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EVIDENCE BRIEF

Effect of Cleaning and Sterilization Processes on the Cutting Efficiency of Dental Burs

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Key Messages

- Among the eight experimental studies that were reviewed, six studies reported a significant decrease in the cutting efficiency of dental burs after repeated cleaning and sterilization processes, while two studies reported no influence of sterilization processes on the cutting efficiency of dental burs.
- Surface topography of burs was assessed in a few studies using scanning electron microscopy (SEM), stereomicroscopy evaluation or x-ray photoelectron spectroscopy, to evaluate alterations in the surface and subsurface characteristics of burs following cleaning and sterilization processes.
- A study observed that conventional electroplated diamond burs underwent greater structural alterations with a reduced cutting efficiency after sterilization, in comparison to Welded Diamond and Vacuum Diffusion Technology (WDVDT) burs.
- Findings from a study concluded that sterilization by dry heat was the method that least affected the cutting capacity of carbide burs, followed by sterilization using autoclave.

Issue and Research Question

Infection Prevention and Control (IPAC) measures, including proper reprocessing of dental instruments, are crucial to prevent or minimize the risk of cross-contamination in dental settings. Dental burs are critical cutting instruments used with a dental hand piece or dental drill for clinical procedures like cavity preparation (preparing cavities for fillings), polishing, root canal treatment, extractions, implant placement and crown and bridge preparation (shaping the tooth to receive dental prosthesis), among many others. The required level of reprocessing to ensure the sterility of dental burs before clinical use is, cleaning followed by sterilization.[1] There are several methods that can be used to attain sterility of dental burs and the commonly used acceptable methods include, automated cleaning (using washer-disinfector or ultrasonic cleaners) followed by sterilization using autoclave (steam sterilization) or hot air oven (dry heat). However, many studies have reported that repeated cleaning and sterilization of dental burs may affect the functionality of the burs.[2, 3] The most significantly reported effect of cleaning and sterilization processes on dental burs is on their cutting efficiency. Cutting efficiency of a dental bur is defined as the quantity of substrate (tooth structure or dental material) that can be removed by the bur within a specified time.[3,4] A longer cutting time indicates lower cutting efficiency.[3] The cutting effectiveness of dental burs is essential to perform dental procedures efficiently and to prevent thermal damage or irritation to dental tissues, particularly the pulp tissue.[2] In addition to cleaning and sterilization processes, other factors that are reported to influence the cutting efficiency of burs include: repeated use of the burs (service life), hand piece load, grit size of the bur, coolant flow, tooth structure or the nature of the dental material being removed, and the design or type of bur.[3–5]

A synthesis of the effect of various cleaning and sterilization processes on the cutting efficiency of dental burs is currently unavailable. Hence, this evidence brief reviews the available scientific literature to assess the effect of various cleaning and sterilization processes on the cutting efficiency of dental burs.

Methods

Public Health Ontario (PHO) Library Services conducted a literature search for English- language articles published between 2000 – June 23rd, 2023. The search involved three databases: MEDLINE, Embase, and Scopus. The following search terms were included, but were not limited to: dental burs, cutting effectiveness, sterilization, and decontamination. The full search strategy is available upon request from PHO.

Articles were eligible for inclusion if they were experimental in design and assessed the effect of various cleaning and/or sterilization methods on the cutting efficiency of dental burs. Articles published earlier than 2000 were excluded due to outdated medical reprocessing methods and recent advancements in dental bur design.

Two reviewers independently screened title and abstracts of the scientific literature. Consensus was achieved through discussion. Full text articles were retrieved, and reviewed by one reviewer, followed by extraction of relevant information from each article.

One reviewer conducted quality appraisal. The Checklist for Reporting In-vitro Studies (CRIS) was used to appraise quality of the experimental in-vitro studies. Quality appraisal results are available upon request.

