

# Efeito da Desinfecção Simulada por Microondas na Resistência da União Dente-Resina Acrílica

## Effect of Simulated Microwave Disinfection on Bond Strength of Acrylic Teeth and Denture Base Resins

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### Resumo

Este trabalho teve como objetivo verificar a resistência ao impacto da união dente-resina acrílica, sob efeito da desinfecção por microondas. Moldes de gesso nas muflas foram preenchidos com silicone laboratorial e sobre estes foram adaptados dentes molares de resina acrílica contendo um cilindro de cera (6 mm de diâmetro) na base. O conjunto foi revestido com silicone laboratorial e a mufla preenchida com gesso. A mufla foi aberta e os conjuntos dente-cilindro de cera removidos dos moldes. Dentes molares (n=160), isentos de contato com cera foram utilizados e suas bases de fixação submetidas aos seguintes tratamentos: controle, desgaste com broca, retenção com broca e condicionamento com monômero. Foi utilizada resina termopolimerizável (Clássico) em ciclo de banho de água (ciclo longo) e resina para microondas (Onda-Cryl). Os corpos-de-prova foram desincludidos após esfriamento das muflas em bancada. Oitenta corpos-de-prova foram submetidos à desinfecção por microondas por 3 minutos a 650 W, imersos em 150 mL de água e a outra metade não foi submetida ao tratamento descrito. Após armazenagem em água à temperatura de 37°C por 24 horas, os corpos-de-prova foram submetidos ao teste de resistência ao impacto da união dente-resina, em máquina Otto Wolpert Werke (sistema Charpy) com 40 kpcm de impacto. Os resultados obtidos transformados para kgf/cm<sup>2</sup> foram: resina termo ativada sem desinfecção (11,68 ± 2,6), resina termo ativada com desinfecção (10,11 ± 2,78), resina microondas sem desinfecção (14,92 ± 3,25) e resina microondas com desinfecção (12,92 ± 2,21). A desinfecção em microondas afetou significativamente a força de união ao impacto entre o dente e a resina acrílica.

**Palavras Chave:** Desinfecção por microondas. Resistência ao impacto. União dente-resina acrílica.

### Abstract

*The aim of this study was to evaluate the effect of microwave disinfection on bond strength of acrylic teeth and denture base resin. Moulds were obtained in metal or plastic flasks and filled with laboratory silicone, in which a molar acrylic tooth was included using a wax cylinder (6 mm) to join it to the tooth base. The set was invested using laboratory silicone and type III dental stone. The flask was opened and the wax cylinder removed from the tooth. Teeth were adapted in the molds with the ridge laps previously having been submitted to the following treatments: 1 – no treatment; 2 – bur abrasion; 3 – bur grooving and 4 – etched by monomer. Eighty rods of Clássico acrylic resin attached to the tooth ridge laps were polymerized in bath cycle at 74°C for 9 hours, and 80 rods of Onda-Cryl acrylic resin were polymerized in a 900 W-domestic microwave oven. Specimens were deflasked after bench cooling. Forty specimens of each acrylic resin were submitted to microwave disinfection in a domestic oven at 650W for 3 minutes, individually immersed in 150 mL of water. Other specimens were not disinfected (control). Specimens were stored in water at 37°C for 24 hours before impact testing using the Charpy impact strength test calibrated to 40 kpcm. Data were submitted to analysis of variance and Tukey's test at 5% level of significance. Different tooth ridge lap treatments promoted different effects on the tooth-resin bond strength, under both conditions of simulated disinfection by microwave energy.*

**Keywords:** Microwave disinfection. Impact strength. Tooth-resin bond.

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### 1 Introduction

Many factors may be linked to the loss of natural teeth, and it is essential to replace them. In most cases, complete

and partial dentures are the only alternative for rehabilitating the masticatory system. However, these prostheses can be contaminated by pathogenic microorganisms during the manufacturing stages<sup>1</sup>.

In addition to the microbial contamination caused in the stages of manufacture or manipulation, the dentures can be contaminated during clinical use. In an effort to eliminate or reduce cross-contamination, prostheses should be disinfected with suitable chemical solutions<sup>1</sup>.

Chemical disinfection of prostheses using solutions of glutaraldehyde, sodium hypochlorite, iodoform, chlorhexidine, chlorine dioxide or alcohol has been recommended by several authors in order to avoid cross-contamination caused by the spread of pathogens<sup>1-4</sup>.

Most of the work dental clinics send to laboratories has been contaminated with pathogenic bacteria, which could be transmitted to the technicians through direct contact or during

polishing procedures<sup>5</sup>.

