Stomatologija, Baltic Dental and Maxillofacial Journal, 10: 96-100, 2008

Influence of laser-welding and electroerosion on passive fit of implant-supported prosthesis

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SUMMARY

This study investigated the influence of laser welding and electroerosion procedure on the passive fit of interim fixed implant-supported titanium frameworks. Twenty frameworks were made from a master model, with five parallel placed implants in the inter foramen region, and cast in commercially pure titanium. The frameworks were divided into 4 groups: 10 samples were tested before (G1) and after (G2) electroerosion application; and another 10 were sectioned into five pieces and laser welded before (G3) and after (G4) electroerosion application. The passive fit between the UCLA abutment of the framework and the implant was evaluated using an optical microscope Olympus STM (Olympus Optical Co., Tokyo, Japan) with 0.0005mm of accuracy. Statistical analyses showed significant differences between G1 and G2, G1 and G3, G1 and G4, G2 and G4. However, no statistical difference was observed when comparing G2 and G3. These results indicate that frameworks may show a more precise adaptation if they are sectioned and laser welded. In the same way, electroerosion improves the precision in the framework adaptation.

Key words: implant-supported, dental prosthesis, complete centure.

INTRODUCTION

In oral rehabilitation with osseointegrated implants, it is most important to establish passiveness among the prosthetic components and implants to assure osseointegration and the long-term success of the prosthesis (1,2). Passiveness is obtained when there is precise adaptation between the prosthetic components and the implants, without marginal gap formation. Factors related to clinical and laboratory procedures, involved in implant rehabilitation, influence this adaptation. Among these factors, the casting process involves a series of variables that must be controlled in order to minimize possible distortions, as these generate an overload in the system causing rupture of the cement (in case of cemented prosthesis), screw or denture fractures and even loss of the osseointegration (3,4). Among the materials used for manufacturing metal implant-supported frameworks, titanium became a perfectly feasible option for its favorable characteristics such as mechanical resistance, high corrosion resistance, biocompatibility and low cost. However, there are some inconvenient aspects regarding its marginal adaptation (due to its low specific mass) and reactivity with oxygen at high temperatures, which requires the use of special equipment in order to produce an inert environment for its casting and welding (5). Distortions resulting from conventional casting done by the lost wax technique (6) became worse when done in large pieces, especially when it crosses the mandibular arch (7). Therefore, sectioning these structures and submitting the segments to weld, which enable better passivity of implant-supported frameworks, are frequently adopted procedures.

Laser welding has been shown to be an efficient method for obtaining better adaptation of implant-supported frameworks. Some of the advantages of this technique are the concentrated energy source, which minimizes distortion problems; and the possibility of greater precision, due to the intimate contact among the parts to be welded (lower quantity of material generates lower distortion) (7,8).

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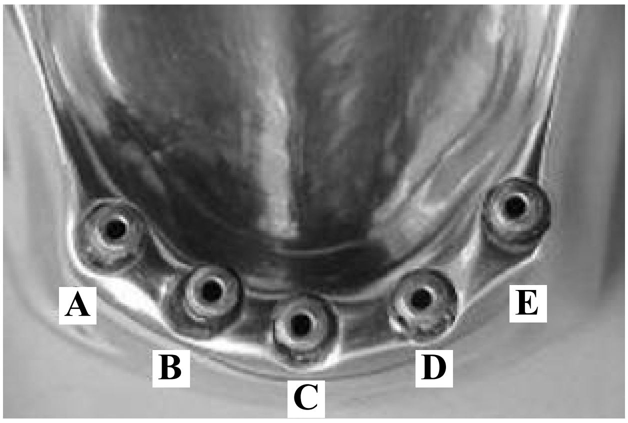