Main Findings

The database search identified 89 articles, of which eight articles met inclusion criteria.[2-9] Given that the recommended method of reprocessing dental burs is automated cleaning (using washer-disinfectors or ultrasonic cleaners) followed by steam sterilization, we included all articles that assessed the effect of various cleaning and sterilization methods on the cutting efficiency of dental burs.[1]

Of the eight included studies, six reported significant reduction in the cutting efficiency of burs after cleaning and sterilization processes,[2,4,5-8] while two studies reported no significant influence of sterilization methods on the cutting efficiency of burs.[3,9] The included studies are from Korea,[3] China,[5] India,[7] Malaysia,[2] Brazil,[4,6,8] and USA.[9] No studies were reported from Canada. Diamond or carbide dental burs were used for the experimental studies, with one study including both carbide and diamond burs.[6] The cleaning methods used in most of the included studies were either ultrasonic cleaning,[3,6,7] or cleaning under running water,[2,8] and the sterilization methods used in the experimental studies included steam sterilization using autoclave,[2–9] dry heat,[2,8] 2% glutaraldehyde,[7,8] microwave irradiation,[8] cold sterilization using 5% chlorhexidine gluconate solution,[3] or gas sterilization in an ethylene oxide gas sterilizer.[3] None of the studies used washer-disinfector, which is the most effective and recommended method for cleaning dental burs.[10]

The methods that are commonly used to assess the cutting efficiency of burs are discussed first, followed by a section on the observed changes in the cutting efficiency of burs after cleaning and sterilization processes. Under the observed changes in cutting efficiency, findings are organized based on the reported outcomes – reduction in the cutting efficiency of burs or no change in the cutting efficiency of burs, as a result of cleaning and sterilization processes.

Assessing cutting efficiency

In most studies, the cutting efficiency of dental burs was primarily assessed using the "weight-loss method" in which, the burs were made to cut a specific substrate and the difference between the weight of the substrate before and after cutting represented the lost weight. The cutting efficiency was calculated by dividing the lost weight of the substrate by the time taken by the bur to make the cut. The studies had either a pre-determined amount of substrate to be cut or a specified duration to make a cut. The cutting substrates that were used in the studies to assess the cutting efficiency of burs were ceramic blocks, composite resin, or natural teeth. Apart from assessing the cutting efficiency of burs using the weight-loss method, the actual structure of the dental burs was also observed for changes, in most studies. Alterations in the surface topography of burs following cleaning and sterilization processes were studied using scanning electron microscopy (SEM), stereomicroscopy evaluation or x-ray photoelectron spectroscopy. Since diamond burs are constructed of a stainless-steel body bonded with diamond grains, alterations in its surface and subsurface characteristics following cleaning and sterilization were evaluated based on changes in the shape of the tip structure and the amount of loss of diamond particles, both of which correlates to a reduced cutting efficiency of the burs.

Change in Cutting Efficiency

Six experimental studies reported a significant decrease in cutting efficiency of dental burs after repeated cleaning and sterilization processes while two experimental studies reported no influence of sterilization processes on the cutting efficiency of burs.

Reduced Cutting Efficiency

Among the six experimental studies that reported a significant decrease in the cutting efficiency, three studies evaluated the effect of various sterilization methods on the cutting efficiency of burs in comparison to non-sterilization,[2,4,8] one study observed structural damage on burs following repeated reprocessing,[6] and two studies assessed the effect of sterilization processes on the cutting efficiency of burs based on different fabrication methods of the burs.[5,7]

