

EVALUATION OF COMPRESSIVE STRENGTH AND SURFACE ROUGHNESS OF REPEATED SURGICAL FISSURE CARBIDE BUR

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ARTICLE HISTORY

Received: 6 February 2026 **Revised:** 27 February 2026 **Published:** 13 March 2026

ABSTRACT

In this paper, impacted tooth are mostly found in human, especially the mandibular third molars. Due to their inability to erupt, they often are surgically removed, and may necessitate the use of surgical round and fissure carbide bur at the osteotomy site. In clinical scenarios, these surgical burs are reused following sterilization. However, they may lose their cutting efficacy following each reuse. The objectives of the study were to compare the compressive strength and surface roughness of surgical fissure carbide bur after each of four successive reuses. For this study, 15 new carbide fissure surgical burs were utilized, each bur was used to make a longitudinal cut on molar teeth for 1 to 4 cutting and sterilization cycles, following each cycle the burs were evaluated using scanning electron microscopy (SEM) and, confocal laser microscopy, and their compressive strength was measured. Statistical analysis was carried out with one-way ANOVA and Tukey post hoc test with p-value 0.05 statistically significant. The results revealed the surface roughness of surgical carbide fissure burs altered statically significantly following their first usage as compared to the unused new burs. Although statically not significant, a large decrease in their compressive strength was noted between the 2nd and 3rd reuse cycles. Statistically significant decrease in compressive strength of burs was noted at the 4th cycle as compared to controls. Therefore, to maintain cutting efficiency and to prevent breakage, surgical carbide fissure burs should not be reused more than 2 times following sterilization.

Keywords: Surgical Carbide Bur, Repeated Sterilization, Surface Roughness

CITATION INFORMATION: Nimphiboon, N., Chaiyasamut, T., & Vorakulpipat, C. (2026). Evaluation of Compressive Strength and Surface Roughness of Repeated Surgical Fissure Carbide Bur. *Procedia of Multidisciplinary Research*, 4(3), 1.

INTRODUCTION

In the dental literature data on dental fissure bur are limited and are mostly focused on surgical cutting and drilling process, for example dental implant placement and surgical removal of impacted tooth (Bogovič et al., 2015; Harder, 2013; Chacon et al., 2016; Misir et al., 2009). One of the most common surgical procedures carried out by oral and maxillofacial surgeons is the surgical removal of impacted third molar. An overall incidence rate of approximately 20% in the population. Pell & Gregory have classified impacted third molar from relatively easy to extremely difficult to remove. Depending on the procedure and, age of patient, postoperative pain, swelling, trismus, and paresthesia varies (Rullo et al., 2013; Renton et al., 2011; Akinwande, 1991; Santamaria & Arteagoitia, 1997; Garcia et al., 2001; Yuasa et al., 2002; Cortell et al., 2011).

The procedure of oral surgery may also necessitate the use of surgical fissure and round bur for osteotomy for better access (Yacker & Klein, 1996). Apart from operator's skill, the cutting efficiency of surgical fissure bur is also clinically relevant, for example, sharp burs cut more efficiently than worn burs (Eriksson & Albrektsson, 1984) because deformations on the bur's cutting edges could lead to a reduction in the cutting efficiency. Moreover, the temperature of the bone during a surgical procedure can also induce thermal osteonecrosis (Tehemar, 1999). The heat is generated during the osteotomy is less in sharp burs compared to worn burs (Yacker & Klein, 1996). Further evidence can be seen in the study of Eriksson and Albrektsson (1984), who showed that worn burs cause a more significant and continuous temperature rise than new burs. Diamond rotary instruments are used for machining ceramic restorations, where as tungsten carbide burs are used for milling titanium, titanium alloys, and resin blocks. Successive use leads to an expected decline in their performance, (Ida et al., 1985) with eventual replacement after repeated machining (Kononen et al., 1995). The aim of the present in-vitro study was to evaluate surface roughness and compressive strength of surgical fissure carbide bur after each of four successive reuses.

LITERATURE REVIEWS

Some impacted lower third molar surgery can involve osteotomy, will can result in postoperative pain and swelling (Rullo et al., 2013). Therefore, the clinical factors that increase the risk of damage to the surrounding tissue should be minimized. One of the factors to minimize this is to use surgical burs that are efficient. As it is difficult to predict the cutting efficiency of surgical bur, the surgeon should focus on the deformation of the cutting edges of surgical burs following multiple osteotomies and sterilization cycles (Montero-Aguilar et al., 2019).

