Laser Weldings Versus Electrical Weldings in Dental Technology
A corrosion approach study

DANIELA MARIA POP¹, MIHAI ROMINU¹, FLORIN IONEL TOPALĂ², COSMIN SINESCU¹, DORIN DODENCIU¹, ROXANA OTILIA ROMINU¹, LAVINIA ARDELEAN¹, LAURA CRISTINA RUSU¹, MIHAIELA ANDON², EMANUELA LIDIA PETRESCU¹, MEDA-LAVINIA NEGRUTIU¹ ¹ University of Medicine and Pharmacy „Victor Babeș” Timisoara, Faculty of Dentistry, 1989 Revolutiei Blv., 300070, Timisoara, Romania
² University of Medicine and Pharmacy „Victor Babeș” Timisoara, Faculty of Pharmacy, 1989 Revolutiei Blv., 300070, Timisoara, Romania

Dental prostheses often present defects at the level of the metallic frameworks, which need to be repaired. In order to avoid the disadvantages of traditional joining procedures used in dental prostheses technology, new welding methods were developed. The aim of these study was to evaluate the corrosion of laser welding and electrical welding of dental alloys, depending on the structure morphology and joining method. Comparative investigations of the welded areas are important for weld quality evaluation and to establish the limitations of this repairing method in practical use. In order to obtain maximum precision and high quality weldings, which would fulfill current requirements, it is important that modern analysis concepts be used for each particular case, based on an interdisciplinary collaboration.

Keywords: soldering, laser welding, sincristalyzation, corrosion

The manufacturing of dental prostheses with metallic framework supposes to perform technical steps that can be associated with errors: vicious adaptation on prosthetic field or defects in material that can lead to the prosthesis fracture [1-3]. Solving this problems is difficult and sometimes the clinical-technical steps must be repeated.

The metallic frameworks of dental prosthesis can present defects, which need to be repaired. For this purpose, the most frequent used technologies are the common soldering procedures, but the final product is not corrosion stable, the welding procedures and the adhesive technique [4-6]. In the dental technology, the most fervently used welding methods are- laser welding, which needs an initial high investment, micro impulse or plasma welding and the sincristalization method or electrical welding [7-10].

Dental alloys are subject to functional influences in the oral cavity and interact with the intraoral environment [9-12].

The choosing of the soldering technique is influenced by several factors such as: type of alloy to be soldered, functioning mode of the device (protective environment necessary or not), working parameters, penetration depth, expenses, using additional material or not, associated thermal modifications [13-17].

The aim of this study was to evaluate the corrosion of laser welding and electrical welding of dental alloys, depending on the structure morphology and joining method. Comparative investigations of the welded areas are important for weld quality evaluation and to establish the limitations of this repairing method in practical use.

Experimental part
Materials and methods
For this study, we considered the frameworks of metal-ceramic crowns, made from Ti and Co-Cr alloy, by the classical melting-casting technique and by a milling technology.

After obtaining the two groups of samples, we simulated defects, oriented on those areas that require optimizations in practical use. So, defects of 1,5 mm were realized on the vestibular surface, at the cervical level, using metall burns. The covering of the defects was made by two welding procedures, using filling material.

For the laser welding we used pulsed Nd-Yag. Laser equipment (Orotig), with the following parameters: 1064 nm wavelength, 10 ms repetition rate and 6.58 kJ/cm² energy density (for Ti specimens) and 12ms repetition rate and 7.49 kJ/cm² energy density for Co-Cr alloys. The relative position of the laser focus determines the quality and configuration of the welding.

For the electrical welding we used Syncristalization System Implamed Argon Control unit. This type of welding is made through points and pressure, performed in an argon protective environment. The welding series are divided in three stages: pre-gase, welding and post-gase. Pressure is exerted for a longer period of time than the welding. The welding stages are represented by: applying of the electrodes and exerting pressure without electric power, then the welding stage with combined action: pressure and electric, and finally the cooling phase when only pressure is exerted.

The advantages of the sincristalization methods are: working time is reduced, minimal thermal modifications, soldering takes place in a short period of time.

