Evaluation of the Effect of Sterilization and Disinfection of Rotary Diamond Burs on their Cutting Efficiency: An in vitro Study

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ABSTRACT

Aim: This study aims to evaluate the effect of sterilization and disinfection of rotary diamond burs on their cutting efficiency.

Materials and methods: A total of 20 freshly extracted intact premolar teeth were subjected to tooth preparation using rotary diamond burs. Group I (n = 10) teeth were subjected to electroplated burs and group II (n = 10) teeth were subjected to welded diamond and vacuum diffusion technology (WDVDT) burs. They were further subdivided into two subgroups, groups I1 and I2, and II1 and II2 (n = 5 each), depending on different sterilization procedures. Each bur was then subjected to the stereomicroscopic examination, preusage and after the first usage, 5th and 10th subsequent usages. Each tooth was also measured for its weight using a digital weighing machine (pre- and post-preparation) to assess the cutting efficiency.

Results: On statistical comparison, the results of the study revealed that there is a definitive correlation between groups I and II specimens (p = 0.0002*, F = 17.7172). However, there was no statistical significance observed within the subgroups (p = 1.0000, F = 0.00001).

Conclusion: The conventional electroplated burs, when subjected to different sterilization procedures, resulted in greater structural alterations with a reduced cutting efficiency when compared with WDVDT burs.

Clinical significance: Diamond rotary burs should be sterilized and disinfected to prevent cross-contamination between the patient and dental personnel. However, different sterilization and disinfection methods can have undesirable effects on the ability of the burs to effectively reduce the tooth structure. Irrespective of the type of bur and sterilization process used, the cutting efficiency decreases.

Keywords: Autoclaved, Electroplated burs, Sterilization, Welded vacuum diffusion technology burs.

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INTRODUCTION

Diamond rotary burs in fixed prosthodontics have been used for overall tooth preparation, marginal finishing, enameoplasty, and finishing of the definitive restoration. They are a potential source for cross-contamination between the patient and dental personnel, as they may become heavily contaminated with necrotic tissues, saliva, blood, and pathogens during their usage. Due to the complex architecture of the rotary diamond burs, they are difficult to clean and sterilize.

The most common sterilization and disinfection methods for rotary cutting instruments are dry heat, autoclaving, microwave irradiation, and immersion in chemical solutions. Even though these procedures are important for a safe dental treatment, these may result in alterations in the surface and subsurface characteristics and the cutting efficiency of the burs.

The rotary cutting burs used in fixed prosthodontics are generally electroplated, composed of high-resistant metals, such as steel or stainless steel with small gaps or depressions in which the diamond particles are electroplated. On repeated sterilization, the metal matrix of the electroplated diamond burs is vulnerable to corrosion and changes in the molecules of the bonding agent that make it more frail to resist the spread of tension during function, leading to the crater formation by the loss of diamond particles, which reduces its cutting efficiency.

Moreover, the heterogeneity in the shape of the diamond granules makes the surface irregular, favoring the retention of dental debris, microorganisms, and materials which complicates the process of sterilization and disinfection of burs.

The newer technology burs (WDVDT) have a high concentration of 80% diamond grains, which are regularly arranged till the core of the instrument. In an electroplated bur, the diamond grain ratio to metal is 1:99, whereas in WDVDT, it is 80:20. Resistance to wear and shape distortion is 10 to 15 times more for WDVDT burs than electroplated, due to the high bond strength between diamond grains and improved cutting efficiency.

The use of rotary cutting burs with a reduced cutting efficiency may cause heat and vibration on the enamel...
and dentin and may result in pulp injuries and higher restoration leakage. Therefore, it is desirable to have minimal effects of different sterilization and disinfection methods on the ability of the burs to effectively cut the tooth structure. Thus, this study aimed to evaluate the effect of two different sterilization and disinfection procedures and their effect on the cutting efficacy of two different rotary diamond burs with their subsequent usage.