Microorganisms found in pumice slurry come from contaminated prostheses, polished without previous cleaning or disinfecting<sup>6</sup>. These microorganisms can contaminate sterile prosthesis during the polishing procedures through the pumice slurry or the wheel of felt material routinely used in prosthetic laboratories<sup>7</sup>.

To minimize the disadvantages of chemical disinfection, such as denture staining and irritation of oral tissues<sup>8,9</sup>, the use of microwave energy has been suggested as a simple alternative for prosthesis disinfection, and is considered an easy, simple-to-implement method with a relatively low operating cost<sup>8</sup>.

Originally used in dentistry for polymerizing heat-activated acrylic resin<sup>10,11</sup>, irradiating resilient linings, and acrylic resins immersed in water in a domestic microwave oven effectively sterilizes specimens contaminated by fungi<sup>12</sup>. Moreover, complete maxillary dentures contaminated with microorganisms were effectively sterilized by microwave irradiation of 650 W, after 3 minutes of exposure<sup>13</sup>.

Various authors have suggested changes in the tooth base surfaces, with the aim of increasing the bond strength between the acrylic resin and artificial tooth. Among these modifications are glossy ridge lap grooving with a bur<sup>14,15</sup>, glossy ridge lap grinding with a bur<sup>16</sup>, glossy ridge lap etched with monomer<sup>17,19</sup> and the application of adhesive agents<sup>20</sup>.

In view of these considerations, it would be appropriate to check the effect of simulated microwave disinfection on the impact strength of the tooth/acrylic resin bond, which can compromise the durability of the union during clinical use.

Therefore, the objective of this study was to evaluate the impact strength of the tooth/acrylic resin (water bath or microwave energy), under conditions of simulated microwave disinfection, where the ridge lap of the tooth was subjected to different treatments (glossy ridge lap unmodified, abraded, grooved or etched by monomer).

The hypothesis verified in this study was that the microwave disinfection could change the impact strength of the tooth/acrylic resin bond, irrespective of the type of treatment provided at the base of the tooth.

## 2 Materials and Method

Rectangular wax mold patterns were poured into each plastic (Classico; Classico Dental Products, Sao Paulo, SP, Brazil) or metal flasks (Safrany; Safrany Metallurgy, Sao Paulo, SP, Brazil), according to the type of resin, with type III dental stone (Herodent; Vigodent, Rio de Janeiro, RJ, Brazil), proportioned and manipulated in accordance with the manufacturer's instructions. After removing the wax pattern, the rectangular stone mold was filled with a layer of laboratory silicone putty (Zetalabor; Zhermack, Rovigo, Italy) hard type (85 shore A). Identical shape and size model 34 L acrylic molar teeth (Biotone; Dentsply, Petrópolis, RJ,

Brazil), attached with a wax stick (6 mm in diameter and 20 mm long) at the ridge lap surface, were partially embedded in the silicone layer. The resultant wax stick and attached tooth set was covered with laboratory silicone putty (Zetalabor; Zhermack, Rovigo, Italy). After dental stone isolation with petroleum jelly, the flask was completely poured with type III dental stone (Herodent; Vigodent, Rio de Janeiro, RJ, Brazil) and pressed in a hydraulic press (Linea H; Linea, Sao Paulo, SP, Brazil) for 1 h.

After pressing, the tooth/wax stick set was deflasked and the wax stick removed from the tooth. The tooth was brushed with hot water and liquid household detergent (Bombril; Bombril-Cirio, São Paulo, SP, Brazil) solution to eliminate the wax stick residues and rinsed under running water. Five specimens were made in each flask with the tooth attached to the denture base acrylic resin, proportioned and manipulated in accordance with the manufacturer's instructions, using one of the following protocols: 1- tooth without treatment (control); 2- glossy ridge lap grinding with bur Minicut (Dentsply/Maillefer, Tulsa, Oklaroma); 3- glossy ridge lap grooving with bur number 8 (Dentsply/Maillefer); 4- glossy ridge lap etched by monomer applied for 30 s with a small brush before packing<sup>19</sup>. After this, the teeth were repositioned in silicone molds for packing with the Classico and Onda-Cryl acrylic resins, then they were randomly separated to form 4 groups without disinfection, and 4 groups submitted by simulated microwave disinfection, both according to the changes made on the ridge laps of the teeth (n = 10).