Fais et al. (2009) conducted a study to compare the cutting capacity of carbide burs after sterilization by dry heat (group 1; 170°C for 1 h), autoclave (group 2; Pressure of 1.5 kgf/cm^2 at 127°C for 15 min), microwave irradiation (group 3), glutaraldehyde (group 4; immersion in 10 mL of glutaraldehyde for 10 h) or no sterilization (group 5 - control).[8] The burs were used to cut glass ceramic for twelve 2.5 minute cycles, at a constant speed (350,000 rpm), air pressure (2.2 bar) and water cooling (25 mL/min). After each cutting cycle, the burs were cleaned under running water (for 40 seconds), dried and then sterilized according to their respective experimental group. The mean of the amount of cutting performed by each group after the twelve cycles were: Group 1 = 0.2167 ± 0.0627 g; Group 2 = 0.2077 ± 0.0231 g; Group 3 = 0.1980 ± 0.0326 g; Group 4 = 0.1203 ± 0.0459 g; Group 5 = 0.2642 ± 0.0359 g. The study found that the burs that were autoclaved, microwave irradiated and treated with chemical solution (glutaraldehyde) showed a statistically significant decrease ($p<0.05$) in their cutting capacity, while the burs that were treated with dry heat did not differ significantly ($p > 0.05$) from the non-sterilized control burs. The findings concluded that sterilization by dry heat was the method that least affected the cutting capacity of the carbide burs, followed by sterilization using autoclave. Burs sterilized by chemical solution showed the lowest cutting capacity.[8] Gonzaga et al. (2019) measured changes in the cutting efficiency of diamond burs after five sterilization cycles using autoclave (at 126–129°C 1.7 to 1.8 kgf/cm^2 for 15 min). Cutting efficiency was evaluated based on the time needed by the burs to cut 7.5 mm of resin composite (substrate) and an increased cutting time indicated decreased cutting efficiency. The study found that new non-autoclaved burs had a significantly shorter cutting time (33.38s) when compared with the ones after sterilization using autoclave (39.55s).[4] The study concluded that all diamond burs demonstrated lower cutting efficiency after repeated autoclaving.[4] Suhaimi et al. (2018) assessed the effect of two

different sterilization methods on the cutting efficiency of diamond burs in comparison to a non-sterilization group.[2] The burs were divided into three groups based on the sterilization method: Group A - dry heat (134°C for 15 minutes at 20,400 kPa), Group B - steam under pressure (134°C for 30 minutes with a pressure of 318 kPa), and Group C - control (non-sterilization group). Each bur was used to cut natural teeth for 45 seconds for ten cycles and between the cutting cycles, the burs were cleaned under running water for 40 seconds and sterilised individually according to their sterilization groups. The cutting rate of the burs were determined using the weight loss method and the observed percentage difference in the weight of the samples between the first cut to the final cut were 64.8%, 62.8%, and 50.2% for Group A, B, and C, respectively. The study found significant mean difference ($p = 0.002$) in the cutting efficiency between the non-sterilized burs (Group C) and the sterilised burs, using dry heat (Group A) and steam sterilization (Group B). However, no significant difference ($p>0.05$) in the cutting efficiency was observed between the burs in Group A and B. The study concluded that there is a significant difference in the cutting efficiency between the non-sterilised and sterilised burs, however, there is no significant difference between dry heat and steam sterilization, toward the cutting efficiency of diamond burs.[2] Uchoa et al. (2023) observed structural damage on carbide and diamond dental burs from the first to the fifth cycle of clinical use and reprocessing (pre-rinsing, manual cleaning, ultrasonic cleaning, rinsing, drying, and steam sterilization), through scanning electron microscopy (SEM) analysis.[6] The study did not evaluate clinical efficiency of the burs, however, considering the structural damage, it was inferred that clinical effectiveness will be negatively affected.[6]

