ASK Publishers

ISSN: 3033-3555

Research Article

Journal of Stomatology & Dental Research

In Vitro Comparative of the Cutting Efficiency and Smear Layer of Ceramic Burs, Conventional Tungsten Carbide Burs and Diamond Stone

Ahmed Z El Hoshy

Lecturer, Department of Restorative Dentistry, Faculty of Dentistry, Cairo University, Cairo, Egypt

***Corresponding author**
Ahmed Z El Hoshy, Lecturer, Department of Restorative Dentistry, Faculty of Dentistry, Cairo University, Cairo, Egypt.

Received: November 14, 2023; **Accepted:** November 27, 2023; **Published:** November 30, 2023

ABSTRACT

Purpose: To compare the cutting efficiency and the smear layer of three different types of burs ceramic, tungsten carbide and diamond stone.

Materials and Methods:135 mica-based glass ceramics (Vita blocs Mark II) blocks were used to valuate cutting efficiency by weight loss method. Five points from each type of burs: Cera Bur (komet, Brasseler, Germany): K59, Tungsten Carbide tapered Bur (komet, Brasseler, Germany): H2 010 and diamond points (komet, Brasseler, Germany): 957AM 314 010, were used for cutting procedures. Each bur had made 30 seconds duration cut, each bur was used three times. Cutting was performed under standardized protocol using a specially designed machine for this purpose. Twelve unerupted human third molars were used to obtain Dentin slabs. Cutting was performed using the same protocol and the smear layer created was observed by means of scanning electron microscope.

Results: The values of weight loss were: 0.18 ± 0.08 gm, 0.40 ± 0.07 and 0.50 ± 0.07 gm for each bur respectively. Less dense smear layer was observed with the Cera Bur when compared to the tungsten carbide and diamond burs.

Conclusion: The new tapered fissure ceramic bur can be considered a promising tool for minimally dentistry, while providing a minimal reduction of the sound, hard tooth substance.

Introduction

Despite substantial improvements in oral health during the 20th century, dental caries is still one of the most common health diseases. According to Fusayama in 1979, carious dentin consists of two distinct layers, the outer carious dentin, also called caries infected dentin and inner carious dentin, also called caries affected dentin [1,2]. The development of caries removal techniques has become increasingly conservative and biological, where the main goal is to remove the outer infected layer and keep the inner affected one in order to prevent over cutting of dentin. Such concept has been made possible by a better understanding of the etiology and prevention of dental caries. In addition, conservation of tooth structure during cavity preparation has emerged as a result of the introduction of acid-etching techniques, adhesive restorative materials, and the development of new cavity preparations systems [3].

Differentiation of infected layer and inner affected one by texture and color perception is very subjective and is affected by many factors such as ambient light, hydration, as well as activity of the lesion [4]. Caries detecting dyes have been used to spot carious dentin that should be removed. However, due to lacking of knowledge about remineralization process occurring in carious lesion and the poor physical properties of available restorative materials; cavities were treated by a destructive and aggressive approach following the G.V.Black's concept "Extension for Prevention" [5,4].

Over the years, caries removal methods have been passed through lots of innovations. Starting from the earliest attempt involving the use of hand drill by James Morrison's in 1871 till the development of the modern high-speed drills. During these periods' lots of methods had been developed to provide a less invasive technique, such as the air-abrasive technique, ultrasonic instrumentation, enzymes, chemo-mechanical caries removal and polymeric bur mounted on a low-speed handpiece with cutting limited to the infected layer and the initial layer of affected dentin [7].

Although some of these methods are successful, yet a lot of disadvantages have risen including loss of tactile sensation, and the ability of alumina particle to remove sound tooth structure rather than the carious substrate reported with airabrasion technology; limited application, and the inability to remove soft carious dentine were the main limiting factors regarding the acceptance of ultrasonic cutting tips. In addition the slow actions of chemo-mechanical approach limited its clinical use [8].

Citation: Ahmed Z El Hoshy. In Vitro Comparative of the Cutting Efficiency and Smear Layer of Ceramic Burs, Conventional Tungsten Carbide Burs and Diamond Stone. J Stoma Dent Res. 2023. 1(1): 1-5. DOI: doi.org/10.61440/JSDR.2023.v1.05

Due to the drawbacks found in the previously mentioned methods, development of new mechanical caries removal tool might be of value. It started with the polymeric bur mounted on a low-speed handpiece with cutting limited to the infected layer but it was not that accurate in removal of the desired layer.9 It was reported that the ceramic burs were as effective as conventional tungsten carbide burs in dentin caries excavation [10].

