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ORIGINAL ARTICLE

Influence of sterilization process on cutting effectiveness and durability of ultrasonic tips

Influência do processo de esterilização na efetividade de corte e durabilidade das pontas ultra-sônicas

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ABSTRACT

Objectives: The aim was to evaluate influence of different sterilization methods on cutting effectiveness and durability of cylindrical ultrasonic burs compared with conventional cylindrical diamond-coated burs. **Material and Methods:** Fifteen conventional cylindrical diamond-coated (1092) (KG Sorensen) coupled to a high-speed turbine, and fifteen cylindrical ultrasonic (8.2137) (CVDentus®) burs coupled to an ultrasound-handpiece were used to perform standardized cavity preparations in healthy bovine tooth fragments, cleaned with rubber cup, pumice stone and water. After every 10 preparations, burs were sterilized 9 times in autoclave (SA), oven (SO), or cleaned with brush, soap and water (C). Fragments were weighed and microphotographs of burs were taken at the beginning and end of experiment. Another 9 conventional diamond-coated and 9 CVD burs underwent the same sterilization cycles in autoclave (SAC), oven (SOC) or washed with soap and water (CC) however, without being used for making cavity preparations, serving as control. Descriptive analyses were made of the values found by weighing and microphotography scores. **Results:** Statistically significant differences (Paired Student's-t test) were observed among burs after sterilization (p = 0.0001). SO and SA did not influence cutting effectiveness and durability of ultrasonic and conventional diamond-coated burs. The microphotographs showed morphological differences between the burs used for preparation and the control. **Conclusion:** Sterilization by oven and autoclave did not influence cutting effectiveness and

RESUMO

Objetivo: O objetivo foi avaliar a influência de diferentes métodos de esterilização na efetividade de corte e durabilidade de pontas ultra-sônicas cilíndricas comparadas com pontas diamantadas cilíndricas convencionais. **Material e Métodos:** Quinze pontas diamantadas cilindricas (1092) (KG Sorensen) acopladas a um motor de de alta rotação, e quinze pontas ultrassonicas cilíndricas (8,2137) (CVDentus®) acopladas a um ultra-som foram utilizadas para realizar preparos cavitários padronizados em fragmentos de dentes bovinos higidos, limpos com taça de borracha, pedra-pomes e água. Após cada um dos 10 preparos, as pontas foram 9 vezes esterilizadas em autoclave (SA), estufa (SO), ou limpas com escova, sabão e água (C). Os fragmentos foram pesados e microfotografias das pontas foram tomadas no início e no final do experimento. Outras 9 pontas de diamante CVD e 9 convencionais foram submetidos aos mesmos ciclos de esterilização em autoclave (SAC), forno (SOC) ou lavado com água e sabão (CC) no entanto, sem serem usadas para fazer preparos cavitários, servindo como controle. Realizou-se análise descritiva dos valores encontrados na pesagem e dos scores das microfotografias. **Resultados:** Diferenças estatisticamente significativas (teste t de Student pareado) foram observadas entre as pontas após a esterilização (p = 0,0001). SO e SA não influenciaram na efetividade de corte e durabilidade das pontas diamantadas ultra-sônicas e convencionais. As microfotografias mostraram diferenças morfológicas entre as pontas utilizadas para os preparos e o controle. **Conclusão:** As esterilizaçoes por autoclave e estufa não influenciaram a efetividade de corte e durabilidade das pontas diamantadas

durability of CVD and conventional diamond-coated burs. Conventional diamond-coated burs presented greater structural alterations after performing cavity preparations and cleaning/sterilization procedures, irrespective of the process used.

KEYWORDS

CVdentus; Sterilization; Dental instruments; Infection control.

convencionais. Pontas diamantadas convencionais apresentaram maiores alterações estruturais após a realização de preparos cavitários e procedimentos de limpeza / esterilização, independentemente do processo utilizado.

PALAVRAS-CHAVE

CVdentus; Esterilização; Instrumentos dentários; Controle de infecção.

INTRODUCTION

During cavity preparation, diamond-coated burs are frequently exposed to saliva, blood and oral cavity tissues. In order to prevent the occurrence of cross contamination between patients and professionals, correct washing, disinfection and sterilization of materials must be performed [1-7]. Therefore, the specific substances and methods used during these procedures may interfere in the durability and effectiveness of the burs [8-12].

Conventional diamond-coated burs are manufactured by galvanic deposition of diamond powder onto metal rods, however, there are some limitations inherent to this technology, because the diamonds are easily dislodged, negatively influencing their cutting effectiveness. Moreover, the heterogeneity in the shape of the diamond granules makes the surface irregular, favoring the retention of dental debris, microorganisms and materials, and making the burs more difficult to sterilize and less durable [13-15].