Two experimental studies assessed the effect of sterilization methods on the cutting efficiency of burs, based on different fabrication methods of the burs. Nayakar et al. (2018) evaluated the effect of sterilization on the cutting efficiency of two different types of diamond burs – electroplated diamond burs and welded diamond and vacuum diffusion technology (WDVDT) burs.[7] Samples from both types of burs were subjected to two different sterilization procedures - autoclaving (125°C and 0.7 kPa for 15 minutes) and chemical sterilization (2% glutaraldehyde for 10 hours). The burs were used to cut natural teeth for one minute and after each cut, the instrument was washed for 60 seconds in an ultrasonic cleaner followed by sterilization using autoclave or 2% glutaraldehyde, depending on their respective group. The burs were subjected to stereomicroscopic evaluation to evaluate the surface topography, before they were used for cutting and subsequently at the 1^{st}, 5^{th}, and 10^{th} usages. The cutting efficiency of conventional electroplated burs decreased rapidly after repeated use and sterilization (using autoclave or 2% glutaraldehyde) at 1^{st}, $5^{th,}$ and 10^{th} subsequent intervals, as compared to WDVDT burs. Under stereomicroscopic evaluation, both the types of burs showed alteration in the shape of the tip structure, after the 1^{st} interval. However, at the 5^{th} interval, electroplated burs showed both alteration in the shape of the tip as well as loss of part of the diamond structure, while WDVDT burs did not. At the 10^{th} interval, both electroplated and WDVDT burs showed alteration in the shape of the tip and loss of part of the diamond structure. The study found a significant difference in mean cutting efficiency values between the two types of burs ($p < 0.0002$), but no statistically significant differences were found between the type of sterilization procedures ($p = 1.0000$). The study concluded that all the conventional electroplated diamond burs underwent greater structural alterations with a reduced cutting efficiency after sterilization using autoclave or glutaraldehyde, in comparison to WDVDT burs.[7] Yu et al. (2021) evaluated the influence of repetitive autoclaving (0, 5, 10 or 15 cycles) on diamond burs fabricated via different methods (single-element electroplating, multi-element electroplating, or brazing).[5] Compared to the non-autoclaved group, the cutting efficiency of the multi-element and single-element electroplated diamond burs decreased significantly after autoclaving 5, 10, and 15 times ($P < 0.05$). The cutting efficiency of the single-element electroplated diamond burs decreased significantly after autoclaving five times but was not reduced further after 10 or 15 times. In contrast, cutting efficiency of the multi-element diamond burs was decreased significantly after autoclaving five times, and the decreasing trend continued after 10 and 15 times. The cutting efficiency of the brazed diamond burs started to decrease significantly after 10 cycles ($P < 0.05$). The study concluded that autoclaving can significantly decrease the cutting efficiency of all three types of diamond burs, and the extent of the

influence was related to the fabrication method. Brazed diamond burs showed a greater resistance to autoclaving than the electroplated diamond burs. Five autoclaving cycles could significantly decrease the cutting efficiency of single-element and multi-element electroplated diamond burs ($P < 0.05$) and ten autoclaving cycles could significantly decrease the cutting efficiency of brazed diamond burs ($P < 0.05$).[5]

No change in the cutting efficiency

Two experimental studies reported no significant influence of sterilization methods on the cutting efficiency of dental burs. Bae et al. (2014) conducted a study to identify differences in the cutting efficiency of diamond dental burs with repeated cuts and sterilization.[3] At first, the study measured changes in the cutting efficiency of diamond burs with repeated cuts on a ceramic block. Each test bur made ten repeated cuts for one minute each and measurement of the cutting efficiency was recorded after each cut, using the weight-loss method. Following the first study, changes in the cutting efficiency was measured with ten cycles of repeated cuts and sterilization (using autoclave, cold sterilization, or gas sterilization), to study the influence of decontamination methods on the cutting efficiency of the burs. The burs were divided into three groups based on the sterilization method, and each cut on the ceramic block was followed by ultrasonic cleaning for 60 seconds and then sterilization based on their respective groups - autoclave (125^0C and 0.7 kPa for 15 minutes), immersion in a cold sterilizing solution (20 minutes in a 5% chlorhexidine gluconate solution) or gas sterilization (160^0C for 4 hours in an ethylene oxide gas sterilizer). The study found that the cutting efficiency of diamond burs decreased as the number of cuts increased and this decrease was particularly large after the first cut. However, neither the cutting efficiency nor the total cut amount varied with the three decontamination methods. The study concluded that repeated disinfection by autoclaving, immersion in chlorhexidine gluconate, or ethylene oxide gas had no significant influence on the decreasing trend of the cutting efficiency of the diamond burs.[3] Spranley et al. (2009) examined the cutting efficiency of carbide burs after multiple autoclaving cycles, by judging their initial sharpness and their ability to maintain sharpness throughout a cavity preparation.[9] The burs were randomly divided into five groups (those not autoclaved at all and those that had been autoclaved one, two, five or ten times) and qualitative evaluation of the cutting efficiency of burs from each group was conducted by experienced clinicians. The study showed no statistical difference in terms of the visual appearance of a unautoclaved bur and one that had been autoclaved ten times ($p=1.000$). The study concluded that up to ten autoclaving cycles did not significantly affect perception of either initial sharpness or cutting effectiveness of the burs.[9]

