DIFFERENT TYPES OF LASER WELDING IN DENTAL TECHNOLOGY

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REZUMAT

Introducere: Restaurările protetice cu componentă metalică turnată din titan sunt utilizate din ce în ce mai des, îndeosebi la pacienții cu alergii la alte aliaje dentare, datorită biocompatibilității excelente a titanului și aliajelor sale. Pentru a uni componente turnate din titan sau aliajele sale se utilizează frecvent solidarizarea cu raze infraroșii sau sudura cu laser. **Obiectiv:** Scopul acestui studiu este de a investiga efectul mediului protector de gaz de argon asupra rezistenței sudurilor probelor realizate prin turnare din titan și Ti-6Al-7Nb și compararea acestor rezultate cu cele obținute în cazul altor două aliaje dentare convenționale. **Material și metode:** Sudura aliajelor cu laser s-a realizat în regim pulsat, cu un echipament Nd-Yag (Orotig). Metoda de sudură cu laser este de preferat în cazul solidarizării componentelor de titan și aliajelor sale, deoarece acestea au o rată crescută de absorbție a radiației laser și conductivitate termică scăzută, comparativ cu alte aliaje dentare, de exemplu, pe bază de aur. Cu toate aceste, reactivitatea crescută a titanului topit cu oxigenul din aer în timpul sudurii, poate afecta rezistența legăturii obținute. **Rezultate și concluzii:** Ținând cont de limitele acestui studiu, se pot trage următoarele concluzii: 1. Rezultatele indică faptul că mediul protector de argon este neapărat necesar în cazul sudurii titatnului și aliajului Ti-6Al-7Nb; 2. În ciuda utilizării mediului protector de argon, jumătate din probele realizate din aliaj nobil și sudate au cedat, datorită porilor care se formează la sudură; 3. Mediul protectiv de argon s-a dovedit a fi în detrimentul eficienței sudurii aliajelor de Co-Cr, în condițiile utilizate în acest studiu.

Cuvinte cheie: sudură cu laser, mediu protector de argon, turnarea aliajelor

ABSTRACT

Introduction: Cast titanium restorations have been clinically applied to an increasing number of patients, particularly in those with allergies to other dental alloys, because titanium and its alloys possess excellent biocompatibility. To connect cast titanium and its alloys, infrared soldering and laser welding are commonly employed methods. **Objective:** The purpose of this study is to investigate the effect of argon gas shielding on the strength of laser-welded cast Ti and Ti-6Al-7Nb and compared the results to those of two dental casting alloys. **Material and methods:** The alloy's ability to weld was evaluated with a pulsed Nd-Yag Laser equipment (Orotig). Laser welding is suitable to weld titanium and its alloys because they have higher rates of laser beam absorption and lower thermal conductivity than do other dental casting alloys such as gold alloys; however, due to the strong reactivity of molten titanium with oxygen in ambient air, the incorporation of oxygen during laser welding may affect the joint strength. **Results and conclusions:** Under the limitations of this study, the following conclusions can be drawn: 1. The results indicate that argon shielding is definitely necessary when laser-welding CP Ti and Ti-6Al-7Nb are used; 2. Regardless of the argon gas shielding, the failure load for the laser-welded gold alloy was half that of the control specimens because of the pores created during the welding process. 3. Argon shielding was found to be detrimental to effective welding of Co-Cr alloy under the conditions used in this study.

Key Words: laser welding, argon gas shilding, alloy casting

INTRODUCTION

Cast titanium restorations have been clinically applied to an increasing number of patients, particularly in those with allergies to other dental alloys, because titanium and its alloys possess excellent biocompatibility. Titanium is characteristically difficult to cast and solder and it is necessary to use special equipment to cast or solder titanium frameworks.[1,2] To connect cast titanium and its alloys, infrared soldering and laser welding are commonly employed methods.[3]

Laser welding is suitable to weld titanium and its alloys because they have higher rates of laser beam absorption and lower thermal conductivity than do other dental casting alloys such as gold alloys; however, due to the strong reactivity of molten titanium with oxygen in ambient air, the incorporation of oxygen during laser welding may affect the joint strength.[4] The mechanical strength of a welded joint is important in terms of the longevity of the prosthesis since a weak joint can cause failure of the metal framework during habitual use.[5-7]

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Laser welding is an advantageous method of connecting or repairing metal prosthetic frameworks because there are fewer effects of heating on the area surrounding the spot to be welded, and no further procedures, such as those used for conventional soldering, are necessary.[2]

This study investigated the effect of argon gas shielding on the laser-welded strengths of cast Ti and Ti-6Al-7Nb and compared the results to those of laser-welded cast dental alloys.

MATERIALS AND METHODS

The commercially pure Ti, Ti-6Al-7Nb and three dental casting (Ni-Cr, gold and Co-Cr) alloys are used in this study. Two types of wax plate patterns were prepared for the laser-welded (0.5×3.0×10 mm) and nonwelded (control) (0.5×3.0×20 mm) specimens. The plate patterns were invested in the molds and then cast with each metal. Each casting procedure followed the manufacturer's instructions. After casting, the molds were allowed to bench-cool to room temperature. The cast plates were then divested, air-abraded with 50-µmAl_2O_3 particles, and ultrasonically cleaned with acetone for 10 minutes.