Classico and Onda-Cryl resins (Classico; Classico Dental Products, São Paulo, SP, Brazil) were proportioned and manipulated in accordance with the manufacturer's instructions, and pressed in the plastic stage. The flasks were placed in traditional clamps after final pressing in a hydraulic press (Linea H; Linea, São Paulo, SP, Brazil) under a load of 1,250 kgf or 950 kgf compression, respectively. Eighty specimens (n=10) were conventionally packed, polymerized in a water bath at  $\pm 74^{\circ}\text{C}$  for 9 h in a polymerizing unit (Termotron; Piracicaba, Sao Paulo, SP, Brazil), and eighty specimens were polymerized in a 900 W domestic microwave oven (Continental; Continental Domestic Lines, Manaus, AM, Brazil) following the manufacture's recommendations: Phase 1 - three minutes at 40% power, phase 2 - four minutes with 0% power, and phase 3 - three minutes with 90% power. Specimens were deflasked after flask cooling at room temperature, and finished with abrasive stones.

Afterwards, half of the specimens of every group were submitted to simulated microwave disinfection in a domestic microwave oven (Continental; Continental Domestic Lines, Manaus, AM, Brazil) for 3 minutes at 650 W<sup>13,21</sup>. For this procedure the specimens were individually immersed in 150 mL of distilled water in a glass container<sup>22</sup>. The specimen was removed from the glass container with tweezers after water-cooling at room temperature, and air dried before the impact

strength test.

After water storage at 37°C for 24 h, the bond impact strength test was performed in the non-disinfected (control) specimens and in those submitted to simulated microwave disinfection, with an impact machine (Wolpert; Otto Wolpert-Werke, Ludwigshafen/Rhein, Germany), using the Charpy system with an impact load of 40 kpcm. The impact strength (kgf/cm<sup>2</sup>) was calculated as a function of the load applied at the moment of specimen failure (kpcm) and tooth/resin bonding area, using the equation:

$$IS = F / \Pi \cdot r^2$$

where:

IS = Impact strength (kgf/cm<sup>2</sup>).

F = Failure load (kpcm).

$\Pi r^2$  = tooth/resin bonding area; where:  $\Pi = 3.1416$  and  $r^2 = 0.09\text{cm}^2$ ; thus,  $0.09 \times 3.1416 = 0.28\text{cm}^2$ .

The failure mode after the impact strength test was observed under an optical microscope (EMZ-TR; Meiji Tecno Co., Tokyo, Japan), at 1.5x magnification. Data was statistically evaluated using a three-way analysis of variance (ANOVA), considering resin, the basic treatment and disinfection by microwave. Comparisons were conducted using Tukey's test ( $p \leq 0.05$ ).

### 3 Results

Table 1 shows the comparison of results of impact strength between tooth-resin irrespective of the tooth base treatment. There was statistical difference in values between the groups with and without simulated disinfection for both types of resin, with lower value for disinfection. When the resins were compared, there was statistical difference between the conditions with and without disinfection, with higher impact values for the resin activated by microwave energy, in both methods.

Table 1 - Mean values of bond strength between tooth-resin (MPa) for resin and disinfecting factors, irrespective of the tooth base treatment

Disinfection	Classico	Onda-Cryl
Without disinfection	11.68 ± 2.60 A,b	14.92 ± 3.25 A,a
With disinfection	10.11 ± 2.78 B,b	12.92 ± 2.21 B,a

Means followed by different letters differ by Tukey's test (5%). Upper case letters compare averages in each column and lower case letters compare means in each line.

Tables 2 and 3 show the comparison of mean values for each resin, considering microwave disinfection and tooth base treatment factors.

Table 2 - Mean values of bond strength between tooth-resin (MPa) for the disinfection factors and tooth base treatment, only for Classico resin

Treatment	Without Disinfection	With Disinfection
Control	12.35 ± 2.96 A, a	8.42 ± 2.53 BC, b
Abraded	14.14 ± 3.85 A, a	13.14 ± 3.82 A, a
Bur Retention	12.14 ± 4.07 A, a	11.71 ± 4.42 AB, a
Monomer	8.00 ± 2.82 B, a	7.14 ± 2.5 C, a

Means followed by different letters differ by the Tukey's test (5%). Upper case letters compare means in each column and lower case letters, means in each line

Table 2 shows that in Classico resin without disinfection, there was a statistical difference between tooth base treatments, with lower value, only when they were monomer etched. With simulated disinfection, abraded ridge lap and monomer etched specimens showed statistical difference, while the value of abraded specimens was similar to that of the retention treatment, and the value of control specimens was similar to that of the monomer treatment. When the comparison was made between disinfection factors, the control showed statistical difference, with lower value for the simulated disinfection.