Discussion and Conclusions

The included studies used a range of experimental methods to evaluate the effect of cleaning and sterilization processes on the cutting efficiency of dental burs. The methods used to evaluate the cutting efficiency of burs varied across studies, with the most used method being the weight-loss method. Other methods included scanning electron microscopy analysis, stereomicroscopic evaluation, x-ray photoelectron spectroscopy or subjective evaluation by experienced clinicians. The inconsistences and variability across studies in terms of the evaluation of cutting efficiency, bur type, substrate used, cleaning and sterilization processes, make comparability across the studies difficult. Only a few studies indicated a constant hand piece load and coolant flow, which are also factors that are reported to influence the cutting efficiency of burs, in addition to cleaning and sterilization methods. Most of the experimental studies evaluated the effect of repeated cuts and sterilization on the cutting efficiency of burs, rather than the effect of repeated sterilization alone. Since repeated cutting has been proven to reduce the cutting efficiency of dental burs, it is difficult to infer the effect of sterilization alone on the cutting efficiency of the burs. Among the eight included experimental studies, six studies reported a significant decrease in the cutting efficiency of dental burs after repeated cleaning and sterilization processes, while two studies reported no influence of sterilization processes on the cutting efficiency of burs. Since the sterilization process varied across studies, there is not enough evidence to strongly

support any particular sterilization process that does not reduce the cutting efficiency of burs significantly. Two studies found no significant difference between the type of sterilization procedure, toward the cutting efficiency of the burs. One study reported that sterilization by dry heat was the method that least affected the cutting capacity of carbide burs, followed by sterilization using autoclave. However, with respect to diamond burs, no significant differences were reported between the effect of dry heat or autoclave on cutting efficiency. The number of cycles used to evaluate the cutting efficiency of the burs varied across studies from 1 to 15 cycles of repeated use and reprocessing. It is difficult to assess significant changes in the cutting efficiency of the burs, with respect to the cutting time, amount of substrate cut, and alteration in the surface topography of the burs, after each reprocessing cycle. It was observed in a study that electroplated diamond burs showed alteration in the shape of the tip and loss of part of the diamond structure after the 5^{th} cycle of reprocessing, correlating to a reduced cutting efficiency. One study concluded that five autoclaving cycles could significantly decrease the cutting efficiency of single-element and multi-element electroplated diamond burs and ten autoclaving cycles could significantly decrease the cutting efficiency of brazed diamond burs. Moreover, it is unclear how the cutting efficiency of burs will be affected following multiple reprocessing in a clinical environment where varying procedures are performed and factors like duration of cutting and cutting substrate have to be considered. According to Provincial Infectious Diseases Advisory Committee (PIDAC) on Infection Prevention and Control, Glass Bead Sterilizer, chemiclave sterilization, ultraviolet light, microwave ovens and boiling are unacceptable methods of disinfection or sterilization in Canada,[1] and therefore, these procedures should not be considered for sterilization. Overall, most of the reviewed studies suggest reduced cutting efficiency of dental burs with repeated cleaning and sterilization processes.

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