Fig. 1. Master model

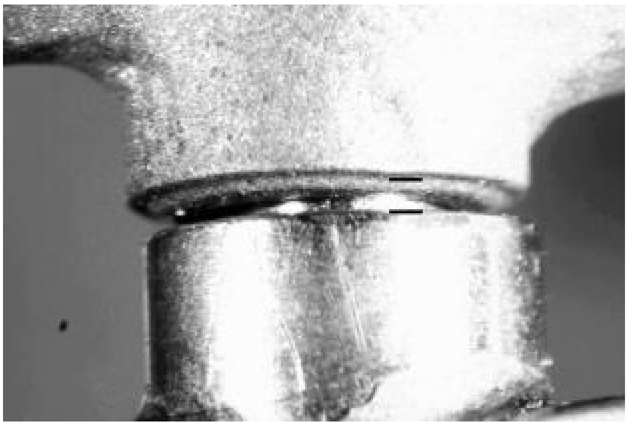

Fig. 2. Marginal discrepancy between the prosthetic component and the implant

Another alternative found to overcome casting and passive seating difficulties is the use of electroerosion (EDM – Electrical Discharge Machining) (9,10,11,12). The application of electroerosion in dentistry includes correction of imprecise implant-supported dentures and cervical discrepancies of single titanium crowns, and refinement of irregularities generated by cast procedure in UCLA abutment. The mechanism of the electroerosion improves the fit of the cervical margin by a process that involves electrical discharges that gradually melt the metal until clinically feasible adaptation is obtained.

MATERIAL AND METHODS

In this study, a master model made of a copper-aluminum alloy was built to represent a clinical case of an edentulous mandible. Five titanium implants of 3.75 x 13 mm (Conexão Sistemas de Prótese – Brazil) were placed in the mandibular symphysis region. To standardize the measurements and statistical analysis, the implants were denominated A, B, C, D and E (Fig. 1).

Calcinable UCLA abutments were connected to each implant and 20 frameworks were waxed. The samples were included in a special coating (Rematitan Plus, Dentaurum J. P. Winkelstroeter KG, Pforzheim, Germany) in accordance with the manufacturer's instructions. The frameworks were cast with a duly programmed and adjusted titanium-casting machine (Rematitan, Dentaurum, Pforzheim, Germany). After the casting procedure, the frameworks were finished and polished, using a metal protector to preserve their interfaces (Polishing protector – Restore/Lifecore-USA). Ten (10) frameworks were tested without being sectioned before (Group 1) and after electroerosion application (Group 2), and 10 (ten) frameworks were sectioned into 5 pieces each one, with an extra-fine carborundum disk, screwed into their respective implants, laser welded and tested before (Group 3) and after electroerosion application (Group 4). (Table)

To analyze the dimensional alteration, represented by the degree of marginal discrepancy between the prosthetic component and the implant (Fig. 2), an optic microscope (STM, Olympus Optical Co., Tokyo, Japan) with precision of 0.0005 mm was used.

Each metal structure was placed in the metal master model and the titanium screw that corresponds to implant A was tightened with a torque of 10 Ncm, with a manual torquemeter (Restore/Lifecore-USA). This procedure was used to verify the degree of discrepancies of components E and C. The procedure was repeated with the screw on the opposite distal (E) to measure implants A and C'. Vertical discrepancies were measured with the optic microscope in the vestibular and lingual regions at the implant-prosthesis interface of the three implants previously denominated with letters A, C and E. With these measurements, the mean rate of the distal implants (A and E) and central implants (C and C') was calculated.

The Electrical Discharge Machining (EDM) equipment (Tel Med Technologies – Port Huron – Michigan – USA) was used to apply electroerosion. A plaster model was obtained from the original implant position impression (transfer impression) and positioned in the electroerosion equipment. The titanium framework was screwed at the gypsum model and the electrodes of the equipment were placed around it, interconnected with copper wires, aiming the transfer of electrical current to the entire metal framework. To start electroerosion, this entire system was completely submerged in dielectric liquid (Fig. 3) that presents insulating, conduction and cooling functions. An electrical current that generates temperatures of 3000 to 5000°C is established between the electrode and the metal framework. Such energy melts the metal, reducing the interferences, and therefore, refining the marginal interface. This process occurs constantly in ascending/