The duration of time a bur remains sharp depends on its, composition, surface, and the quality of the bone tissue at osteotomy site. Various designs or types of burs are also available with improved efficiency of the cutting edge (Sartori et al., 2012; Brisman, 1996). The heat generation during drilling procedures can cause necrosis of the surrounding cells and are affected by several factors such as pressure, thickness of cortical bone, irrigation, duration and cutting motion, drill shape, speed, and diameter of drills. Repeated use of dental bur can blunt their cutting edges, leading to a decreased cutting efficiency which has a potency to cause high temperature rise at the surgical site (Mendes et al., 2014).

Heat sterilization of fissure carbide burs, can be achieved using three primary methods: steam sterilization, dry heat sterilization, and chemical steam sterilization. Steam sterilization (autoclaving) is the most widely used technique and involves exposing cleaned, dried, and packaged fissure carbide burs to pressurized steam, which facilitates effective heat transfer through the packaging. Sterilization cycles are typically conducted at 121 °C or 134 °C, with exposure times ranging from 5 to 30 min (Dioguardi et al., 2021).

Similarly, Bayerlein et al. (2006) tested spherical burs on the porcine jaws made from different materials by zirconium oxide and aluminum oxide mixed with ceramics. Although the study concluded that the design, type of material, and mechanical properties of the bur significantly affected the cutting efficiency and durability, confounding factors such as cleaning and sterilization (could result in micro scratches). Moreover, studies have concluded that surgical burs can be used in the implant osteotomies more than once without resulting in a significant temperature rise of the bone tissue (Yacker & Klein, 1996; Sumer et al., 2001).

Cordioli and Majzoub (1997) studied bovine bone blocks and observed temperature increase by 3.3 mm diameter drill was significantly smaller than the 2 mm twist drill. Drill diameter played an important role in heat generation and it was observed that the small angles may result in increased temperatures (Chacon et al., 2016; Oh et al., 2011).

By preserving surrounding bone and soft tissues, minimally traumatic extraction techniques contribute to enhanced wound healing and a lower incidence of postoperative complications, which is especially important in impacted tooth surgery where extensive bone removal and tooth sectioning are often required (Xing et al., 2025).

RESEARCH METHODOLOGY

Fifteen new surgical burs were obtained from single supplier (dent mat). The stainless-steel burs were manufactured by Meisinger (Germany), and were fissure shaped with dimensions of 0.16 mm diameter, and 4.5 mm length. The teeth included for simulated cuts were mandibular first molar, second molar and third molar.

The teeth were cut with low-speed handpiece (W&H PERFECTA 300) by a single experienced oral and maxillofacial surgeon (post-graduate student). Tooth cutting was initiated under saline irrigation from the central groove, and a longitudinal cut was made until the pulp was reached. This was followed by sectioning at the furcation to split the roots. After completing the first cutting cycle, the fissure carbide bur was subjected to Ethylene Oxide (EO) sterilization.

A new bur was then used for two such successive sessions of cutting and sterilization. This process was repeated for other burs to complete a total of three and four cutting and sterilization cycles for fifteen burs and were examined as described

SEM analysis:

SEM (JSM-6610LV, JEOL Ltd., Tokyo, Japan) images were taken new bur, in their new condition and after each cycle up to the fourth reuse. These evaluations were carried out to characterize the wear of the bur and debris. Photomicrographs were obtained at 20x, 50x magnification to evaluate the textures.

Surface roughness measurements:

Surface roughness measurements were evaluated at the bur tips by confocal laser microscopy (Lext 3D measuring laser microscope OLS5100). All measurements were carried out before and after tooth section and were presented as mean roughness (Ra) in micrometers.

Compressive strength Measurements:

Universal testing machine (Instron5566, Instron Ltd., Buckinghamshire, England) was used to measure the compressive strength at 3 force levels: 100N, 1000N, 10000N, at the stainless steel blades for cutting test. The velocity was set at 0.5 mm/min. Following stabilization with V block (individual block), velocity and force was selected.

RESEARCH RESULTS

Scanning electron microscopy

The study included 15 fissure carbide burs which were evaluated for the characterization the wear and debris. The SEM images showed that carbide bur before cutting smoother than 1st cycles. However, 2nd, 3rd, 4th cycles showed smoother than 1st cycle. Photomicrographs were obtained at 20x, 50x magnification to evaluate textures as shown on Figure 1, 2, 3, 4, 5

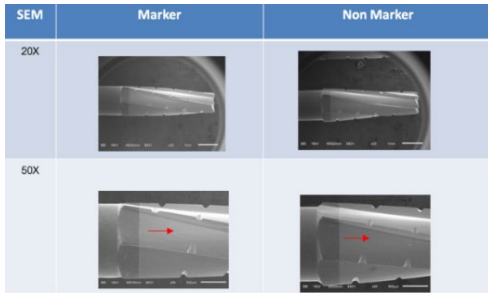


Figure 1 SEM images of carbide bur before cutting

The arrow showed the surface of carbide fissure bur after sterilization.