MATERIALS AND METHODS

In this study, 20 freshly extracted intact premolar teeth were included, which were free from any type of surface flaws (Fig. 1). Two types of rotary diamond burs were included in the study: Electroplated burs (Mani, Japan) and WDVDT burs (DAART, Russia). The resultant specimens were divided into two main groups, namely group I: teeth subjected to electroplated burs (n = 10) and group II: teeth subjected to WDVDT burs (n = 10). Both the rotary cutting burs were subjected to two different sterilization procedures: Autoclaving (Confident, India) and chemical sterilization (glutaraldehyde 2%, Cidex, Johnson and Johnson). The specimens were further subdivided into group I1: teeth subjected to electroplated burs that underwent autoclave sterilization (n = 5) and group I2: teeth subjected to electroplated burs that underwent glutaraldehyde sterilization (n = 5), group III: teeth subjected to WDVDT burs that underwent autoclave sterilization (n = 5), and group II2: teeth subjected to WDVDT burs that underwent glutaraldehyde sterilization (n = 5).

Sample Preparation

All the teeth were premeasured for their weight using a digital weighing machine (Adventurer™, India) (Fig. 2) and the resultant values were recorded. Each tooth was mounted on a plaster block (2.5 × 2.5 cm) up to 2 mm above the cementoenamel junction. The rotary diamond burs in each group were subjected to stereomicroscopic evaluation to evaluate the surface topography before they were subjected to tooth preparation. The specimens with the plaster block were mounted on a milling unit and a standardized crown preparation procedure was followed (Fig. 3). Each Torpedo diamond bur was used to prepare the tooth on their axial surfaces continuously for 1 minute. After each cut, the instrument was washed for 60 seconds in an ultrasonic cleaner and then sterilized by autoclaving or chemical sterilization: autoclaving disinfection 125°C and 0.7 kPa for 15 minutes and chemical sterilization by immersing in 10 mL of 2%
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glutaraldehyde for 10 hours at room temperature as per the manufacturer’s recommendations. The prepared teeth were measured for their weight and then tabulated. The rotary diamond burs from each group were subjected to stereomicroscopic evaluation (Luxeo4Z LABOMED, ×40) to evaluate the effect of sterilization procedures on their surface topography. The resultant values were subjectively scored as Score 0: absence of tip wear and loss of part of the diamond structure, Score 1: alteration in the shape of the tip structure, Score 2: loss of part of the diamond structure, Score 3: alteration in the shape and loss of part of the diamond structure, Score 4: alteration in the shape and loss of diamond structure, and Score 5: loss of diamond structure with complete exposure of metal.3,7 These procedures were repeated for all the groups and the resultant rotary diamond burs were then subjected to stereomicroscopic evaluation with their subsequent usage at 1st, 5th, and 10th intervals3 (Figs 4 to 6). The resultant data for the weighed specimens in each group and subgroup were statistically analyzed using a two-way analysis of variance (ANOVA) test and Tukey’s multiple post hoc procedures to draw the conclusions from the resultant data.

RESULTS

The specimens in groups I and II showed structural alterations after tooth preparation and subsequent sterilization and disinfection procedures. The cutting efficiency of the rotary diamond burs is shown in Tables 1 to 3 and Graph 1.

Descriptive statistical measures, such as mean and standard deviation (SD) values were computed for all the study groups. To collectively compare the means of the study groups, a two-way ANOVA test was used (p < 0.05), and a pairwise comparison of the test group was done using Tukey’s multiple post hoc procedures (p < 0.05).

The mean cutting efficiency values for group II2 (mean = 0.0564, SD = 0.0164) were significantly higher
than those for group III (mean = 0.0537, SD = 0.0122). Similarly, group II has significantly higher mean cutting efficiency values (mean = 0.0338, SD = 0.0166) than those of group II (mean = 0.0365, SD = 0.0142). The mean cutting efficiency of the specimens in group II was higher than in group I (Table 1 and Graph 1).

A two-way ANOVA for the significance (p<0.05) of two groups indicated that there was a significant difference in the mean cutting efficiency values between groups I and II (F = 17.7172, p<0.0002; Table 2). On pairwise comparison of two groups (I and II) by Tukey’s multiple post hoc procedures, statistically significant

![Figs 6A to D: (A and B) Electroplated bur sterilized by autoclaving, glutaraldehyde (Score 3). (C and D) WDVDT bur sterilized by autoclaving, glutaraldehyde (Score 3) after 10th interval](image)

**Table 1:** Mean and SD of cutting efficiency of rotary diamond burs (in g) in the two main groups (groups I and II) and two subgroups (1 and 2)