In the mid-1990s, the National Institute for Space Research (INPE) developed an artificial diamond, produced by the process of chemical steam deposition adhered to angulated molybdenum rods, living rise to the CVDentus burs, which are used coupled to an ultrasound handpiece [16-20].

CVDentus burs have been used for different purposes, primarily for minimally invasive cavity preparation, as they have the characteristic of very conservative tissue removal [21-25]. They are also helpful when used in endodontic treatments [26], and for the removal of excess material from gingival margins without harming the periodontal tissue [27]. In addition, these burs present surface uniformity and completely coalescent edges, which provide a better finishing quality and greater facility in cavity cleaning, when compared with conventional diamond-coated burs [19].

The different characteristics of methods used for sterilization define their use: sterilization in an oven requires the material to remain at 170 ºC for 1 h or at 160 ºC for 2 h. The dry heat produced by the oven promotes sterilization by bacterial dehydration. The time spent to complete this cycle and the number of variables that interfere in it contributed to limiting its use [28].

Autoclaving promotes sterilization by the action of steam from water superheated to 121 ºC or 134 ºC and maintained under pressure of 1 or 2 atm, with a dwell time of between 30 and 15 min, respectively. With the increase in heat and humidity, bacteria are denatured, and it is therefore considered more practical and effective than the oven [11,29,30].

The morphological characteristics of diamond-coated and ultrasonic burs, such as surface shape, may make the cleaning and sterilization process difficult or easy, and it is suggested that the behavior or ultrasonic burs under the action of these different sterilization

methods may also differ. Therefore, the aim of the present study was to evaluate the influence of different sterilization methods on the cutting effectiveness and durability of cylindrical ultrasonic burs in comparison with conventional cylindrical diamond-coated burs.

MATERIAL AND METHODS

In this study, 15 conventional cylindrical diamond-coated burs (1092) (KG Sorensen, Alphaville-SP, Brazil) coupled to a high-speed turbine, and 15 cylindrical ultrasonic burs (8.2137) (CVDentus® Clorovale Diamantes, São José dos Campos-SP, Brazil) coupled to an ultrasound handpiece were used. These 30 burs were divided into 6 groups, composed of five burs of each type, which were used to perform cavity preparations. Three hundred healthy bovine anterior teeth, with the absence of cracks and structural defects were selected. The teeth were cleaned with a rubber cup, pumice stone and water. The mesial and distal portions of the roots were removed, by using a diamond-coated disc in a precision cutting machine ISOMET™ 1000 (Buehler®, Lake Bluff, II, USA), and the specimens were embedded in PVC tubes (1 cm high by 2 cm in diameter) with condensation silicone (Zetalabor® - Zhermack, Italy).

These test specimens were fitted to a standardizing machine [21] that allowed each preparation in the enamel surface to be performed in120 s, with a run distance of 3.5 mm, speed 5.3 mm/s and pressure of 0.12 N.

After each preparation the burs were submitted to cleaning with a brush, soap and water (C), sterilization in an autoclave (SA) at 134 ºC for 4 min or sterilized in an oven (SO) at 170 ºC for 1 h, as recommended by the Brazilian Ministry of Health.

The cavity preparation and cleaning or sterilization sequence was repeated until each tip had completed 1200 s of use in ten test specimens and nine cleaning or sterilization cycles (Table 1).

To evaluate the cutting effectiveness of each tip, specimens were weighed before and after the preparations, using a precision scale Sartorius BL 210S.

To evaluate the effect of sterilization on this effectiveness, the differences in weights obtained before and after the cavity preparation and cleaning or sterilization cycles were calculated. This difference in weight among the blocks of test specimens showed the quantity of tissue removed.

In addition, the burs were observed under a stereoscopic microscope and digital images were obtained by using the Leika Qwin (100x

Table 1 - Tip specifications, quantity of tooth specimens used, time of performing cavity preparations and number of cleaning/ sterilization cycles

	Conventional diamond-coated tip (n)	CVDentus tip (n)	Number of test specimens used	Total preparation time	Cleaning/Sterilization cycles
SA	5	5	100	1200”	9
SO	5	5	100	1200”	9
C	5	5	100	1200”	9
SAC	5	5	0	0	9
SOC	5	5	0	0	9
CC	5	5	0	0	9

SA: Sterilization in autoclave
SAC: Sterilization in autoclave without cavity preparation
SO: Sterilization in oven
SOC: Sterilization in oven without cavity preparation
C: Cleaning with brush, water and soap
CC : Cleaning with brush, water and soap without cavity preparation

magnification) program, before beginning the preparations and after the ninth cleaning or sterilization cycles. These digital images were analyzed and classified in accordance with the adapted scores:

• Score 0: absence of tip wear and loss of part of the diamond structure

• Score 1: alteration in shape of the tip structure

• Score 2: Loss of part of the diamond structure

• Score 3: Alteration in shape and loss of part of the diamond structure

• Score 4: Alteration in shape and loss of diamond structure

• Score 5: loss of diamond structure with complete exposure of metal

As control of durability, another nine ultrasonic burs and nine conventional diamond-coated burs were brushed with soap and water (CC), sterilized in an autoclave (SAC) or oven (SOC). These burs were not used for cavity preparations, and were analyzed by means of microphotographs, with the purpose of comparing them with the burs used to perform cavity preparations.