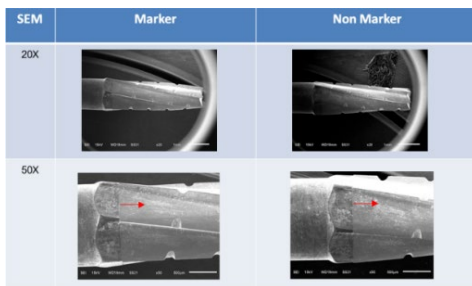


Figure 2 SEM images of carbide bur that have undergone 1 reuse

The arrow showed the surface of carbide fissure bur after 1st time reuse that show roughness and debris of carbide fissure bur.

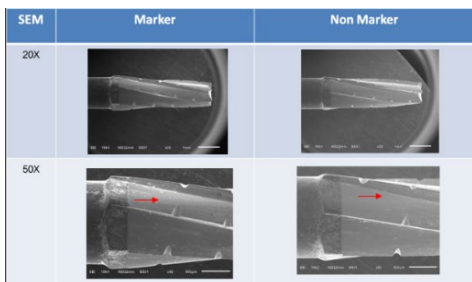


Figure 3 SEM images of carbide bur that have undergone 2 reuse cycle

The arrow showed the surface of carbide fissure bur after 2nd time reuse that show less roughness and debris of carbide fissure bur.

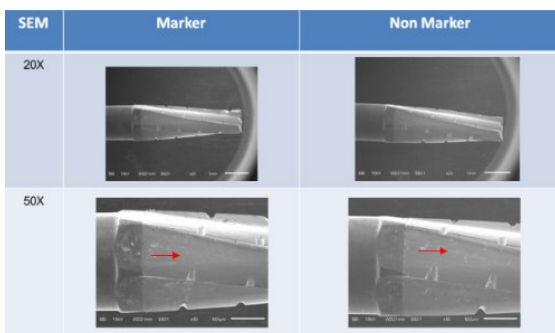


Figure 4 SEM images of carbide bur that have undergone 3 reuse cycles

The arrow showed the surface of carbide fissure bur after 3rd time reuse that showed less roughness and debris of carbide fissure bur.

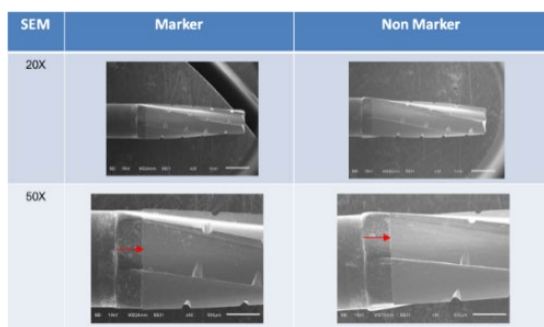


Figure 5 SEM images of carbide bur that have undergone 4 reuse cycles

The arrow showed the surface of carbide fissure bur after 4th time reuse that showed less roughness and debris of carbide fissure bur.

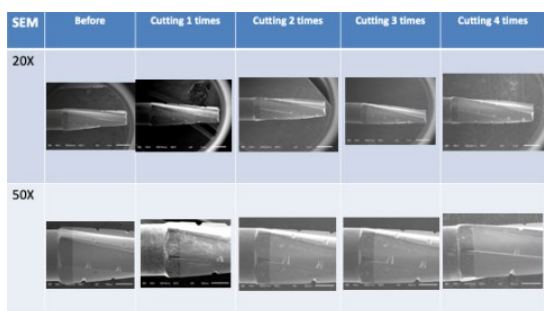


Figure 6 SEM Marker (pen marker on one side)

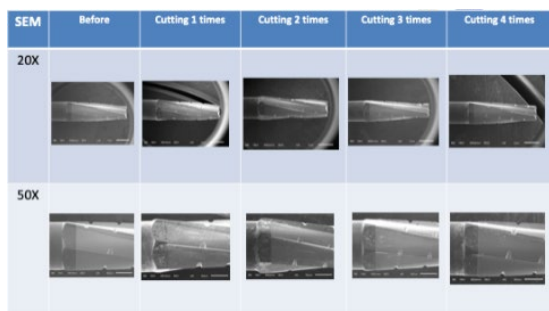


Figure 7 SEM Non-Marker (no pen marker on other side)

Surface roughness

Comparison of surface roughness and compressive force showed that there were significant differences among the reuse cycles. One-way ANOVA and Tukey post hoc test indicated statistically significant difference as shown in Table 1, 2, 3, 4.