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean ± SD</th>
<th>SE</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I with subgroup 1 (electroplated autoclaved burs)</td>
<td>0.0365 ± 0.0142</td>
<td>0.1193</td>
<td>39.01</td>
</tr>
<tr>
<td>Group I with subgroup 2 (electroplated glutaraldehyde burs)</td>
<td>0.0338 ± 0.0166</td>
<td>0.1287</td>
<td>48.99</td>
</tr>
<tr>
<td>Group II with subgroup 1 (WDVDT burs)</td>
<td>0.0537 ± 0.0122</td>
<td>0.1104</td>
<td>22.71</td>
</tr>
<tr>
<td>Group II with subgroup 2 (WDVDT burs)</td>
<td>0.0564 ± 0.0164</td>
<td>0.1280</td>
<td>29.05</td>
</tr>
</tbody>
</table>

SE: Standard error; CV: Coefficient of variation

**Table 2:** Comparison of two main groups (groups I and II) and two subgroups (1 and 2) with respect to cutting efficiency of the rotary diamond burs (in g) by two-way ANOVA test

<table>
<thead>
<tr>
<th>Sources of variation</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean sum of squares</th>
<th>f-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main group</td>
<td>1</td>
<td>0.00396</td>
<td>0.00396</td>
<td>17.7172</td>
<td>0.0002*</td>
</tr>
<tr>
<td>Subgroups</td>
<td>1</td>
<td>0.00001</td>
<td>0.00001</td>
<td>0.0001</td>
<td>1.0000</td>
</tr>
<tr>
<td>2-way interactions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main group × subgroup</td>
<td>1</td>
<td>0.00007</td>
<td>0.00007</td>
<td>0.3262</td>
<td>0.5715</td>
</tr>
<tr>
<td>Error</td>
<td>36</td>
<td>0.00805</td>
<td>0.00022</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>39</td>
<td>0.01208</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

p<0.05: suggests the level of significance; f-value: suggests the mean variations between or within the samples; *p<0.0002: indicates that there is a statistical significance between groups I and II.

**Table 3:** Pairwise comparison of groups (groups I and II) and two subgroups (1 and 2) with respect to the cutting efficiency of the rotary diamond burs (in g) by Tukey’s multiple post hoc procedures

<table>
<thead>
<tr>
<th>Group with subgroups</th>
<th>Group I with subgroup 1</th>
<th>Group I with subgroup 2</th>
<th>Group II with subgroup 1</th>
<th>Group II with subgroup 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group I with subgroup 1</td>
<td>0.0365 ± 0.0142</td>
<td>0.0338 ± 0.0166</td>
<td>0.0537 ± 0.0122</td>
<td>0.0564 ± 0.0164</td>
</tr>
<tr>
<td>Group I with subgroup 2</td>
<td>p = 0.9775</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group II with subgroup 1</td>
<td>p = 0.0500*</td>
<td>p = 0.0256*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group II with subgroup 2</td>
<td>p = 0.0256*</td>
<td>p = 0.0092*</td>
<td>p = 0.9775</td>
<td></td>
</tr>
</tbody>
</table>

*Statistically significant
differences were found among both groups (p = 0.0002*, F = 17.7172), but no statistically significant differences were found within subgroups 1 and 2 (p = 1.0000, F = 0.00001; Table 3).

The results of this study revealed that the mean cutting efficiency values ranged from 48.99 to 22.71%, and there was a statistically significant difference (p < 0.05) between specimens in group I and II.

**DISCUSSION**

Rotary diamond instruments are often the source of cross-contamination in dental operatory because they are contaminated with blood, saliva, necrotic tissue, and pathogens; therefore, it is important to make sure that the sterilization is properly done which minimizes any associated risk of cross-contamination of patients with fatal microbes.3,6,11 The rotary diamond bur can be a mode of transmission of infectious diseases (e.g., hepatitis B, herpes virus, and human immunodeficiency virus) through blood, saliva, and soft tissue.12 The goal of instrument sterilization in dentistry is to protect patients from cross-contamination through instruments.11 The sterilization process probably affects the metal matrix, which acts as a bonding agent to keep the diamond grains together and corrodes the metal matrix, and brings about the changes in the molecules of the bonding agent, which leads to the crater formation on its surface by the loss of diamond grains, which prevents their further use.3,8,9 Similar findings were reported by Simamoto et al,8 Fais et al,2 and Boldieri et al7 that the conventional diamond-coated burs presented structural alterations after performing sterilization process, irrespective of the method of sterilization.