In Onda-Cryl resin without disinfection (table 3), the retention and monomer treatments showed no statistical difference. These treatments were statistically different from the control, which presented a lower value. The control showed a similar value to that of the abraded tooth, whose value was similar to those of the retention and monomer treatments. Under the condition with simulated disinfection, the abraded tooth showed significant difference when compared with the monomer treatment, with a lower value. Abraded treatment values were similar to those of the control and retention treatment values, while the monomer value was similar to those of the control and retention treatment values. When comparison was made between microwave disinfection factors, the abraded and control groups showed no statistical difference. The retention and monomer groups showed significant difference, with a lower value for the simulated disinfection condition.

Table 3 - Mean Values Of Bond Strength Between Tooth-Resin (Mpa) For The Disinfection Factors And Tooth Base Treatment, Only For Onda-Cryl Resin

Treatment	Without Disinfection	With Disinfection
Control	10.53 ± 4.03 B, a	13.00 ± 3.25 AB, a
Abraded	14.75 ± 4.10 AB, a	15.35 ± 4.28 A, a
Retention Bur	18.00 ± 4.03 A, a	13.28 ± 4.25 AB, b
Monomer	16.57 ± 5.60 A, a	10.00 ± 1.78 B, b

Means followed by different letters differ by Tukey's test (5%). Upper case letters compare means in each column and lower case letters, means in each line.

The microscopic analysis showed that the fracture failures were predominantly mixed (adhesive and cohesive in the denture base resin) in all groups (figure 1).



**Figure 1** – Illustrative image of mixed failures

#### 4 Discussion

The purpose of this study was to evaluate the impact bond strength between tooth-resin under conditions of simulated microwave disinfection, when the base of the tooth was submitted to different treatments. The hypothesis that the simulated microwave disinfection could change the values of impact strength of tooth-resin, irrespective of the types of tooth base treatment was partially confirmed.

When the treatments performed at the base of the teeth are not taken into consideration, the simulated microwave disinfection is shown to decrease the value of impact strength in both resins, with a statistical difference when compared with the value without disinfection (table 1). However, the tables 2 and 3 show that this is a misleading result.

Irradiation with microwave energy generates heat inside the acrylic resin mass<sup>23</sup>, increasing the degree of conversion of chemically activated acrylic resin<sup>24</sup> and decreasing the level of residual monomer<sup>25</sup>. As speculated in previous work, there is an increase in the rigidity of acrylic resin irradiated by microwave energy, promoting decrease in the cohesive bond strength<sup>22</sup>, which must have occurred in this study in the microwave radiated specimens.

The literature shows that despite the small increase in hardness, the flexural strength of the acrylic resin was not changed by microwave irradiation. An explanation for the increase in hardness is the absence of plasticizer effect of water in the irradiated resin<sup>11</sup>. In this study, the microwave disinfection decreased the mean values of impact strength of the tooth-resin bond in both resins.

When the resins were compared, Onda-Cryl showed higher impact strength, with statistical difference when compared with Classico resin, under both conditions of disinfection (table 1). This result seems to be related to the fact that the microwave-activated resin also provides a satisfactory

bond between tooth and resin<sup>26,27</sup>. The microwave activated resin presents fewer residual monomers<sup>25</sup> and has physical properties similar to those of conventional acrylic resin<sup>26,28-29</sup>. Furthermore, the microwave activated resin can promote lower interpenetration of polymeric chains between tooth and the denture base, show fewer cross-links and decrease the amount of functional groups able to combine chemically<sup>30</sup>.

Nevertheless, the impact strength promoted by microwave activated resin was higher under both conditions of disinfection (table 1). This seems to be unrelated to the higher degree of conversion promoting smaller amount of residual monomer<sup>25</sup>. In this study, the rigidity caused by the conversion of monomer would not have negative effect on the impact strength values, especially when it appears that the resin values obtained by the Onda-Cryl was higher and statistically different when compared with Classico resin, under both conditions of disinfection.

According to table 2, the Classico resin under the condition without disinfection showed statistical difference between the tooth base treatments, with a lower value, only when monomer was compared with other treatments. The control, abraded and retention treatments showed no statistical difference.

The literature has shown that monomer etching and abrasion treatment of the tooth base before pressing are procedures that do not improve the bond to the acrylic resin<sup>17,31</sup>. This study also showed that without disinfection, the values of impact strength for the abrasion, perforation and control treatments were similar and statistically different from the monomer etched treatment, with a lower value.

Although there may be influence of the chemical interaction between resin and tooth base on the impact strength, the monomer etched treatment has a marked effect on reducing the fracture load of tooth-resin bond<sup>32</sup>. In view of this, it is possible to speculate that the difference in values between the impact strength of the monomer and other treatments was probably due to the structural change in the tooth surface by the chemical action of the monomer. The literature has shown that the application of monomer on the tooth base reduces the strength of the bond between the tooth and acrylic resin<sup>17,33</sup>.

