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Experimental Study on Physical Parameters Involved in Laser Welding of CO-CR Alloys

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Introduction

One of the modern methods of removable partial dentures defect repairs uses the pulsed laser with relative low average out power [1,2]. This is known as a precise and rapid joining method, but its success depends on the control of many parameters [3,4,5]. Welding presents particularities in accordance with alloy composition and structures that have to be welded [6]. Practically there are two different situations: laser joining with or without filling material (without filling material for fissures and fractures; with filling material in order to join some clasp components with the rest of the framework), and laser build up (for casting errors, fractures with lack of substance).

Objectives

The PURPOSE of the study was to make experimental investigations regarding the optimal welding parameters applied to Co-Cr-Mo alloys related to the framework defect.

Material and Methods

In order to evaluate the welding parameters several framework defects were simulated for the experimental study. The removable partial dentures frameworks were cast using a Co-Cr alloy (Vaskut Kohászati KFT, Budapest, Hungary) and as filling material a special 0.5 mm diameter Co-Cr wire Finalloy (Fino, Bad Bocklet, Deutschland) was used.

Several defects were simulated in different components of Co-Cr frameworks:
- broken lingual bars (Fig. 1, 2),
- fractured continuous clasp (Fig. 2),
- casting defect at a Roach clasp (Fig. 3),
- cast circumferential clasp arm fracture (Fig. 4).

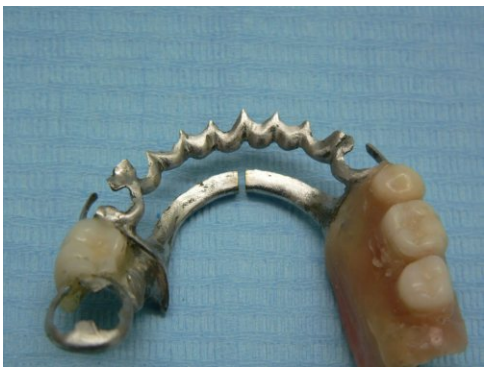

Fig. 1. Broken lingual bar.

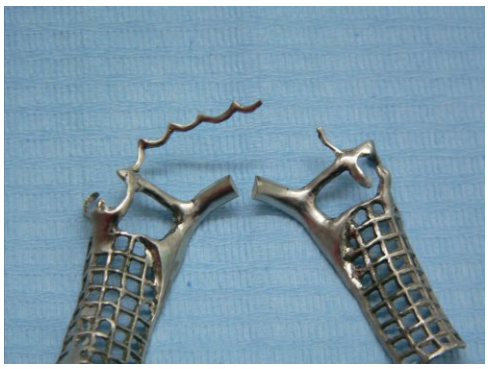

Fig. 2. Fractured continuous clasp and lingual bar.

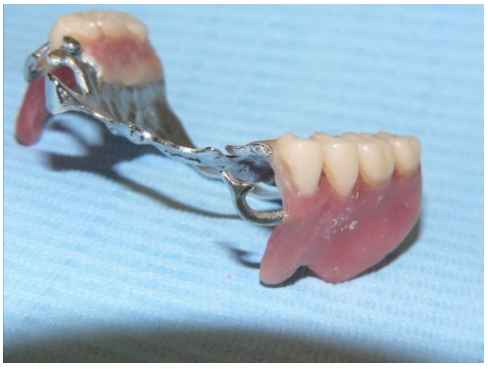

Fig. 3. Casting defect at a Roach clasp.

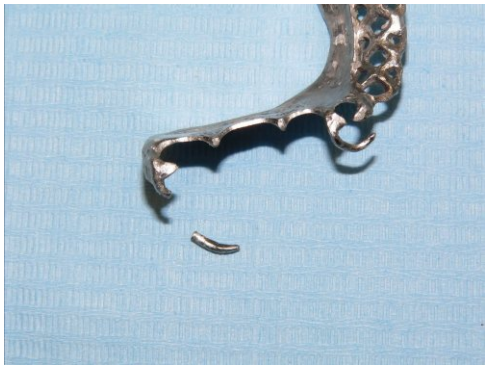

Fig. 4. Broken cast circumferential clasp.