The advent of new materials, techniques, and overall knowledge has transformed the field of dentistry.3,12 Rotary diamond burs also underwent transformation from the conventional electroplated burs to the newer technology of welded diamond and vacuum diffusion burs. The WDT instruments are made with Patent technology, WDVDT, where diamond grains are welded together under very high temperature. In the WDT instrument, the diamond grain ratio to metal is 80:20, whereas in the electroplated one, it is 1:99.10 Taking these factors into consideration, this study was undertaken to assess the cutting efficiency of rotary diamond burs after their sterilization and disinfection. Freshly extracted intact teeth were subjected to tooth preparation using conventional electroplated and newer technology WDVDT rotary diamond burs. These burs were then sterilized and disinfected by either autoclaving or immersing in glutaraldehyde. Each tooth was measured for its weight loss pre- and postpreparation to assess the cutting efficiency. Each bur was also subjected to the stereomicroscopic examination, preuse and at first use, 5th and 10th subsequent usages. These methods were in accordance with the studies carried out by Bae et al1, Fais et al,2 Porto et al,3 Boldieri et al7 and Simamoto et al.8 It was observed that the conventional electroplated burs, when subjected to different sterilization procedures, resulted in greater structural alterations with a reduced cutting efficiency when compared with WDVDT burs.

Although the use of disposable instruments is recommended to minimize the possibility of cross-infection, their cutting efficiency appears to be lower than that of standard diamond rotary instruments. Even allowing for the required disinfection and sterilization procedures after each use, standard diamond rotary instruments would still be preferable.1

Conventional diamond-coated burs are manufactured by galvanic deposition of diamond powder onto metal rods.7 Due to the presence of diamond grains with sharp edges on the surface of diamond instruments, they are more susceptible for abrasion.3,8 The variation in the particle size permits more cutting capacity by forming an increased number of cutting edges. The sterilization process probably affects the metal matrix, which acts as a bonding agent to keep the diamond grains together and corrodes the metal matrix, and brings about the changes in the molecules of the bonding agent, which leads to the crater formation on its surface by the loss of diamond grains, which prevents their further use.3,8,9
of whether they were sterilized in autoclave (group I1) or glutaraldehyde (group I2), underwent changes in the shape and loss of part of the diamond structure more as compared with WDVDT burs (group II). This was in accordance with the study conducted by Boldieri et al,7 which stated that the conventional diamond-coated burs presented greater structural alterations after performing the tooth preparations and cleaning/sterilization procedures, irrespective of the process used.

The cutting efficiency of both the burs after sterilization and disinfection was also checked by the weight loss method. The cutting efficiency decreased rapidly after the repeated use of conventional electroplated burs at 1st, 5th, and 10th subsequent intervals as compared with WDVDT burs. This was in accordance with the study conducted by Borges et al,14 which showed that repeated sterilization of diamond instruments may decrease their cutting effectiveness due to the loss of diamond particles caused by the effects of sterilization on the matrix that binds the diamond particles to the shank.

Within the limitations of this study, the results revealed that there was a statistically significant difference in the cutting efficiency between the electroplated burs and WDVDT burs, whereas there was no statistically significant difference in the cutting efficiency between the burs sterilized by either autoclave or glutaraldehyde.

Newer technology burs, i.e., WDVDT burs, have a high concentration of diamond grains, which are regularly arranged till the core of the instrument. These rotary cutting diamond burs (WDVDT) have a high concentration of 80% diamond grains, and their resistance to wear is 10 to 15 times more than electroplated ones, with an improved cutting efficiency.10 This resistance to wear and shape distortion is due to the high bond strength between the diamond grains as compared with conventional electroplated burs where the diamonds are easily dislodged, negatively influencing their cutting effectiveness.7,10 With the above properties inherent in WDVDT burs, it helps in the reduction in overall cost and in increased cutting efficiency.10

**CONCLUSION**

- The conventional electroplated diamond burs presented greater structural alterations after tooth preparation and sterilization and disinfection procedures, irrespective of the process used as compared with WDVDT burs.
- The cutting efficiency decreased rapidly after repeated uses of conventional electroplated burs as compared with WDVDT burs.

**REFERENCES**