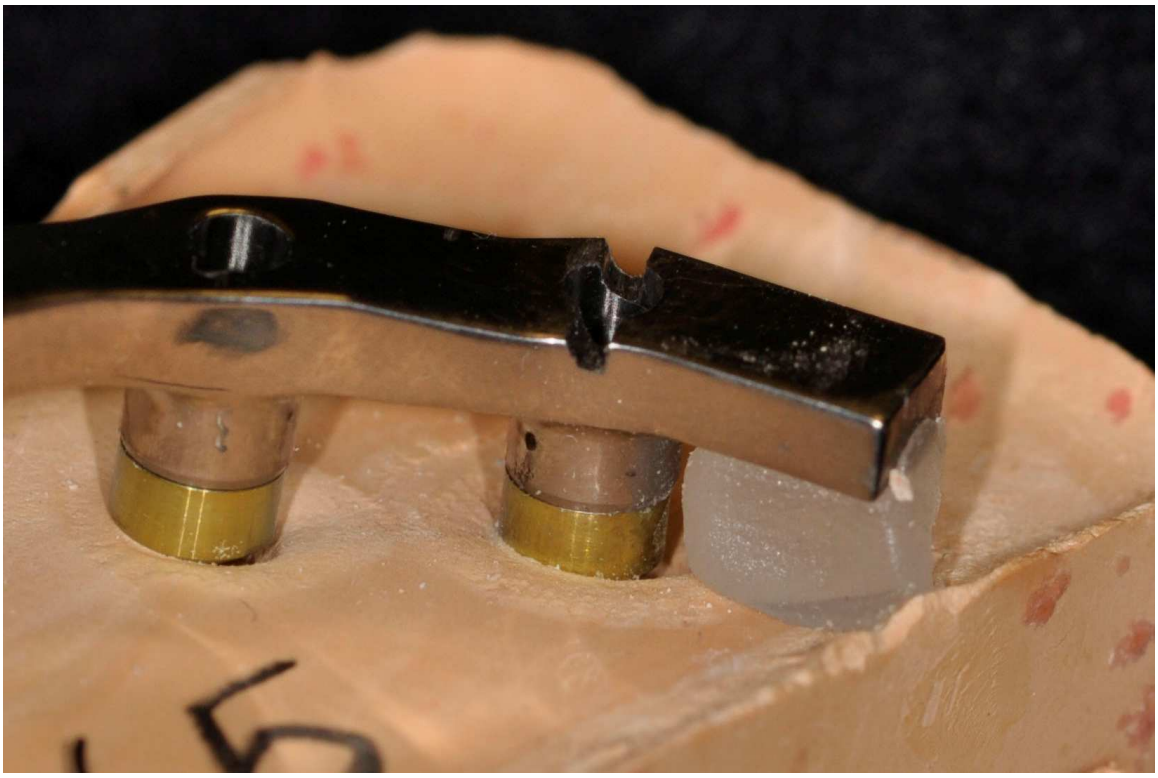

Figure 11: Light cured tray resin material between framework cantilever and stone model specimen to prevent downward movement of framework when measurements were done.

