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A Novel Framework to Eliminate the Effects of Casting Distortion when Fabricating a Fixed, Detachable Screw-Retained Prosthesis

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Abstract

The ideal fixed, detachable framework sits passively on the implants and does not introduce any stress. Several techniques in the literature compensate for an ill-fitting framework. These techniques require extra visits, chairtime, and laboratory time and only mitigate the stress; the stress is not eliminated. A framework is presented here that eliminates the stress transmitted to the implants by encircling the abutment cylinders and not directly incorporating them into the framework. Furthermore, the framework mitigates the stress from the polymerization distortion of acrylic when processing the acrylic onto the prosthesis.

A fixed, detachable prosthesis typically is a multiple implant prosthesis that requires a precisely fitting screw-retained framework. An ill-fitting framework will need to be sectioned and soldered or welded to achieve an acceptable fit.[1-4]

Many[2,3,5] have ascribed maladies such as bone loss around the implants, screw loosening, screw breakage, and implant and prosthesis fracture to ill-fitting frameworks. Others[2,6] have found that although a framework is ill fitting, no biologic or prosthetic complications have occurred. Jemt and Book surmised that there were no complications because of a biologic tolerance.[6] Wee et al[2] discussed the distortion equation, the sum of all factors contributing to the final distortion when manufacturing a definitive implant prosthesis. This distortion causes an internal stress within the implant-prosthesis complex. When this internal stress is paired with a functional stress (e.g., chewing) the total stress may be tolerated because of biologic tolerance or not tolerated, leading to a biologic or prosthetic breakdown.[2] Wee et al's[2] distortion equation states that distortion may be introduced at six points: (1) Impression procedure + (2) Master cast fabrication + (3) Wax pattern fabrication + (4) Framework fabrication + (5) Definitive prosthesis fabrication + (6) Definitive prosthesis delivery = Final distortion

When fabricating a screw-retained fixed, detachable restoration one goal is to mitigate the sources of distortion so when the final sum of distortion is paired with chewing, the resultant stress on the implant-prosthesis complex is less than the biologic tolerance, therefore leading to no complications. Since the individual patient's biologic tolerance is not known, the goal is to introduce no distortion, or as close to no distortion as possible. Errors introduced in one step of the distortion equation are carried over to subsequent steps, and at times magnified.[2] Errors introduced in the impression making step can be seen as misfits in the metal framework. There are techniques[2-4] to mitigate these errors but not to eliminate them.

The following clinical report will illustrate a technique to eliminate the effects of distortion when fabricating a metal framework for a fixed, detachable screw-retained prosthesis. This framework design will in turn mitigate distortion when processing acrylic onto it.

Clinical report

A 57-year-old man presented with mutilated dentition consisting of multiple missing teeth and periodontally and endodontically involved dentition with severely decayed and fractured teeth. Vertical dimension had been lost, and no occlusal scheme was present. The patient was classified as a Class IV partially edentulous patient based on the American College of Prosthodontists Prosthodontic Diagnostic Index for partially edentulous patients.[8] The patient was treatment planned for extraction of the remaining teeth in the mandibular arch and placement of six implants to be restored with a fixed, detachable prosthesis.

The remaining teeth were extracted, and the extraction sockets were allowed to heal for 3 months. Three 3.4 mm × 10 mm implants (Axiom Anthogyr, Sallanches, France) were placed in

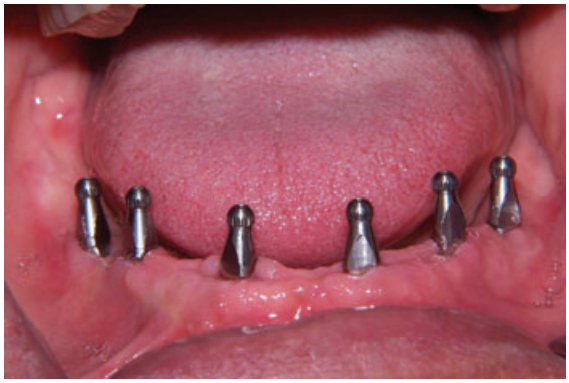

Figure 1 Impression copings installed.

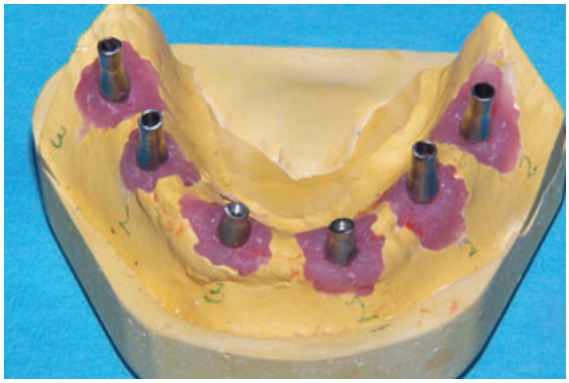

Figure 2 Master Cast with abutments and attached titanium cylinders.