Table 1 Comparison of roughness and compressive force by one-way ANOVA and Tukey post hoc test showed variations among the carbide bur group. Mention unit for each parameter in the table.

Cut	Roughness		Roughness NM		Force	
	Mean	SD	Mean	SD	Mean	SD
0	0.16 ^a	0.12	0.20 ^a	0.14	316.53 ^a	34.09
1	0.36 ^b	0.19	0.28 ^a	0.19	310.07 ^a	73.69
2	0.34 ^b	0.14	0.25 ^a	0.18	307.11 ^a	57.28
3	0.34 ^b	0.14	0.20 ^a	0.10	276.49 ^a	34.58
4	0.31 ^{ab}	0.14	0.22 ^a	0.15	266.75 ^a	54.44
P-value	.003		.484		.041	

Table 2 Comparison of roughness (Marker) among burs with various cutting cycles using One-way ANOVA and Dunnett post hoc test

Cut	Roughness		p-value*
	Mean	SD	
0	0.16	0.12	Ref
1	0.36	0.19	.002
2	0.34	0.14	.005
3	0.34	0.14	.006
4	0.31	0.14	.034
P-value[#]	.003		

P-value[#] from One way ANOVA

P-value* from Dunnett test

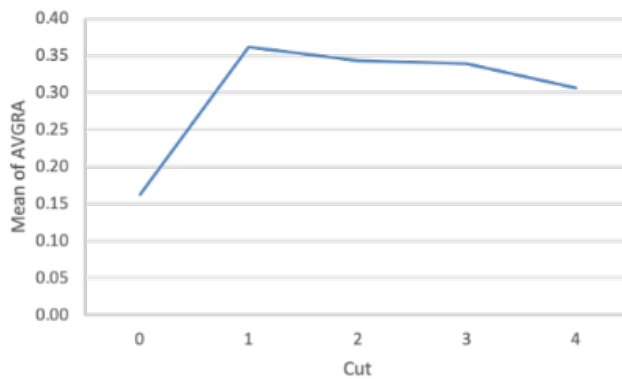


Figure 8 Comparison of roughness (Marker) among burs with various cutting cycles using One-way ANOVA and Dunnett post hoc test

Table 3 Comparison of roughness (Non marker) among burs with various cutting cycles using One-way ANOVA and Dunnett post hoc test

Cut	Roughness NM		P-value*
	Mean	SD	
0	0.20	0.14	Ref
1	0.28	0.19	.344
2	0.25	0.18	.745
3	0.20	0.10	1.000
4	0.22	0.15	.983
P-value[#]	.484		

P-value[#] from One way ANOVA

P-value* from Dunnett test

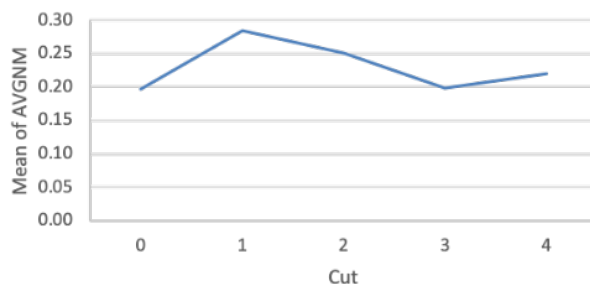


Figure 9 Comparison of roughness (Non marker) among burs with various cutting cycles using One-way ANOVA and Dunnett post hoc test

Table 4 Comparison of compressive force among burs with various cutting cycles using One-way ANOVA and Dunnett post hoc test

Cut	Force		P-value*
	Mean	SD	
0	316.53 ^a	34.09	Ref
1	310.07 ^a	73.69	.992
2	307.11 ^a	57.28	.968
3	276.49 ^a	34.58	.132
4	266.75 ^a	54.44	.042
P-value [#]	.041		

