4-1-2009

Repairing an Implant Titanium Milled Framework using Laser Welding Technology: A Clinical Report

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Accepted version. *The Journal of Prosthetic Dentistry,* Vol. 101, No. 4 (April 2009): 221-225. DOI.
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The Journal of Prosthetic Dentistry, Vol. 101, No. 4 (April, 2009): 221-225. DOI.

Contents

Repairing an implant titanium milled framework using laser welding technology: A clinical report

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The application of laser welding technology allows titanium to be welded predictably and precisely to achieve accurate fit of a milled framework. Laser energy results in localized heat production, thereby reducing thermal expansion. Unlike soldering, laser energy can be directed to a small area, making it possible to laser weld close to acrylic resin or ceramic. This article describes the use of laser welding to repair an implant titanium milled fixed denture. A quick, cost-effective, accurate repair was accomplished, and the repaired framework possessed adequate strength and the same precise fit as the original framework. (J Prosthet Dent 2009;101:221-225).

The use of titanium has become increasingly popular in implant dentistry. Titanium was discovered in 1791 by William Gregor and has the advantages of excellent corrosion resistance, light weight, and biocompatibility.[1] However, soldering titanium is difficult due to its high melting point (1660°C) and high reactivity.[2] Titanium belongs to the transition metal group in the periodic table and is highly reactive with elements like aluminum, nitrogen, carbon, and oxygen.[3, 4] Therefore, when joining titanium to itself or other metals, it is necessary to shield the metal to prevent oxidation.

Laser welding of titanium has been shown to be a better option than soldering.[2]Laser welding helps to overcome the disadvantages of highly reactive titanium by providing a shielding gas during the welding process. Lasers are based on Albert Einstein's principle of light amplification by stimulated emission of radiation.[5] The laser is a form of electromagnetic radiation that behaves both as a particle and a wave. It differs from ordinary light, and the difference can be attributed to its monochromatism, collimation, and coherency.[6] Lasers are considered to be monochromatic, as they emit energy of a single color and wavelength. The laser beam is coherent, as each wavelength is equal in shape and size, and its collimation property is owing to its capacity to be concentrated into an intensely focused energy beam.[6]

The degree of laser energy absorption by the target is dependent on the wavelength of the laser energy.[7] The selection of a specific laser is dependent on the desired target.[7] The depth of laser penetration increases with an increased rate of laser beam absorption and low thermal conductivity.[2] A high rate of laser beam absorption (0.4%) and low thermal conductivity (0.17 W/cm degree) make laser welding of titanium advantageous.[2]

Lasers can be classified in several ways, for example, based on their active medium, wave length, delivery system, emission mode, tissue absorption, or clinical application.[5] Classification of lasers based on the active medium is most common. Neodymium:YAG (Nd:YAG) lasers are solid active medium lasers frequently used in dentistry to weld dental alloys. The solid active medium in Nd:YAG lasers is a garnet crystal combined with the rare earth elements yttrium and aluminum, doped with neodymium ions.[5] The available Nd:YAG models for dental use have an emission wavelength of 1064 nm and a melting point of 1950°C.[5]

The Nd:YAG laser energy emission occurs when an intensive light from the lamps is directed at the Nd:YAG laser crystal, which generates a nondirectional light of laser wavelength. Fully reflecting and partially transmitting mirrors mounted outside the laser crystal reflect this light back to the crystal.[5] However, a part of the laser light also exits through the partially transmitting mirror, and is concentrated to a high energy density by the focal point of the mirror. This energy, created in a short time (0.5-20 ms) at the focal points of the mirror, heats up the metal beyond its melting point, resulting in welding.[5]

Advantages of laser welding include: (1) laser-welded joints are stronger than soldered joints[8]; (2) localized heat is produced, thus avoiding expansion and distortion[8]; (3) the need to fabricate a refractory cast is eliminated; (4) welding can be performed in close proximity with acrylic resin or ceramics[2]; and (5) an accurately fitting framework can be obtained.[2, 7, 9] Disadvantages of laser welding include technique sensitivity and increased equipment cost.