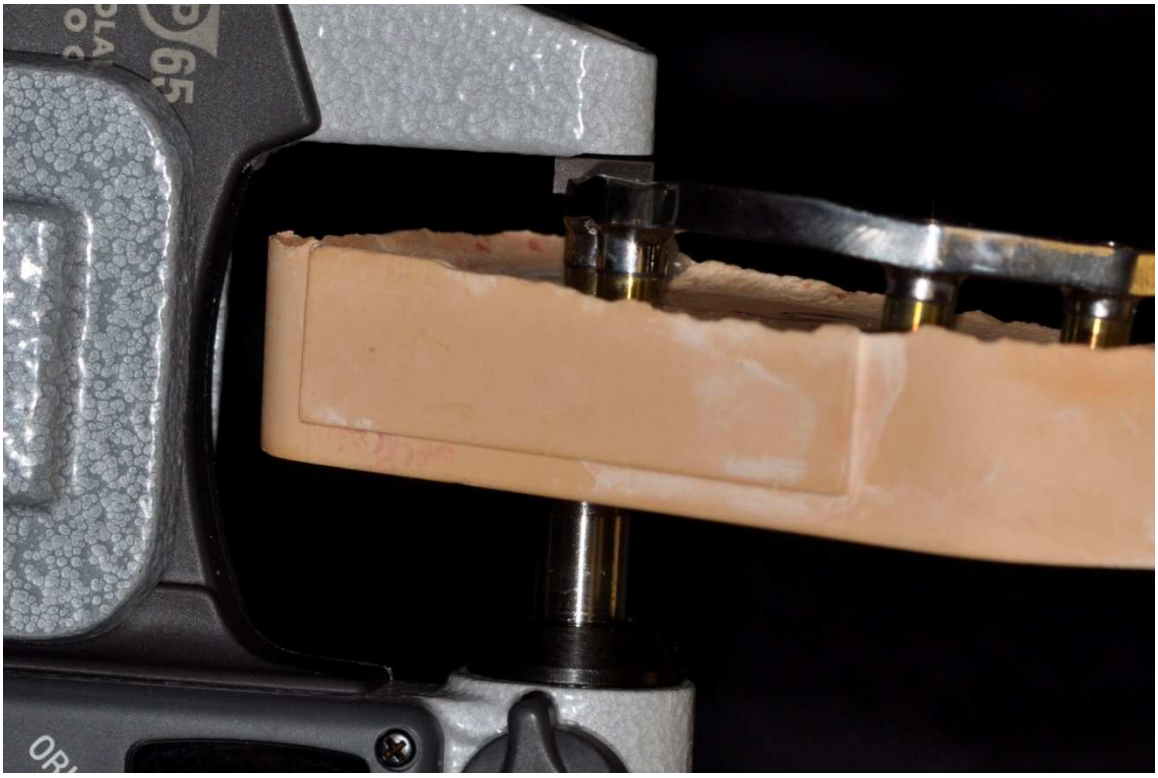

Figure 12: Measuring the overall vertical dimension of framework and the implant analog.

Statistical analysis:

One examiner conducted all measurements. These measurements were recorded in Microsoft Excel (Excel 2010, Microsoft Corp.), and statistical analysis was also conducted using also Microsoft Excel.

The distortion values compared among the two groups using Student's t-test at an alpha level of 0.05.

CHAPTER IV

RESULTS

The distortion values for the two groups are presented on table 1. Group 1 (GC Pattern) has an average value of 29.71 µm (Figure 13). Group 2 (Triad Gel) has the lowest average distortion value which is 27.8 µm. There was no statistical significance difference between the two groups (p=.42) (table 2).

Table 1: Distortion values in µm for the samples.

Group 1 (GC Pattern)		Group 2 (Triad Gel)	
Cast number	Distortion	Cast number	Distortion
1	41.00	1	11.33
2	11.11	2	19.00
3	18.33	3	12.33
4	88.33	4	13.00
5	13.67	5	29.33
6	18.67	6	11.33
7	18.67	7	72.00
8	36.67	8	19.33
9	13.67	9	33.00
10	37.00	10	57.33
Mean	29.71	Mean	27.80
SD	23.33	SD	21.09

Figure 13: Mean Distortion Values for each group.