For comparison among the different groups, the paired t-test was used. The durability data were descriptively analyzed.

RESULTS

The burs used in Groups (CC), (SAC) and (SOC) showed no difference whatever in shape and structure.

The weight loss of the specimens after cavity preparations is shown in Table 2.

The values found showed normal distribution. Statistically significant differences ($p < 0.05$) were observed when the conventional burs were compared with the ultrasonic burs after the three methods of sterilization ($p = 0.0001$). In addition, sterilization in the oven also significantly influenced ($p = 0.0003$) the cutting effectiveness of the conventional diamond-coated burs when compared with the control group and the method of sterilization in autoclave.

The results of the stereoscopic microscopy analysis of the burs are presented in Table 3 and illustrated in Figure 1.

Table 2 - Mean of difference in weight (grams) of test specimens before and after cavity preparations

Burs	CVDentus® (CVD)			Conventional Diamond-coated (DC)		
Groups	SA	SO	C	SA	SO	C
Means	0.0151	0.0123	0.0140	0.0537	0.0376	0.0521

SA: Sterilization in Autoclave
SO: Sterilization in oven
C: Cleaning

Table 3 - Descriptive analysis of digital images of ultrasonic burs (CVD) and conventional diamond-coated burs (DC) before (b) and after (a) cavity preparations

	Sterilization in autoclave (SA)				Sterilization in oven (SO)				Cleaning with brush Scores (C)			
Scores	CVDb	CVDa	DCb	DCa	CVDb	CVDa	DCb	DCa	CVDb	CVDa	DCb	DCa
0	5	2	5		5	2	5		5	2	5	
1		2				3		5		3		
2												
3		1		5								4
4												
5												1
Total	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**

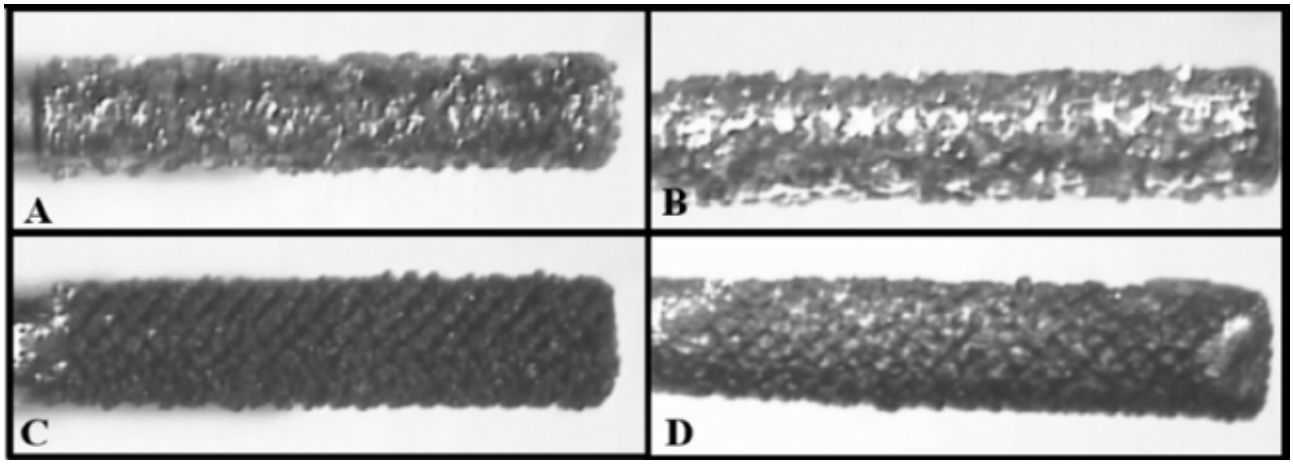

Figure 1 - Morphological change observed in analysis under stereoscopic microscope; A: DC tip before preparation and sterilization cycles. B: DC tip after preparation and sterilization cycles in autoclave - Score 3: Alteration in shape and loss of part of the diamond structure. C: CVD tip before preparation and sterilization cycles. B: CVD tip after preparation and sterilization cycles in autoclave - Score 3: Alteration in shape and loss of part of the diamond structure.