P-value[#] from One way ANOVA

P-value* from Dunnett test

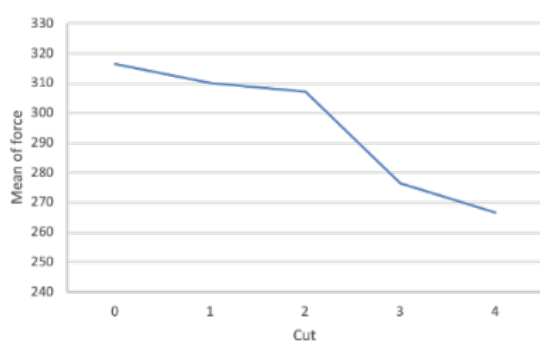


Figure 10 Comparison of compressive force among burs with various cutting cycles using One-way ANOVA and Dunnett post hoc test

DISCUSSION & CONCLUSION

Carbide fissure bur is commonly used in oral surgery. Third molars had been many specific anatomy in human. Normally, it is used for cutting tooth from buccal pit or longitudinally. When carbide fissure bur is used, heat is generated at the sharp working end. Studies by Reingewirtz et al. (1997) and Ercoli et al. (2004) have noted that the heat production affects bone healing and critical temperature should be carefully considered to minimize heat production. In this study, SEM analysis and surface roughness and compressive strength of carbide fissure burs were compared in accordance to the number of reuse cycles.

According to previous studies Montero-Aguilar et al. (2019) considered the increased clinical risk of the surrounding tissue damage from cutting edges deformations in a surgical bur after multiple osteotomies and sterilization cycles. Moreover, Mendes et al. (2014) recommended that the heat generation during drilling procedures can lead to necrosis of the surrounding cells. Studied have shown that dental bur sterilization process that use pressure steam autoclave was the best method for decontamination compared to manual scrubbing, hot air oven glass bead, and ultrasonic method (Sajjanshetty et al., 2014). Especially, high-pressure steam autoclave showed 100% sterility for new unused burs and 5% positive bacterial contamination of the reused bur. In comparison to low-pressure steam autoclaving showed 100% sterility of reused burs (Al-Jandan et al., 2016). Comparing to another diamond burs demonstrated lower cutting efficiency after repeated autoclaving. Cutting efficiency did not decrease as the number of cuts increased (Gonzaga et al., 2019).

However, the most appropriate method was autoclave compared to hot air oven, glass bead sterilization, ultrasonic cleaner, autoclave, chemiclave and various chemical disinfectants (Ferreira et al., 2014). Similarly, mechanical debridement by scrubbing brush and immersing in soap water prior to autoclaving is essential to reduce the debris of the pulpal remnants (Borse

et al., 2022). Fais et al. (2009) evaluated geometric modifications resulting from microstructural changes induced by oxidation or corrosion of the steel during certain sterilization processes have also been reported.

Steam sterilization (autoclaving) is the most widely used method for fissure carbide burs. This process involves exposing cleaned, dried, and packaged burs to pressurized steam, which enables effective heat transfer through the packaging materials. Standard sterilization cycles are typically performed at 121 °C or 134 °C for exposure times ranging from 5 to 30 minutes. While these parameters are sufficient to ensure microbial inactivation, repeated exposure to high temperatures and pressure may influence the mechanical properties, cutting efficiency, and surface integrity of carbide burs when burs are reused multiple times in clinical practice (Dioguardi et al., 2021).

Additionally, the burs' compressive strength and cutting effectiveness decrease over time (Luebke et al., 1980). Similarly, Mendes et al. (2014) evaluated the deformation, surface roughness, and mass loss of stainless steel, diamond-like carbon (DLC)-coated, and zirconia drills after multiple osteotomies combined with sterilization procedures.

This study has several limitations. First, the sample size was relatively small, comprising only 15 fissure carbide burs, which may limit the generalizability of the findings. Second, the in vitro study design may not accurately replicate the complex conditions of the oral cavity, including variations in saliva, temperature, and occlusal forces. Additionally, the age range of the samples may not be representative of the broader patient population. Furthermore, the investigation was restricted to burs from a single manufacturer and included only fissure carbide burs. Future studies should incorporate larger sample sizes, multiple manufacturers, different bur designs (such as round carbide burs), and in vivo experimental conditions to enhance the clinical relevance and external validity of the results.

In conclusion of this study revealed the surface roughness of surgical carbide fissure burs altered statically significantly following their first usage compared to the unused new burs. Although statistically not significant, there was a large decrease in the compressive strength between the 2nd and 3rd reuse cycles. Between the 3rd and 4th cycles, there was a statistically significant decrease in the compressive strength as compared to the new burs. Therefore, it is recommended that the surgical carbide fissure burs should not be reused more than 2 times following sterilization to maintain efficiency and prevent breakage.

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Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Conflicts of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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