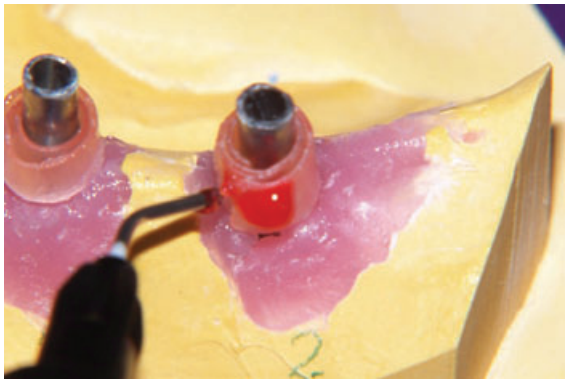

Figure 3 Wax spacers and application of light-cured gel for the fabrication of rings.

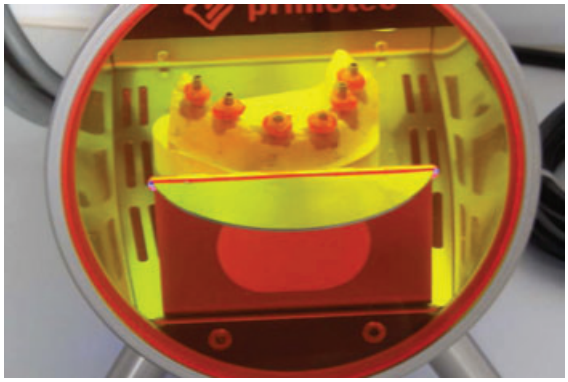

Figure 4 Polymerization of rings in chamber.

the position of the mandibular first molars and the mandibular right first bicuspid. Another three 3.4 mm × 12 mm implants (Axiom Anthogyr) were placed in the position of the mandibular lateral incisors and the left first bicuspid. All implants were allowed to osseointegrate for 4 months.

Impressions were made with vinylpolysiloxane (Affinis heavy body/Affinis precious, Coltene-Whaledent, Altstätten, Switzerland; Fig 1). The impressions were poured using a tissue silicone (GI mask, Coltene-Whaledent) and type IV dental stone (Esthetic base 300, Dentona AG, Dortmund, Germany). The GI mask was placed just around the implants and not on the entire crestal area of the ridge, thus allowing stone to be present in between the fixtures. This enabled the placement of tissue stops on the framework and subsequent orientation of the framework.

A facebow transfer was achieved, and centric relation (CR) and occlusal vertical dimension (OVD) were established by employing conventional complete denture principles. Once the casts were mounted, conical abutments (Anthogyr) were attached over the implant replicas, and the corresponding titanium cylinders were attached over them. The posterior cylinders were cut at the determined OVD and the anterior ones to the desirable height (Fig 2).

Two thicknesses of casting wax (Kerr, Orange, CA), approximately 2 mm, were intimately wrapped, the wax touching the cylinders, around each Ti cylinder to act as spacers for the framework (Fig 3). The spacer thickness should not be greater than 3 or 4 mm because that would make the framework bulky and tooth set-up difficult, possibly resulting in awkward esthetics. A 2-mm spacer allows for enough space between the ring and the cylinder for acrylic to flow and attach the rings to the cylinders during polymerization and yet does not create a bulky framework that would interfere with esthetics when setting teeth.

Rings were fashioned around each spacer using a light-cured (LC) gel (Primopattern LC gel, Primotec, Bad Homburg, Germany), and these rings were then photo-polymerized in a light-curing chamber (Met alight mini, Primotec; Fig 4). LC gel has a linear shrinkage of 0.27%.

Following curing of the rings, they were joined together by means of an LC paste (Primopattern LC paste, Primotec) and returned to the light-curing unit for polymerization. LC paste has a linear shrinkage of 0.27% as well.