When planning to laser weld joints, attention must be directed to the depth of the energy penetration. Circumferential welding along with a sufficient laser beam overlap of 80% is recommended by laser manufacturers. Prior to welding, multiple tacking at opposite sides is recommended to stabilize the joints, and the fitting accuracy should be evaluated periodically by placing the work pieces back on the cast, if possible. Adequate stabilization helps to achieve precise fit and thus minimizes the development of stresses in the joint. Positioning of the laser beam and parent metal with the work piece is important. The parent metal is placed at an angle to the work piece of approximately 45 degrees, and the laser beam is positioned such that one third of it is directed at the parent metal and two thirds are directed at the work piece to be welded. Laser manufacturers recommend airborne-particle abrasion prior to laser welding. As titanium is highly reactive, a shielding gas, usually argon, is used to protect the joints during welding.

Parameters that affect the quality of welding include voltage, expressed in volts (v), pulse length (time), expressed in milliseconds (ms), and the beam diameter (or focus), expressed as joules/cm^2.[2] Increasing voltage increases the depth of penetration. The greater the pulse length, the wider is the melt spot. Beam diameter controls how the energy is spread over a given area. The smaller the beam size, the deeper is the laser weld.

Several studies have demonstrated that the application of laser welding technology allows titanium to be welded predictably and precisely to achieve accurate fit of a milled framework.[2, 4, 7, 8] The purpose of this clinical report was to describe the repair of an implant milled titanium fixed denture using laser welding technology.

Clinical Report

A 54-year-old partially edentulous woman presented to the postgraduate prosthodontic clinic at the State University of New York at Buffalo for an implant-supported fixed partial denture.

On examination, she had multiple missing teeth in both maxillary and mandibular arches; these were extracted 5 years prior due to decay and periodontal disease. The remaining maxillary dentition was healthy and consisted of the right second molar and left first and second molars. The mandibular 4 anterior teeth presented with decay and mobility and were determined to be nonrestorable. The patient was dissatisfied with the retention and stability of her existing partial denture and desired to have fixed restorations. The treatment plans presented to her consisted of extraction of the existing mandibular teeth and fabrication of a conventional maxillary removable partial denture and mandibular complete denture, or implant placement in both arches followed by restoration of the implants with fixed dentures after healing. The patient opted for the maxillary and mandibular implant fixed dentures.

Maxillary and mandibular diagnostic impressions were made with irreversible hydrocolloid impression material (Jeltrate; Dentsply Intl, York, Pa). Maxillomandibular records were made with record bases and vinyl polysiloxane occlusal registration material (Blu-Mousse; Parkell, Inc, Edgewood, NY). The diagnostic casts were mounted in centric occlusion. A diagnostic tooth arrangement was accomplished and a prosthesis for computed tomographic (CT) scanning was fabricated. Implant placement was planned using the CT scan and implant planning software (NobelGuide; Nobel Biocare USA, Yorba Linda, Calif). Six implants (NobelReplace Tapered Groovy; Nobel Biocare USA) were placed in the maxillary arch and 5 were placed in the mandibular arch; all were immediately loaded with a provisional implant fixed restoration (Teeth-in-an-Hour; Nobel Biocare USA).

After 5 months of osseointegration, implant-level impressions were made with impression copings (Impression coping, closed tray, implant level; Nobel Biocare USA) and vinyl polysiloxane impression material (Aquasil; Dentsply Intl). Type IV dental stone (ResinRock; Whip Mix Corp, Louisville, Ky) was used to make a verification cast. A maxillary and mandibular framework was fabricated with temporary abutments (Titanium Temporary Coping, Multi-Unit; Nobel Biocare USA) and autopolymerizing acrylic resin (Pattern Resin LS; GC America, Alsip, Ill) and was sent to the processing facility (Nobel Biocare AB, Göteborg, Sweden) to be scanned and milled for fabrication of the titanium framework. After fabrication, the titanium milled frameworks were evaluated intraorally to verify the fit (Fig. 1). Acrylic resin denture teeth (Ivoclar Vivadent, Amherst, NY) were then arranged and processed to this framework. During the recovery procedure following the processing of the acrylic resin to the maxillary framework, a distal terminal implant screw channel was damaged (Fig. 2). This resulted in a nonretentive implant screw within the screw channel. A repair was proposed and performed to correct this problem. Since the original fit of the prosthesis was good, implant replicas (Implant Replicas, NobelReplace; Nobel Biocare USA) were placed on the prosthesis, and a verification cast was poured in type IV dental stone (ResinRock; Whip Mix Corp). An index of the denture teeth and the framework was fabricated with silicone laboratory putty (Lab-Putty; Coltène/Whaledent, Inc, Cuyahoga Falls, Ohio) to aid in tooth arrangement after the framework was repaired. The faulty abutment was then sectioned from the remaining framework with a 0.3-mm-thick silicon carbide disc (Separating discs; Brasseler USA, Savannah, Ga) (Fig. 3). Acrylic resin was stripped from the sectioned piece. The remaining prosthesis was returned to the patient.

