Joint quality assessment of three different laser welded dental alloys

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INTRODUCTION

During the past years, laser welding has been extended to dental technique as it permits the joining of various pieces made of similar or different alloys, which might be difficult with other techniques. The quality of laser welded joints of some dental alloys can be evaluated by different invasive and non- invasive methods.

MATERIAL AND METHODS

The alloys assessed by us are the titanium-based TA6V4 alloy, a standard Au–Pd alloy for the metallo-ceramic technique and the C alloy (Cr-Co-Mo).

The TA6V4 alloy is a titanium-based alloy containing 6% aluminum and 4% vanadium, mainly used in manufacturing prefabricated pieces for implantology.

The Au–Pd alloy used in the the metallo-ceramic technique is a standard alloy, containing 51.2% Au, 38.6% Pd, indium, gallium and ruthenium as additional elements.

The third alloy is the C alloy, containing 65%Co, 29% Cr, 5% Mo, C, Si and Mn, which is currently used by the authors in making metallic components of partial dentures.

Plates of these alloys were cast, their thickness varying from 0.4 mm to 0.9 mm, and they were welded with a laboratory Nd-Yag laser: LASER 65 L – TITEC. Fig. 1.

Fig. 1. LASER 65 L – TITEC

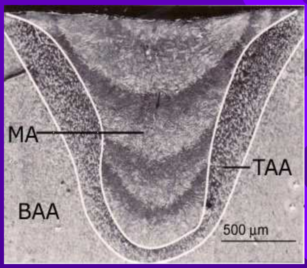

Fig. 2. SEM observation of the TA6V4 cord sample

RESULTS AND DISCUSSION

Metallurgic analysis of the TA6V4 alloy sample, by metallography and scanning electronic microscope observation, after a single impulse laser impact, reveals the following: after cooling there is a melting area (MA), a thermally-affected area (TAA) and an area corresponding to the base alloy (BAA). Fig. 2. The elasticity limit during high temperatures decreases and the resistance to wear is rather unaffected by laser welding.

For the Au–Pd alloy used in the metallo-ceramic technique, the figures show the successive impacts leading to the welding of the two pieces. Like in the case of a titanium-based alloy, there is a very perturbed TAA and a lamellar structure of the melting area. Fig. 3.

For the C alloy, the welding area, dyed in yellow, shows no fissures in the immediate vicinity of the welding – in the TAA – because the laser is used at very low temperatures and there are no contractions in the analyzed material.

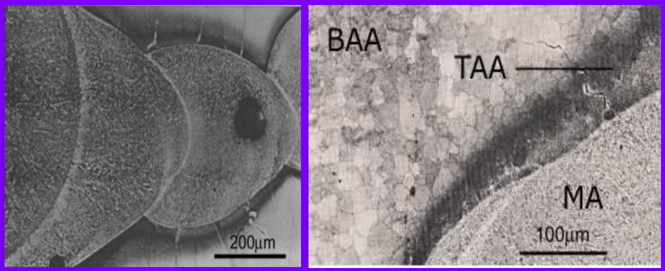

Fig. 3. Welded area: SEM (right) and metallography (left)

However, X-rays show radio-transparence in the fusion area, which indicates that the fusion is a superficial one and does not cover the entire thickness of the fused alloy. Fig. 4. Although C alloy plates used are not very thick, welding does not cover the whole depth. This results in the fragility of the welding.

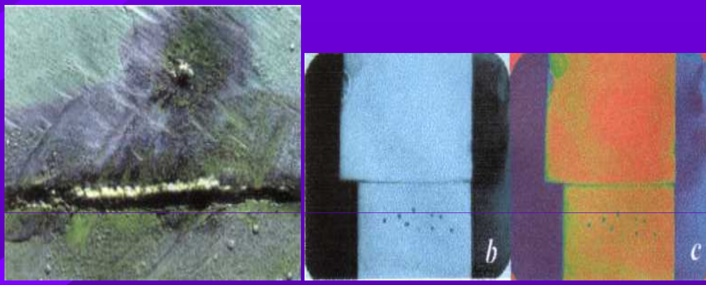

Fig. 4. Assessment of the welded area: a. basic fuchsin dye-staining (left), b. X-ray, c. pseudo-chromatization (right)

In the case of TA6V4 alloy it is important to observe that the cooling speed plays an important role on its mechanical characteristics due to its influence on the phase transformation structures into a solid state. The elasticity limit during high temperatures decreases and the resistance to wear is rather unaffected by laser welding due to the fact that the cord has no porosities or other defects (cracks, snaps).

In case of the Au–Pd alloy for the metallo-ceramic technique, it appears that the resistance to fracture of the laser welded area is higher than in the case of brazing. On the other hand, the resistance to wear of laser welding is lower than that of brazing.

Concerning the C alloy, the fusion area - laser welding - seems microscopically fragile, being easily breakable. X-rays do not show fissures in the fusion area or in the thickness of the basic material.

CONCLUSION

Laser welding is suitable to weld titanium and its alloys because they have higher rates of laser beam absorption and lower thermal conductivity than other dental casting alloys, such as gold alloys; however, due to the strong reactivity of molten titanium with oxygen, the incorporation of oxygen during laser welding may affect the joint strength.

As a rule, laser welding is mechanically satisfactory. In order to avoid problems, initially, both parts of the joined piece should be subjected to low level energy impacts, followed by greater energy for filling.