The now-cured framework was finished and sent to the dental laboratory for casting. The framework was cast out of a nickel-based base metal alloy (Nicor, Shutz Dental GmbH, Rosbach, Germany) and sandblasted, as were the Ti cylinders, with 100-μm Al2O3 at 4 bars of pressure with the exception of the tissue stops (Fig 5). Repeated layers of pink composite opaquer

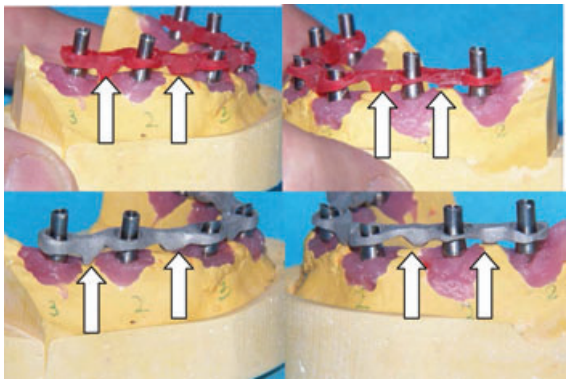

Figure 5 Finished light-cured frame (Top); finished definitive metal frame (Bottom). Note the tissue stops.

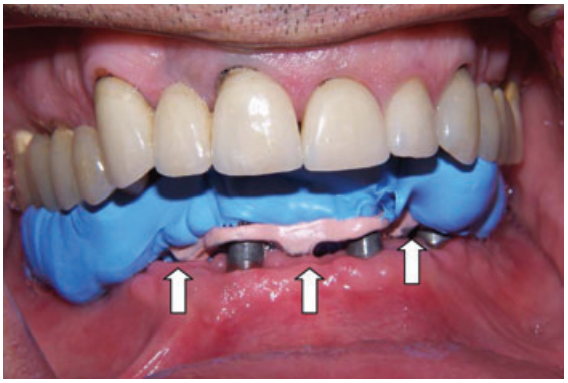

Figure 7 Verification of CR after the establishment of proper fit of the framework. Note tissue stops.

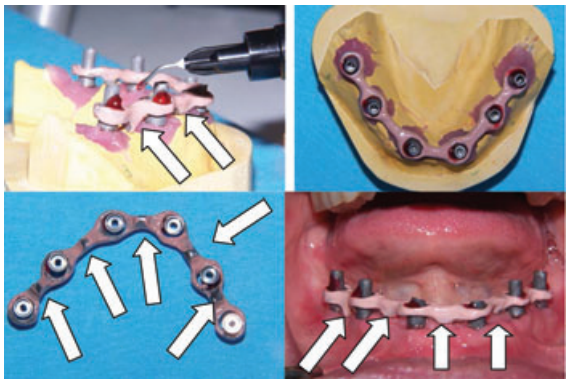

Figure 6 Attaching opaqued framework to titanium abutment cylinders (top left). Occlusal view of framework attached to titanium abutment cylinders (top right). Tissue view of framework with attached titanium abutment cylinders (bottom left). Intraoral view of try-in titanium abutment cylinder—framework complex seated on implants; also being used as a verification jig. (bottom right). Note tissue stops (arrows).

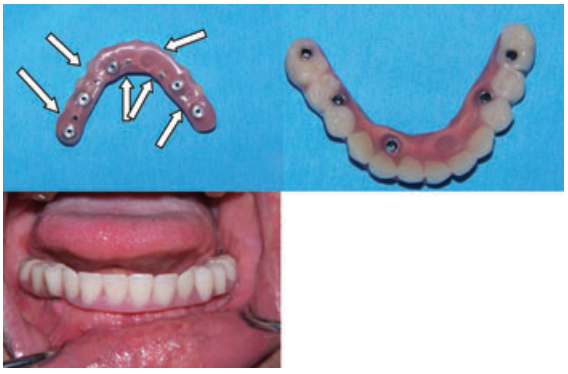

Figure 8 Completed prosthesis occlusal and tissue sides. Note the tissue stops and repaired area where implant failed, lower left lateral (Top). Prosthesis at time of delivery (Bottom).

(Signum, opaque F, Hereaus Kulzer GmbH, Hanau, Germany) were applied and light cured to cover the metal.

With the aid of the LC gel, the cylinders were joined with the framework on the cast, and the framework-cylinder complex was ready to be tried intraorally (Fig 6). Sheffield's One Screw Test[9] was performed, and the framework fit was evaluated clinically and radiographically. The framework-cylinder complex was used as a verification jig. Once fit was verified, CR was verified by injecting an occlusal registration material (Jet-blue, Coltene-Whaledent), using the posterior cylinders as occlusal stops (Fig 7).

At this point, it became apparent that the implant in the position of the mandibular left lateral incisor had failed and was then removed. It was determined that the loss of this implant would not jeopardize the long-term prognosis of the prosthesis.

The definitive prosthesis was delivered and evaluated for esthetics and function (Fig 8). Sheffield's One Screw Test[9] was performed, and the prosthesis fit was evaluated clinically and radiographically. No frame lifting was observed. The abutment screws were screwed in without untoward resistance, typical of a misfit.