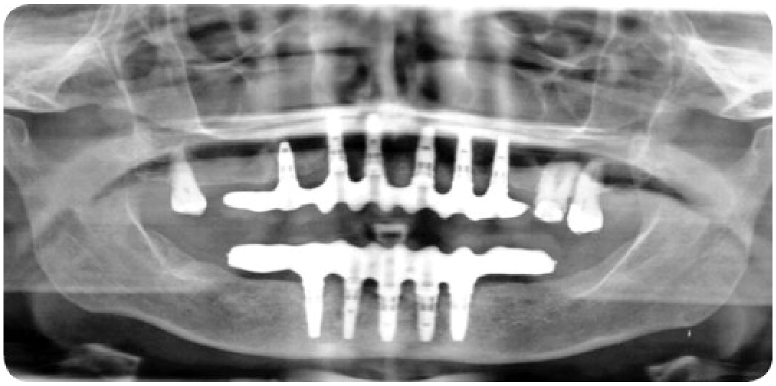

Fig. 1. Preoperative panoramic radiograph.

Fig. 2. Prosthesis with damaged screw channel.

Fig. 3. Sectioned prosthesis.

The manufacturer (Nobel Biocare) requires at least 2 abutments for milling a titanium framework. The damaged, sectioned framework was therefore attached to an adjacent temporary abutment (Titanium Temporary Coping, Multi-Unit; Nobel Biocare USA) (Fig. 4) with autopolymerizing acrylic resin (Pattern Resin LS; GC America) to fulfill this requirement. The damaged framework along with the adjacent temporary abutment was sent to the processing facility (Nobel Biocare AB; Göteborg, Sweden) for scanning and milling.

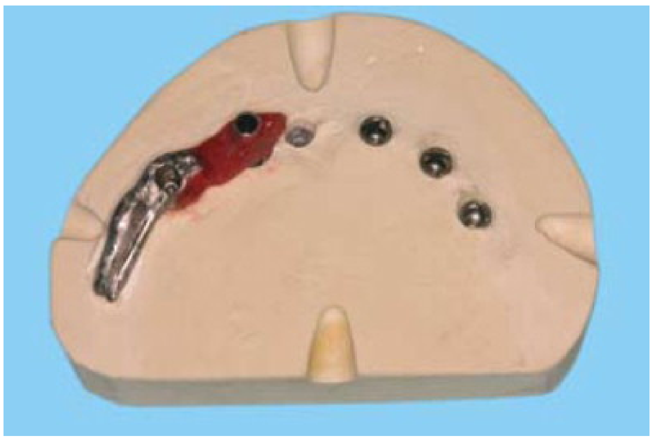

Fig. 4. Fabrication of new framework piece for scanning and milling.

After the new milled component was received, it was sectioned to remove the extra abutment accurately and assembled with the original milled implant fixed partial denture on a verification cast (Fig. 5). The laser welding parameters were set at 270 volts for 6 ms with a beam diameter of 0.7 mm, in accordance with the manufacturer's recommendations. High-purity argon gas was used to shield the joint. The components were airborne-particle abraded with 50-µm aluminum oxide at 5-bar pressure and were rigidly stabilized by tacking at multiple sites with a laser welding machine (LaserStar T plus; BEGO USA, Inc, Lincoln, RI). After stabilizing, circumferential welding was achieved with a parent metal of pure titanium grade 2 wire with a diameter of 0.35 mm (Titan-wire; BEGO USA, Inc). The fit of the framework was periodically evaluated on the verification cast. After laser welding (Fig. 6), the framework was finished and polished using laboratory silicone metal polishers (MetaPro Silicone Polishers; Brasseler USA) with a slow-speed handpiece (Star; StarDental Products, Lancaster, Pa) at 10,000 rpm. The denture tooth arrangement was performed with the help of the laboratory putty matrix. The veneering acrylic resin and denture teeth were subsequently processed to the repaired framework.