Table 2 also shows the influence of simulated microwave disinfection on the impact strength of the bond between the tooth and Classico resin. Simulated disinfection promoted values with a statistical difference, with lower value, when the mechanical treatments (abrasion and retention) were compared with monomer etching. The difference between monomer and mechanical treatments probably occurred for the same reason suggested in the explanation for the condition without disinfection, and that the disinfection by microwave irradiation was not able to change this.

Moreover, when the comparison was made between the simulated disinfection conditions, only the control treatment showed a statistical difference, with lower value for disinfection. This result may mean that the mechanical

changes that occurred in the tooth basis either canceled or minimized the deleterious effect of disinfection by microwave on the impact strength of the tooth-Classico resin bond. This result takes on real significance when considering the possibility of the clinical use of microwave disinfection, without deleterious effects on the bond of teeth with bases modified by mechanical procedures.

Table 3 shows that for the Onda-Cryl resin without disinfection, the treatments with monomer and retention did not differ statistically, however, they differed statistically from the control, with a lower value.

As argued earlier, the components of microwave activated resin can promote a reduced amount of chemical interaction between the denture and tooth base, reducing the cross-linking and functional groups<sup>30</sup>, which however, did not seem to happen or did not cause any visible effect on the results of the impact strength between tooth and Onda-Cryl resin.

The results of this resin are also contradictory to those that show no improvement in bond, when the tooth base was conditioned with monomer or mechanically abraded before pressing<sup>17,31</sup>. Probably this was due to methodological differences between the studies. However, in the specific case of Onda-Cryl resin, we can speculate that there was more chemical interaction between the resin base and the tooth conditioned with monomer, when it appears that the values of impact strength for the monomer and the mechanical treatments (abrasion and retention) were similar, in contrast to the alleged effect of monomer reducing the fracture load on the tooth-resin bond<sup>32</sup>.

The influence of simulated microwave disinfection on the impact strength of the tooth-Onda-Cryl resin bond is also shown in table 3. The treatment promoted values with statistical difference, with a lower value, between abrasion and monomer etching.

When the Onda-Cryl resin subjected to simulated disinfection was considered, it can be assumed that there was better chemical interaction between the resin and abraded tooth base, due to the fact that the bond strength obtained by the monomer is lower. In the specific case of simulated disinfection, this proves the alleged effect that monomer reduces the fracture load on the bond between tooth-resin<sup>32</sup>. The similarity among the other treatments shows the complexity of the effect of microwave irradiation, causing a tendency towards similar results in the different the tooth base treatments.

When the comparison was made between disinfection conditions, the previous speculation becomes more evident and difficult to explain on a scientific basis, when we consider that the decrease in the impact strength values after the microwave disinfection cycle occurred only in some of the treatments. When the specimens were submitted to simulated disinfection, the increase in water temperature as a result of irradiation may have acted as a post-polymerization trigger,

converting the residual monomer<sup>22</sup>. This increased the rigidity, reducing the cohesive strength of the resin, which may have influenced the bond strength. However, this was not evident in all treatments, in which the quality of the bond also depended on the base treatments, which may have affected the final result in a different way.

The failures of impact strength of the tooth-resin bond were predominantly mixed (adhesive and cohesive in the acrylic resin). This may mean that the cohesive strength of acrylic resin is lower than that of the tooth, considering this test. While the microwave disinfection reduced the strength of the tooth-resin bond, we can speculate that the resulting failure of the bond can only occur when the denture is in use, due to mechanical fatigue (repetitive chewing load). It is also possible for movement of the tooth to occur by accidental falling during cleaning, or by a laboratory technique that prevents satisfactory bonding between tooth and resin<sup>22</sup>.

Although the intention of this study was to evaluate the influence of microwave disinfection on the impact strength of the tooth-resin bond, the study is limited with regard to predicting the effect of other variables. Therefore further studies are needed, especially when considering that in patients with complete dentures, the full bite force is compressive and low-intensity.

## 5 Conclusion

Considering the limitations of this study and according to the results analyzed and discussed, the following conclusions can be considered:

1. The various treatments on the tooth base promoted different effects on the impact strength of the tooth-resin bond under both conditions of microwave disinfection.
2. Simulated microwave disinfection decreased the values of impact strength between tooth and Classico acrylic resin only when no treatments were performed in the tooth base.
3. Simulated microwave disinfection decreased the values of impact strength between tooth and Onda-Cryl acrylic resin in the monomer and retention treatments.

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