RESEARCH SUMMARY

Reducing the variations in laser welding

Optimization of operator and physical parameters for laser welding of dental materials

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Objective

Interactions between lasers and materials are very complex phenomena. The success of laser welding procedures in dental metals depends on the operator's control of many parameters. The aims of this study were to evaluate factors relating to the operator's dexterity and the choice of the welding parameters (power, pulse duration and therefore energy), which are recognized determinants of weld quality.

Design

In vitro laboratory study.

Materials and methods

FeNiCr dental drawn wires were chosen for these experiments because their properties are well known. Different diameters of wires were laser welded, then tested in tension and compared to the control material as extruded, in order to evaluate the quality of the welding. Scanning electron microscopy of the fractured zone and micrograph observations perpendicular and parallel to the wire axis were also conducted in order to analyse the depth penetration and the quality of the microstructure. Additionally, the micro-hardness (Vickers type) was measured both in the welded and the heat-affected zones and then compared to the non-welded alloy.

Results

Adequate combination of energy and pulse duration with the power set in the range between 0.8 to 1 kW appears to improve penetration depth of the laser beam and success of the welding procedure. Operator skill is also an important variable.

Conclusion

The variation in laser weld quality in dental FeNiCr wires attributable to operator skill can be minimized by optimization of the physical welding parameters.

IN BRIEF

- The operator's dexterity has a real influence upon laser welding quality but this can be reduced when the choice of welding parameters has been optimized.
- It is possible to avoid the empiric choice of irradiation parameters (energy, pulse duration, power) to improve the welding procedure and get a full penetration depth of the laser beam in the dental alloy used.
- Adequate combination of energy and pulse duration using a power set around 1 KW has been performed on different diameters of FeNiCr orthodontic wires. A classification of welding parameters have been performed for that kind of material and for this type of pulsed Nd-Yag laser, so that the operators can optimize their laser welding procedure.
- Unfortunately, changing the composition of the alloys requires another systematic study.

COMMENT

Laser welders are widely available to the dental profession, especially in the dental laboratory. Their use ranges from orthodontics to removable prosthodontics, and may include such applications as in welding of titanium parts in a correcting system for the alignment of cast suprastructures on implant abutments. Beyond the strong technological appeal of that particular technique for welding parts recognized as difficult to weld properly, there are many unmastered parameters in the welding process when using such systems developed for dental applications.

The authors have properly focused their investigation on the two most common sources of uncertainties in dental laser welding: the ability of the operator, and the proper combination of the two commanding parameters ie the power output and the pulse duration, both linked to define the total energy released by the laser welder. They have shown that the human factor is important on the effectiveness of welding: the spread of the welding strength is high, and influenced by the ability and knowledge of the operators. Proper training will produce more dependable and stronger weld.

Concerning the selection of the optimal values for power output and pulse duration, leading to the most satisfactory weldings, no real model could have been proposed. On the contrary, it has been shown that only an empirical approach could lead to the best selection of parameter values. Moreover, the results obtained are only valid for the tested alloy. Changing the alloy means changing its composition, and therefore its thermal conductivity. Thus the selection of the commanding parameters (power output and pulse duration) which can be set on the machine have to be redefined through a new and lengthy trial and error process.

This work, however, points rightly on the need for a more systematic approach, such as, for example, a complete set of nomograms established for the selection of power outputs and pulse durations for the most common types of dental alloys, maybe ranged according to their thermal conductivity, and on the size of the wires to be welded. But the problem of welding more complex forms will still remain unsolved with these nomograms.

As it appears clearly from this paper, laser welding will still remain a technique which is highly influenced by the ability of the operator, and his knowledge of the effects of the various settings of the controls of his machine on the success of its operation.

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