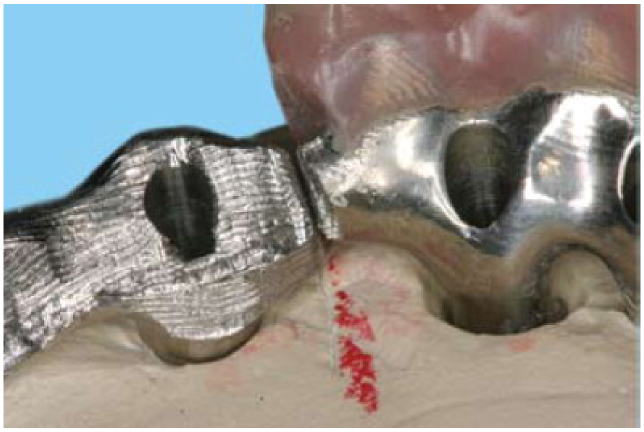

Fig. 5. Assembled existing and new framework sections to be laser welded.

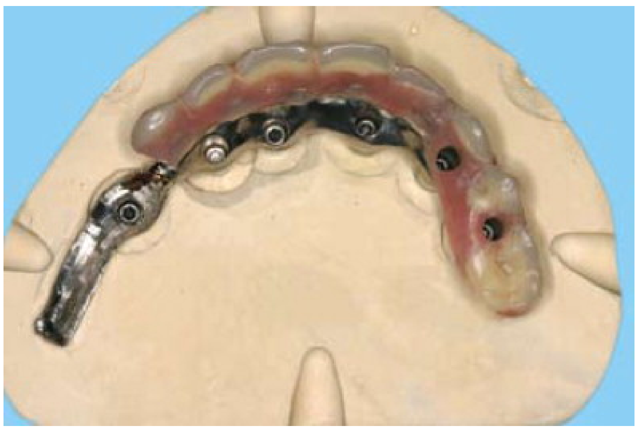

Fig. 6. Laser-welded framework.

The repaired milled titanium fixed partial denture was then evaluated intraorally (Fig. 7), and occlusal adjustments were performed. The implant fixed partial denture was torqued to 35 Ncm, and the screw access openings were sealed. A postinsertion digital panoramic radiograph (Orthophos XG Plus; Sirona Dental Systems LLC, Charlotte, NC) was made (Fig. 8) to evaluate the fit of the framework. The laser welding joint appeared to be slightly radiolucent when compared to the remaining titanium framework. This was due to the fact that only surface welding was performed because of the close proximity of the 2 framework components; therefore, the difference in the density was noticed on the radiograph. The patient was pleased with the fit and appearance of the repaired prosthesis.

Fig. 7. Repaired prosthesis in occlusion.

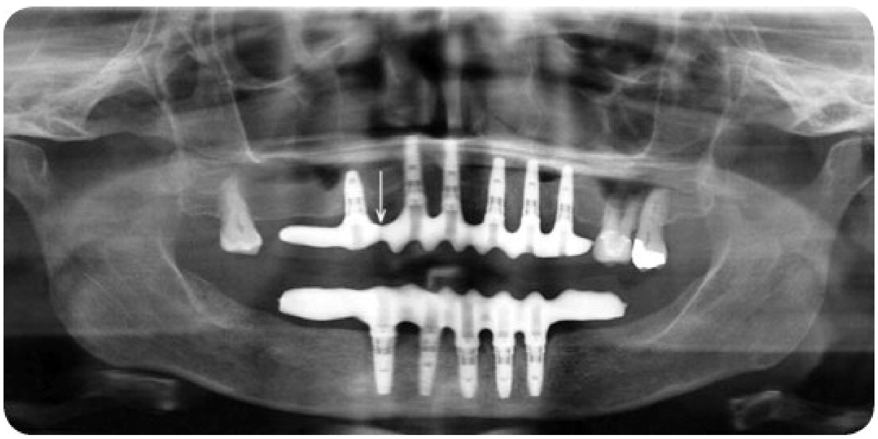

Fig. 8. Postoperative panoramic radiograph showing laser-welded joint.

Although the described technique offered a quick, cost-effective, and accurate repair of the framework, a limitation of this procedure is that it requires in-office use of a laser welding machine, which may make the application of this technique useful to a limited number of clinicians.

Summary

A titanium milled implant fixed partial denture was repaired with the help of laser welding and inserted, allowing for quick, cost-effective repair. The repaired framework appeared to possess adequate strength and the same precise fit as the original framework. The joining of highly reactive titanium is made possible with laser welding; this cannot be accomplished with soldering.

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