Investigations of Different Types of Welding In Dental Technology

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Abstract – The metallic frameworks of dental prosthesis can present defects, which need to be repaired. The modern techniques of joining metal parts in dentistry require experience and supplementary equipment. The aim of this study was the investigation of different types of welding made on Co-Cr and Ti dental alloys. Twelve metal crowns were made and milled from Ti by using a CAD-CAM system. Another 12 metal crowns were obtained by classical casting method from Co-Cr alloy. On both types of samples cervical defects were performed by reducing the crowns length with 1,5 mm. Those defects were repaired through welding technology with laser (Orotig System) and through sincristalization (Argon Control Implamed). All the welding procedures were performed in an argon protected environment. After the defects reparations, corrosion and micro leakage of the welding areas were investigated in all the samples. The value of the solution conductance remains at the same level G10, 225µs+/00, and 05µs for both welding procedures. The value for the sincristalization samples was higher (14, 3 µs) than for the laser samples (12,7 µs) when the micro leakage was investigated. Micro structural changes caused by the rapid solidification stage must be accepted. Before using this technique for repairing prosthetic components, more research is required such as the influence of the cracking and/or the change in microstructure and composition of the soldering zone.

Keywords—laser welding, sincrystalization, corrosion, microleakage

I. INTRODUCTION

The metallic frameworks of dental prosthesis may present defects, which need to be repaired. Solving the associated problems is difficult. For this reason we can used a welding technique. Joining technique that exist are: soldering, overcasting, micro impulse welding, laser beam welding, electrical welding, ultrasound welding, electric arc welding, gas flame welding, explosion welding, electron beam welding, friction welding. 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. In the dental technology, the most frequently used welding methods are: laser welding– which needs an initial high investment, micro impulse or plasma welding and the sincrystalization method or electrical welding. Dental alloys are subjected to functional influences in the oral cavity and interact with the intraoral environment.

In comparison to conventional welding arch, laser welding scores several advantages like narrow welds with controlled bead size, faster welding with a higher productivity, less distortion, narrow heat affected zone and minimum contamination. 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 of additional material or not, associated thermal modifications. In our study, different types of investigation were made: welding made on Co-Cr and Ti dental alloys.

II. MATERIAL AND METHODS

In our study we took in consideration two types of dental alloys used in dental technology and two technologies: melting casting and milling. In the first group of 12 metal crowns we followed the classical melting casting technique. Initially we obtained the wax models, using an immersion
wax, then we applied the 3 mm casting rods, the models were cast invested using the SANIVEST casting investing material. The COLADO Co-Cr alloy made by IVOCLAR was melted by induction and the centrifugal casting was accomplished by the FORNAX apparatus. After casting and removing the casting investment material, the crowns were sandblasted.

For obtaining the second group of 12 crowns we have chosen the CAD-CAM milling, using The CERECON EYE system in conjunction with the CERECON ART made by DEGUSSA. The Ti block is introduced in the milling machine and the crown is obtained in congruency with the facts taken from the computer.

After obtaining the two groups of samples using metal burr, on the vestibular surface, at the cervical level there have been realized defects of 1.5 mm. The covering of the defects was realized using a filling material and two welding techniques: laser and syncristallization. (fig.1, 2, 3)

For the laser welding we used pulsed Nd-Yag. Laser equipment (Orotig) (fig.1), 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 welding of dental alloys only a few types of lasers can be used.

This type of welding is made through points and pressure, performed in an argon protective environment. Soldering of titanium infrastructure directly in oral cavity is possible by using Syncristallization System Argon Control, IMPLAMED (fig.2). 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 two welding procedures were oriented on those areas that require optimizations in practical use. Welded joint is performed through plastic deformation of material in the joint area; plastic deformation is favored by local heating through Joule-Lenz after passing the electric power at the joining area. In both cases the weddings were realized in an argon protective environment.
Corrosion was subsequently evaluated. The welded crowns were isolated with varnish, except the welded region. Then the crowns were immersed in 50ml of saline solution for 60 days. After that we have dosed the value of the saline conductance before and after immersing the crowns. After drying, the crowns 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 crowns 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.

III. RESULTS
The presence of irregularities and defects at the welding area leads to an increased contact surface with the KCl solution. The metal crowns were washed with distilled water and rinsed using a magnetic agitator (fig. 4). The coping was rinsed until the conductivity of the distilled water remained constant which physically means that there are no more ions on the metal surface. The coping was extracted with a tweezer and dried avoiding direct skin contact. The welded area was immersed in an electrolyte solution for a hour in order to allow microleakage.

After allowing ionic micro leakage the coping was immersed in 5 ml of bidistilled water with predetermined electrical conductivity and agitated for 15 minutes. The conductivity of the distilled water was again determined and recorded. The coping was cleaned again by the same means that were described above. The same procedure was then repeated for a part of the coping with the same geometrical shape as the welded area. The values of the conductivity were recorded in table 1. Micro leakage was assessed for all types of welded copings (laser and Sincristalization welding respectively).

From the initial analysis of the 5 cm³ of bidistilled water we observe that the constant value is G 10,225µS ± 0,05µS. The conductance of the obtained solutions by immersing the contra lateral welding witness areas contaminated with electrolytic solution was of 11,55 µS without being any significant
differences between the two crowns.

Table 1. Results

<table>
<thead>
<tr>
<th>Conductivity of the solution (µS)</th>
<th>Control sample</th>
<th>Laser welding</th>
<th>Control sample</th>
<th>Syncristallisation 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>
</tr>
</tbody>
</table>

From analysing the initial conductance of the 5 ml of bidistilled water we can conclude that the determined values were constant (G = 10.22 ± 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 syncristallisation 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 syncristallisation sample as revealed by the macrophotographic analysis. The presence of these defects allowed for an increased mikroleakage (by 12% more increased for the syncristallisation welded areas than for the laser welded one.

IV. CONCLUSION

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. Syncristallization is a welding technique that assures a quality joint which does not need other thermal treatments. The soldering procedure needs a very short period of time and 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. In order to obtain maximum precision and high quality welding that would fulfill current requirements, it is important that modern analysis concepts should be used for each particular case, based on an interdisciplinary collaboration. 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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