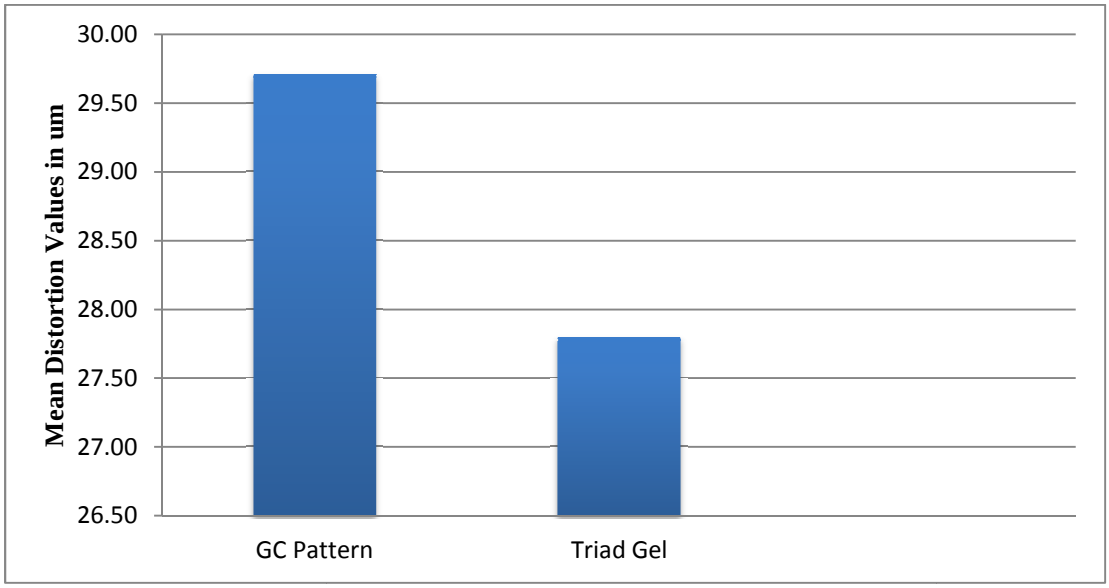

Table 2: Student's t-test

t-Test: Two-Sample Assuming Unequal Variances			
	GC resin	Triad gel	
Mean	29.711333	27.8	
Variance	544.40563	444.9926	
Observations	10	10	
Hypothesized Mean Difference	0		
df	18		
t Stat	0.1921546		
P(T<=t) one-tail	0.4248861		
t Critical one-tail	1.7340636		
P(T<=t) two-tail	0.8497723		
t Critical two-tail	2.100922		

CHAPTER V

DISCUSSION

In this study, the null hypothesis that there is no difference between the accuracy of casts fabricated with light cured Triad verification jigs and casts fabricated with GC Pattern resin pattern verification jigs was accepted.

Framework fabrication for implant supported restorations requires an accurate master cast that has the same implant position as the intraoral. Accuracy of the master cast is affected by factors such as impression material, impression technique, machining tolerance, stone expansion, and cast material.

In this study resin modified type IV die stone (Resin Rock) with dimensional expansion of 0.08% was used to pour all stone samples because of it compressive strength and low linear expansion. Kenyon et al. compared the linear dimensional accuracy of seven die materials and found that Resin rock was more dimensionally accurate than other die materials. In this study, material used to fabricate the verification jigs were GC Pattern Resin and Triad Gel. GC Pattern Resin is a polymethyl-methacrylate (PMMA) resin which is also a self-cure resin. All acrylic resin materials exhibit some polymerization shrinkage. It has been shown that 80% of polymerization shrinkage of PMMA occurs within 17 minutes at room temperature and after 24 hours there is no significant shrinkage that will happen [68]. The reported linear shrinkage for this material is approximately 0.4% [68]. To minimize in this study, the effect of polymerization shrinkage all GC Pattern Resin verification jigs were fabricated and sectioned with a thin disk 24 hours before using them and connecting them back for stone

base fabrication. Therefore, the only shrinkage that will affect the accuracy of GC Pattern Resin verification jigs is the shrinkage of the added resin used to reconnect the jigs which is estimated to be negligible. Triad Gel is a urethane-dimethacrylate resin (UDMA) that does not contain methylmethacrylate monomer. It is also a light cured resin. It has less polymerization shrinkage compared to PMMA acrylic [31]. The linear shrinkage of Triad gel is approximately 0.38 % [69]. Others reported that Triad has a linear shrinkage as small as 0.2% [70]. The small dimensional change of Triad and its good handling proprieties will make this a good material for fabrication of verification jigs.

To make the measurement method represent the clinical situation, the one screw test was used to evaluate the vertical gap at the terminal abutment using a digital micrometer with an accuracy of 1μm to record the vertical gap. Although a one screw test is widely accepted as way to measure the clinical method. It has some shortcomings because rotational displacements and tilt direction of the analogs in the master cast may produce large vertical gaps or may camouflage it [71].

The use of CAD/CAM frameworks for implant restoration has increased due to the superior fit and decreased cost compared to cast framework using noble alloys. These frameworks require an accurate cast prior to scanning and are not designed to be cut and soldered. In the clinical situation, distortion of an implant impression may happen due to the presence of undercuts, improper seating of the impression, angulation of implants, the depth of implant placement, number of implants, and handling of the impression by the technician. In these situations, a dentist can benefit from the use of a verification jig to assess the accuracy of the master cast, to correct the master cast, or to make a new impression.

Using Triad Gel to fabricate a verification jig has an advantage over GC Pattern resin as it can be used in the same day or directly in the patient's mouth. There is no need to wait for 24 hours as with GC Pattern resin. This will reduce number of appointments and cost.

This study cannot be generalized for every implant situation. This study was made on a model of four implants. The Implants used were Nobel Replace RP with a tri-lobe internal connection which is a different situation from an abutment level impression or other implant brands. Every implant brand has a different design and different machining tolerance.

CHAPTER VI

CONCLUSIONS

The vertical gap misfit value in implant framework produced by cast fabricated using GC Pattern resin and Triad Gel verification jigs were measured using one screw test and compared. Triad Gel verification jigs did not produce superior fit compared to GC Pattern resin pattern verification jigs in a master cast with four implant with internal connection.

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