All the repairs were made manually under argon shielding atmosphere. For preliminary attempts the peak power and pulse duration were varied, the pulse repetition rate was kept constant at 1 Hz in order to maintain a constant movement and a pulse overlapping of 80-90%. The diameter of the laser spot was maintained at 0.6 mm in all cases.

Depending on the defect type and dimension, the Nd:YAG laser (TRUMPF HL 124P LCU) was used both for joining with or without filling material, build-up welding and for a combination between the two procedures (Fig. 5, 6). The characteristics of the laser are:
Peak power: 5kW, maximal average power: 120W, pulse duration: 0,3-20ms, maximal repetition rate: 600Hz, pulse energy: 0,1-50J.

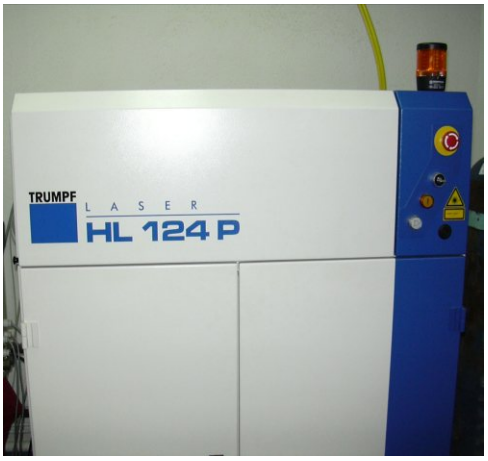

Fig. 5. Nd:YAG laser.

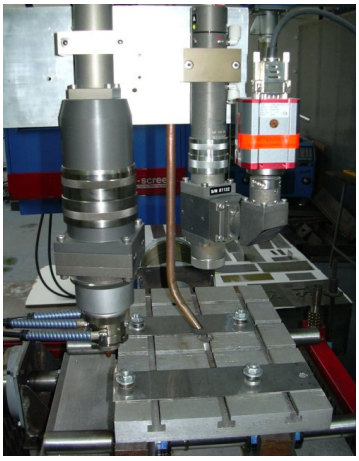
Fig. 6. Welding head of the laser.

Results

The welding parameters were determined for each defect type (Fig. 7, 8, 9, 10) and working step (fixing, joining, filling, planing).
For lingual bar repairs it was used a combination between laser joining with filling material and build-up. The pulse power (Pp), pulse duration (Dp) and pulse energy (Ep) were: Pp = 900W, Dp = 10ms, Ep = 8J for joining ; Pp = 700W, Dp = 20ms, Ep = 14J for build-up; Pp = 600W, Dp = 10ms, Ep = 6J for planing.
The broken continuous clasp was repaired by welding without filling material. The established parameters were: Pp = 800W, Dp = 10ms, Ep = 8J.

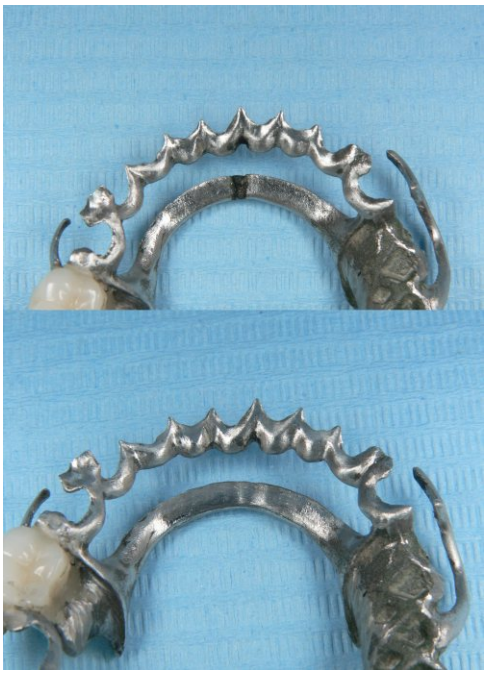
Fig. 7. Repair of a broken lingual bar.