Discussion

When applying Wee et al's distortion equation to the fabrication of a screw-retained fixed, detachable prosthesis, distortion in the impression, master cast, wax pattern, and framework fabrication can be mitigated by using a variety of previously published techniques Wee et al cited.[2] Although the effects are mitigated, they are not eliminated, thus introducing some distortion, hopefully below the patient's tolerance limit. The framework design described in this manuscript eliminates the effects of distortion when fabricating a framework for a fixed, detachable screw-retained prosthesis, and in turn, this design will mitigate the distortion engendered from acrylic polymerization.

Titanium cylinders are connected to the already-placed conical abutments with a screw. One can decide not to place a conical abutment and connect the Ti cylinders directly to the

implant. The authors feel that the conical abutment provides a positive seat and facilitates the orientation and placement of the prosthesis. A framework is cast in base metal with rings that encircle the Ti cylinders. At this point, the rings are not attached to the cylinders; as such, no stress is transferred to the implant via the implant/abutment/cylinder interface.

We attached the framework to the cylinders using the LC gel and photo-polymerization. Because the gel has relatively minimal to no shrinkage, especially in the small amount used, there should be no or negligible distortion introduced. This framework cylinder complex is tried in the mouth, using it as a verification jig. Because it was found that the fit was acceptable, and no misfit was detected, the master cast was then considered verified, and the next step is then tooth set-up. If it is then found that there is a misfit, there is no need to cut and solder and compromise the integrity of the framework. Instead, the abutments can be detached from the framework by simply removing the LC gel, and then the cylinders are connected individually to the implants in the mouth. Intraorally, the framework is reattached to the cylinders using the LC gel. This position could then be transferred to the master cast or a new master cast and can be fabricated with a pick-up impression of the abutment framework complex. This again ensures a passively fitting framework, with negligible or no distortion, onto which teeth can be processed.

Wee et al do not offer a process to mitigate distortion at the definitive prosthesis fabrication stage of the distortion equation. Distortion in the fabrication of the definitive prosthesis is introduced when acrylic is polymerized.[2] The greater volume of polymerizing acrylic generates a greater percentage of distortion. If there is less volume of acrylic present, then there is less percentage of distortion.[7] When processing acrylic on a conventional framework, the bulk of the acrylic polymerizes and affects the force on the framework, which is attached to the abutments. Ultimately the effect is transferred to the implants by way of the implant/abutment connection. The percentage that the bulk of the acrylic distorts also distorts the implant/abutment/cylinder connection.

The implant framework described in this article uses rings that encircle the abutments to protect the abutments from the effects of the forces exerted by the acrylic polymerization distortion. When the bulk of the acrylic polymerizes and distorts, the force acts upon the framework. Because the abutments are not attached to the framework yet, that force on the framework is not transmitted to the abutments. Because the acrylic between the rings and abutments are doughy at the time the larger bulk of acrylic is polymerizing, any force exerted onto the framework will be transferred to the doughy acrylic within the rings. This acrylic will deform but not transmit the force onto the abutments or the abutment/implant/cylinder interface. Because the volume of acrylic within the rings is so small, the distortion will also be small and negligible.

Conclusion

The distortion equation described by Wee et al[2] describes where in the fabrication of a fixed, detachable prosthesis distortions are introduced. Jemt and Book[6] speculated that ill-fitting frameworks did not cause biologic complications because of the biologic tolerance of the system and/or patient. Because we cannot know the biologic tolerance for each patient, the goal is to have a prosthesis that incorporates zero or as close to zero the sum of distortions from the distortion equation. Wee et al[2] cite procedures to reduce the amount of distortion when fabricating a fixed, detachable prosthesis. A framework design has been described that eliminates the effects of distortion and stresses from framework fabrication and mitigates the effects from the polymerization of acrylic when fabricating a fixed, detachable implant prosthesis. The rings encircling the abutments allow the operator to fabricate a metal framework that will not cause any distortion of the implant/abutment/cylinder interface, because the framework passively slips over the abutments and is then attached to the passively fitting abutments. The rings that encircle the abutments also act as a buffer or shock absorber when the forces of polymerization distortion act upon the framework. Because the abutments are not being distorted, the abutment/implant/cylinder interface is not distorted, so the system will not experience stress because of the polymerization distortion. The authors have illustrated a simple technique that can be applied in all dental labs without the need for specialized and expensive equipment. Also, the same technique with minor modifications could be employed if one were to use LC composite resin instead of heat-cured acrylic.

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