Laser welding configurations and tensile specimen used: three or five laser spots were bilaterally applied perpendicular to the surface at the interface. (Fig. 1)

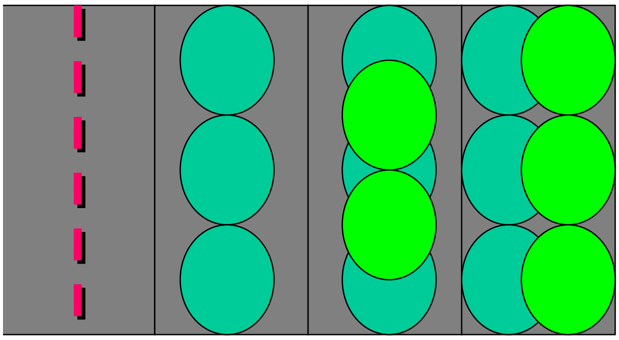

Figure 1. Laser welding configurations and tensile specimen used.

The assembled cast plates were then welded with an Nd:YAG laser (Orotig) at a constant voltage of 200 V, pulse duration of 10 ms, and spot diameter of one mm.

Tensile testing was conducted with a universal testing machine (Model 1125, Instron Corp., Canton, MA) at a crosshead speed of 1 mm/min and a gauge length of 10 mm (grips were attached 5 mm from both ends).

Failure load (N) and elongation (%) were recorded, and the means and standard deviations were calculated.

RESULTS

From the clinical point of view, the results obtained in the present study indicate that if cast pure titanium and Ti-6Al-Nb metal frameworks for prostheses are joined by laser welding under appropriate conditions in conjunction with argon gas shielding, these metal frameworks will have mechanical strength equivalent to that of the nonwelded one piece cast metal frameworks. (Figs. 2,3)

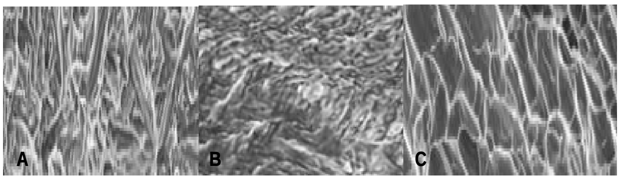

Figure 2. SEM micrographs of the fracture surfaces of Ti specimens. (A) laser welded with argon shielding; (B) laser welded without argon shielding; (C) control.

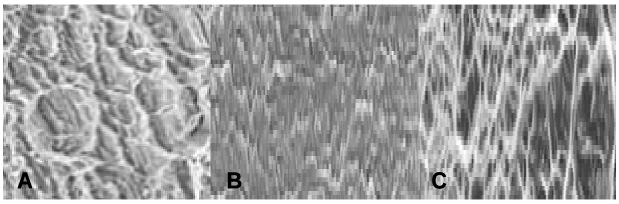

Figure 3. SEM micrographs of the fracture surfaces of Ti-6Al-7Nb (A) laser welded with argon shielding; (B) laser welded without argon shielding; (C) control.

However, the laser welded gold alloy metal framework may not be reliable for long-term usage, regardless of argon shielding, due to the pores created in the alloy. (Fig. 4) As for the Co-Cr alloy, the use of argon shielding may disturb the effective welding of Co-Cr frameworks under conditions similar to those used in this study. (Fig. 4)

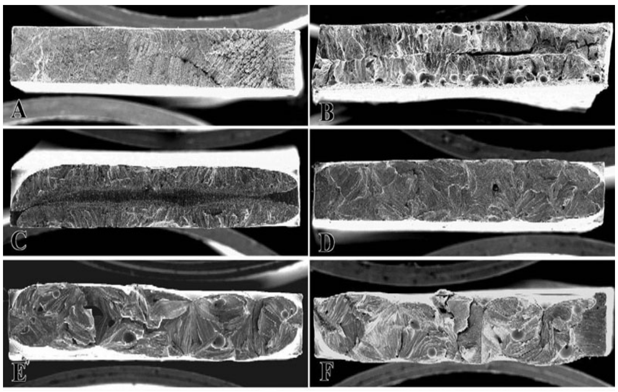

Figure 4. Representative SEM photographs of entire fracture surface (cross-section) for A: Co-Cr control, B: gold martor, C: welded Co-Cr with Ar, D: Co-Cr without Ar, E: gold with Ar, F: gold without Ar.

CONCLUSIONS

Under the limitations of this study, the following conclusions can be drawn:

1. The results indicated that argon shielding is definitely necessary when laser-welding CP Ti and Ti-6Al-7Nb.

2. Regardless of the argon gas shielding, the failure load for the laser-welded gold alloy was half that of the control specimens because of the pores created during the welding process.

3. Argon shielding was found to be detrimental to effective welding of Co-Cr alloy under the conditions used in this study.

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