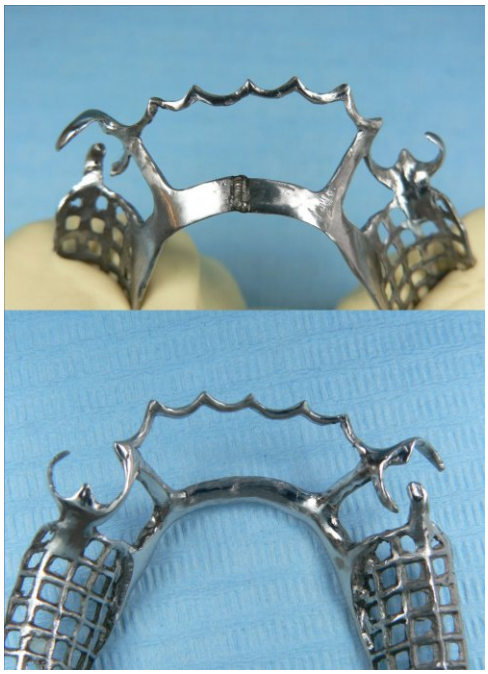
Fig. 8. Repair of the broken continuous clasp and lingual bar.

The fractured circumferential clasp was repaired by welding with filling material.The established parameters were: Pp = 1000W, Dp = 10ms, Ep = 10J.
The defect of the Roach clasp was repaired by laser build-up. The established parameters were: Pp = 700W, Dp = 20ms, Ep = 14J.

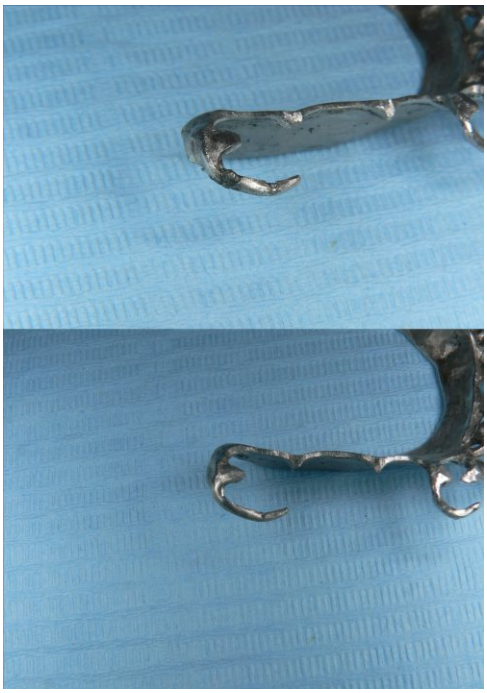

Fig. 9. Repair of the fractured cast circumferential clasp arm.

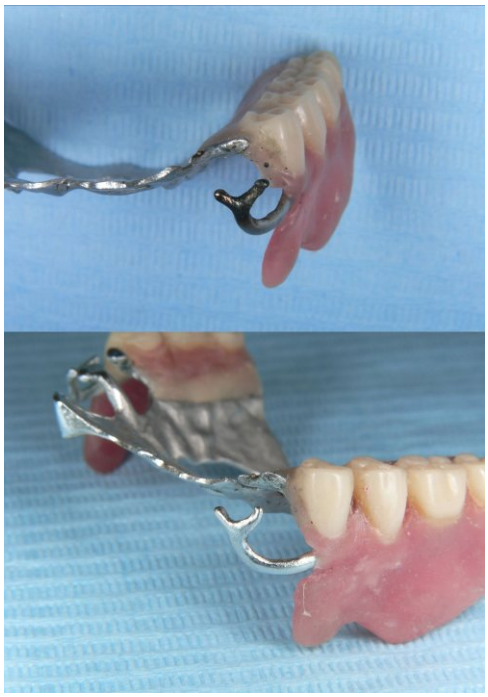

Fig. 10. Repair of the Roach clasp arm.

Conclusions

Selecting the adequate combination of pulse energy, pulse duration and peak power for each welding step is necessary for the succes of the welding procedure. Laser joining without filling material is very exigent, it presumes a perfect surfaces processing and an uniform nearness below 0.1 mm, difficult to obtain in practice. Laser joining with filling material can be applied in case of some defects with minimum lack of substance (clasp arms fractures). In case of larger lack of substance (lingual bar fractures, a clasp missing part) it is necessary to combine laser joining with filling material and laser build up.

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