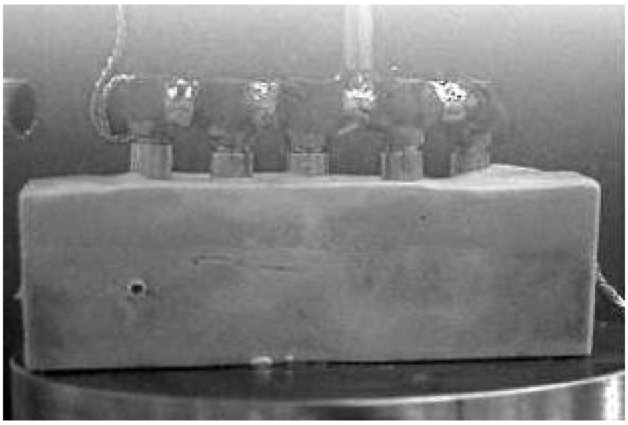

Fig. 3. Framework submerged in dieletric liquid

descending movements until the entire extent of the five abutments touch their respective electrode in a uniform manner. At this time sparks could be seen throughout the contact area between the metal framework and the electrodes. After removing the framework from the machine, the same was microscopically analyzed again.

Statistical analysis was done using the t test for paired observations when comparing G1 and G2, G3 and G4, since the same frameworks were evaluated, before and after the electroerosion procedure. The t test for independent observations was used to make statistical analysis when comparing G1 and G3, G1 and G4, G2 and G3, G2 and G4; for different frameworks were compared, with or without the electroerosion procedure.

RESULTS

A significant difference was observed when comparing G1 and G2, G3 and G4. The results indicate that the electroerosion application significantly improved the marginal adaptation. There was a significant difference between G1 and G3, G1 and G4, G2 and G4.

Table. Groups and Divisions

Groups	No. of Samples	Procedure
G1	10 frameworks	Control group – no procedure
G2	10 frameworks	Electroerosion
G3	10 frameworks	Laser weld
G4	10 frameworks	Laser weld and electroerosion

These results indicate that laser welding improves marginal adaptation, associated or not with electroerosion procedure. There was no significant difference between G2 e G3, indicating that laser welding and electroerosion produce the same results, improving the precision in framework adaptation (Figures 4 and 5).

DISCUSSION

The term passive fit has been used in implantodontics to describe the prosthesis precision that is compatible with the body's ability to properly adapt and remodel itself to the stimulus. This term has been described by Branemark (1) with a value around 10 µm of marginal gap. The passiveness concept has developed and has currently been described as a clinically acceptable adjustment (2), in which the stress conditions are within the physiological limits at which the implant and the prosthesis remain unaltered when installed. Jemt (7) reported that values below 150 µm are clinically acceptable.

Hussaini & Wong (13) found values of 82 to 139 µm in titanium casting of implant-supported dentures. These values are within those found in the present study (values obtained in G2 and G3). Wang & Fenton's (5) study found that passive seating could not be quantified, but associated with larger or smaller marginal discrepancies (vertical axis). In their literature review, the authors found values that ranged from 8 to 196 µm of marginal gaps in cast titanium crowns. In this study, similar results were found in group 3 (laser welding),

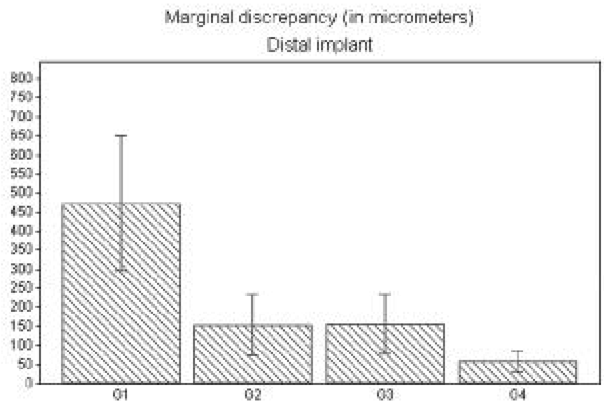

Fig. 4. The mean marginal discrepancy in micrometers of the groups for the distal implants