DISCUSSION

The conventional diamond-coated burs have rods composed of a resistant metal, such as steel or stainless steel with small gaps or depressions in which the diamond grit is lodged. The size and shape of these gaps determine the size and shape of the burs, and the natural or synthetic diamond grit may be bonded to the gaps in the metal in diverse ways, among them the methods of electrolytic co-deposition, welding, agglomeration or the use of adhesives, and these chips may become dislodged with use [31].

The ultrasonic burs of the CVDentus system have a low coefficient of friction and controlled granulometry, making them biologically compatible, as they do not leave metal residues in the teeth and do not aggregate dentinal residues [32]. They provide a hybrid layer similar to that of the conventional diamond-coated and carbide burs [33]. Furthermore, because they are composed of a single diamond stone, with thousands of microscopic edges, suggesting a more lasting durability than the conventional burs.

The mechanism of sterilization in autoclave has been suggested to interfere in the durability and cutting effectiveness of instruments used in the dental office, due to corrosion. The results of descriptive analysis of the digital images (Table 3) showed that all the conventional diamond-coated burs sterilized in autoclave underwent changes in shape and loss of part of the diamond structure (Score 3). Authors such as Siegel et al. [14] and Savage et al. [30], justified the possible corrosion caused as being due to the humid head, Nevertheless, our results showed that the test specimens prepared with the conventional diamond-coated burs, sterilized in autoclave (SA) (Table 2), presented a higher mean weight loss value, suggesting greater cutting effectiveness when compared with the burs sterilized in the oven. It may be suggested that this corrosion caused by the humid head was responsible for the loss of diamond grains from the conventional diamond-coated burs.

Furthermore, it has been suggested that sterilization by dry heat did not diminish the cutting capacity of the rotary instruments, when compared with any other type of sterilization. According to Miller et al. [11] and Cooley et al. [34] the dry environment that promoted bacterial dehydration, indirectly maintained the integrity of the stainless steel instruments, preventing oxidation and corrosion and could even have improved some of the properties, such as fracture strength in different types of burs. In our study, the specimens that were prepared with conventional diamond-coated burs and

sterilized in the oven had a lower weight loss after the preparations than the burs in the other groups (Table 2). However, in the analysis of the photomicrographs, the burs presented only change in shape, without loss of diamonds (Table 3 - Score 1).

Other rotary instruments have also been studied with regard to the influence of sterilization, Fais et al. [10] evaluated the influence of different types of sterilization on the cutting effectiveness of carbide burs and verified that the oven was the method that least affected the cutting capacity of these burs. Whereas, in 2011, Spranley et al. [35], in a similar study concluded that up to 10 cycles of autoclaving did not significantly affect the cutting efficacy in cavity preparation.

We may therefore suggest that performing the cavity preparations contributed to the wear in the majority of the conventional diamond-coated burs, which presented changes in shape and loss of part of the diamond structure, as shown in the microphotographs (Table 3). These findings are in agreement with Siegel and Fraunhofter [14], who suggested the low durability of the burs was due to the type of adhesion of the diamond grit to the metal rod. These alterations were not observed to a great extent in the microphotographs of the ultrasonic burs used for performing cavity preparations, and submitted to the sterilization processes in our study (Table 3) in agreement with the findings of Predebon et al. [17].

The ultrasonic burs provided lower mean weight loss values when compared with the conventional diamond-coated burs, suggesting lower cutting effectiveness, i.e. less wear of dental structure, irrespective of the sterilization/cleaning process used. Vanderlei et al. [36], in their study, reported that the CVDentus burs needed 4 times more time to perform the same preparation as needed when using the conventional diamond-coated tip, also demonstrating its lower cutting capacity.

Predebon et al. [17] observed that the cavity preparations performed with the ultrasonic burs were more conservative than those performed with the conventional diamond-coated burs. Lima et al. [19] also observed that the inner walls of the cavity presented a negative surface shape of the ultrasonic burs used, confirming the above-mentioned affirmative.

Analysis of the microphotographs of the groups in which the burs were only submitted to sterilization/cleaning (SAC, SOC, CC), presented no alteration in structure, differing from those that were used for cavity preparations and sterilized/washed (SA, SO, C). This fact confirms the hypothesis that performing the cavity preparations was responsible for the wear or loss of structure of the burs. Therefore, we suggest that the methods of sterilization alone did not interfere in the durability of the burs.

CONCLUSION

Sterilization by oven and autoclave did not influence the cutting effectiveness and durability of CVD and conventional diamond-coated burs.

The conventional diamond-coated burs presented greater structural alterations after performing the cavity preparations and cleaning/sterilization procedures, irrespective of the process used.

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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