Welded joint is performed through plastic deformation of material in the joint area; plastic deformation is favoured by local heating through Joule-Lenz after passing the electric power at the joining area. In both cases the weldings were realized in an argon protective environment. Corrosion was subsequently evaluated. The welded frameworks were isolated with varnish, except the welded...
Then they were immersed in 50 mL of saline solution for 60 days. After that we have dosed the value of the saline conductance before and after immersing the frameworks. After drying, the welded areas have been visually analyzed (macro photography) and the images obtained were compared. By analyzing the conductance of the saline solution before and after the immersion of the frameworks there were no measurable changes.

The analysis of porosity degree due to welding defects, was performed by an indirect method of local microfiltering of a KCl solution. The specific electrolyte was chosen due to its linear variation in electric conductivity with the concentration and due to the fact that it allows detection by electrochemical conductometric methods even at very small concentrations (10^(-6)-10^(-8) M). The KCl solution used in the study had a concentration of 1M.

The presence of irregularities and defects at the welding area leads to an increased contact surface with the KCl solution. The metal copings were washed with distilled water and rinsed using a magnetic agitator (fig. 1).

The copings were rinsed until the conductivity of the distilled water remained constant, so that there are no more ions on the metal surface. The copings were extracted with a tweezer and dried avoiding direct skin contact. The welded areas were immersed in an electrolyte solution for an hour in order to allow microleakage.

After allowing ionic microleakage the copings were immersed in 5 mL of bidistilled water with predetermined electrical conductivity and agitated for 15 min. The conductivity of the distilled water was again determined and recorded. The copings were cleaned again by the same means that were described above. The same procedure was then repeated for a part of the copings with the same geometrical shape as the welded area.

### Results and discussions

The values of the conductivity were recorded in table 1. Microleakage was assessed for all types of welded copings (laser and Sincristalization welding respectively) (fig. 2 and 3).

From analysing the initial conductance of the 5 mL of bidistilled water we can conclude that the determined values were constant (G = 10.22 μS ± 0.05 μS). The conductivity of the solutions obtained by immersing the areas contralateral to the welded surfaces contaminated with electrolyte solution was 11.55 μS without any significant differences between the copings. Mikroleakage of the electrolyte solution was higher for the sincristallisation welded sample (14.3 μS) than for the laser welded one (12.7 μS). This difference in conductivity confirms the presence of a rougher surface at the welding defects of the sincristalisation sample as revealed by the macrophotographic analysis. The presence of these defects allowed for an increased mikroleakage (by 12% more increased for the sincristalisation welded areas than for the laser welded one.

### Conclusion

In order to obtain maximum precision and high quality weldings, which would fulfill current requirements, it is important that modern analysis concepts be used for each particular case, based on an interdisciplinary collaboration.

Sincristalization is a welding technique that assures a high quality joint which does not need other thermic treatments. The soldering procedure needs a very short period of time, takes place without local heat variations. For high quality and precision of joints, it is important that the used parameters to be adapted to each case separately.

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**Table 1**

<table>
<thead>
<tr>
<th>Conductivity of the solution</th>
<th>Control sample laser welding</th>
<th>Laser welding</th>
<th>Control sample sincristalisation welding</th>
<th>Sincristalisation welding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial phase</td>
<td>10.2</td>
<td>10.2</td>
<td>10.3</td>
<td>10.2</td>
</tr>
<tr>
<td>Final phase</td>
<td>11.3</td>
<td>12.7</td>
<td>11.8</td>
<td>14.3</td>
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**Fig. 1.** Aspects of copings in the magnetic agitator: a. general aspect; b close-up of the framework in the magnetic agitator

**Fig. 2.** The aspect of a Co-Cr coping before (a) and after (b) microleakage

**Fig. 3.** The aspect of a Ti coping before (a) and after (b) microleakage
To obtain precision and high quality welding, it is important that modern analysis concept be used for each particular case. The technician will be able to carry out many prosthesis repairs but he/she must accept micro structural changes caused by the rapid solidification stage.

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