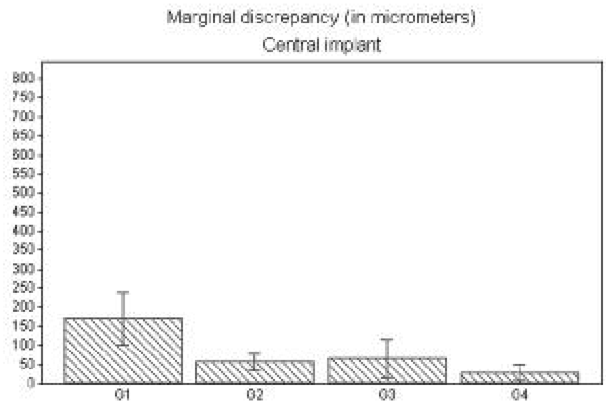

Fig. 5. The mean marginal discrepancy in micrometers of the groups for the central implants

and groups 2 (electroerosion) and 4 (laser weld and electroerosion).

Helldén & Dérand (14) proposed that distortions in cast titanium implant-supported frameworks with vertical gaps of 180 μm for distal and 50 μm for central implants have to be corrected, and the measurement data are very similar to those in the present study for group 2 and group 3. They also reported that 8 Ncm of torque is required to close 30 μm discrepancies. The authors attributed such dimensional alterations to distortion that occurred during casting.

Wee *et al* (15), affirmed that the techniques for determining passive seating between the denture and implant do not give objective results and are also unreliable as regards the methodology. Therefore, it is advisable to use a combination of methods to minimize such discrepancy, resulting in an acceptable degree of passivity in extensive implant-supported prosthesis frameworks. By photoelastic analysis, Waskewicks *et al* (16) observed that sectioning and welding the implant-supported denture frameworks eliminated stress formation around the implants, making the frameworks passive.

In this study, statistically significant differences were found between G1 and G3, confirming the results of other studies that recommended sectioning and welding the framework to improve passive seating of implant-supported dentures.

Although a significant improvement was found in this study between G1 and G3, Bergendal & Palmqvist (17) did not find statistical significance in biological or prosthesis complications among sectioned and laser welded implant frameworks, as well as the ones that did not receive such treatment. Not sectioning the framework has the advantage of eliminating welding time and preventing parts from being structurally weakened. Riedy *et al* (18), showed that titanium laser welded frameworks seated better than those that were not submitted to any type of treatment.

Up to now, this study emphasized that framework sectioning and welding greatly improved its seating on implants (from 472 to 155 μm at the distal implant, and from 170 to 65 μm in the central implant). In this study, electroerosion was applied to all tested samples. Electroerosion allows passive seating, avoids sectioning and welding and prevents the structure from becoming weakened or from fracturing. Another great advantage of the use of EDM is reducing clinical and laboratory sessions. The disadvantage of EDM is the long time required for an acceptable level of adaptation (19).

Schmitt *et al* (20) and Evans (4) applied electroerosion in UCLA type abutments obtaining visible and excellent marginal adaptation of these abutments. The authors therefore concluded that electroerosion significantly improved the adaptation of the frameworks.

In fact, when metal frameworks were submitted to electroerosion, in the same study, they obtained statistically and numerically similar adaptation to the group that received laser welding procedure.

The data for central implant of group 2 and distal implant in group 4 corroborate the Andersson *et al* (12) findings of 42 to 56 μm. For the central implant in group 4, the result of 28μm was significantly better than in the above mentioned studies.

However, the present study was conducted *in-vitro* environment and it need be carry out in *in vivo* to better state the finding noted.

CONCLUSIONS:

Frameworks that are clinically unacceptable after casting may show a precise adaptation if sectioned and laser welded. The same can be said for electroerosion, which not only enables clinically acceptable adaptation for the framework, but also has the advantage of preventing it from being sectioned, which could result in its structural weakening.

Through this study, the authors concluded that: (a) there are large marginal discrepancies in cast frameworks; (b) laser welding and electroerosion caused a similar effect of improving marginal adaptation when used isolated; and (c) when the two techniques were associated, there was a significant improvement in the marginal adaptation of the parts.

ACKNOWLEDGEMENT

The project was financed by FAPESP; São Paulo State Research Support Foundation – "Fundação de Amparo à Pesquisa do Estado de São Paulo – FAPESP" Process Number: 98/01504-3.

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Received: 28 11 2007
Accepted for publishing: 19 09 2008