According to Eick in 1972 and Nakabayashi in 1982, it was found that the structural integrity and surface characteristics of the tooth after caries removal greatly influence the adhesiveness of the restorative material [2,11]. Therefore an ideal cutting instrument must fulfill the requirements of carious tissue removal, resulting in satisfactory morphology with minimum formation of smear layer, so that the adhesive restorative materials can be properly applied [12].

Based on the self-limiting concept, we are looking forward to depend on intelligent cutting tool that can differentiate between the carious infected and affected dentin. Therefore the aim of the present study was to compare in vitro the cutting efficiency of three different cutting points and their corresponding smear layer.

Materials and Methods

Measuring the Cutting Efficiency

The cutting efficiency of a rotating dental instrument may be considered as the ability of that instrument to remove a maximum amount of tooth tissue with a minimum of effort and time involved in the operation [13]. Closely related to the cutting efficiency characteristic of the instrument is its functional life, which may be considered as the time interval through which the instrument may be used effectively to cut tooth tissue [14]. Both the efficiency and the functional life of the rotating instrument are no doubt interrelated, and both characteristics are of significance to the practitioner in his effort to shape the cavity with a minimum of time and effort [7].

Two tests were made in this study:

Cutting Efficiency

Cutting efficiency was measured by weight loss technique. Special device was fabricated (figure 1) to standardize the speed and the pressure of the cutting tip ceramic, carbide or diamond using the same handpiece: T1 Control, ISO 3964, INTRAmatic (Sirona, Germany). The aim of this device was to standardize all the cutting parameters. The pressure was adjusted at (Bar 3); the speed was operated at maximum torque, under a water flow of 25 milliliters per minute for all the specimens [15,16].

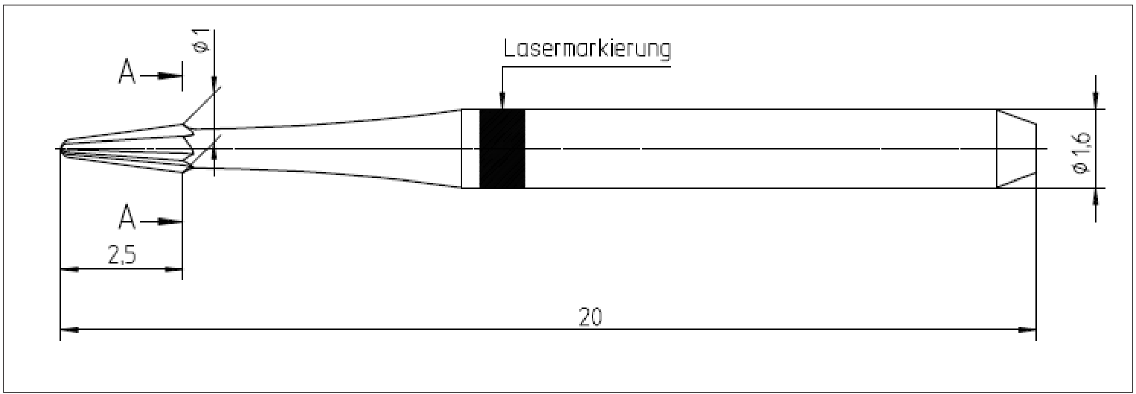

Figure 1: The special fabricated device, to control the cutting parameters

Device Details: It is a single axis linear motion machine, which is consisting of the following items:

1. DC motor with an integrated power screw.
2. Runner Block.
3. Linear guide.
4. Vise.
5. Base.

These items operate in the following manner:

- The Power screw converts the rotary motion of the DC motor to a linear motion.
- The Linear guide provides an accurate smooth linear motion to the Runner Block.
- The Runner Block is driven over the linear guide by the DC motor through the power screw.
- The fixed vise holds the test sample.
- All these items are attached to a fixed base that provides the portability of the whole machine.

Five burs were used from each type; each bur was used 3 times. All burs were new and provided in ISO sizes: Cera Bur (komet, Brasseler, Germany): K59 lot number 314.010. (Figure 2). Tungsten Carbide tapered Bur (komet, Brasseler, Germany): H2 010 lot number 414461 and diamond points (komet, Brasseler, Germany): 957AM 314 010. Each bur made a cut, of 30 seconds' duration. The mica-based glass ceramics: 135 Vitablocs Mark II (Vita Zahnfabrik, Bad Säckingen, and Germany) were used as a substitute for tooth structure in the cutting exercise. All blocks weighted 3gm; they were weighted before and after cutting by decimilligram balance (Mettler Toledo, USA). The handpieces were sprayed with lubricant (KaVo, Germany) for one second before each run. All burs were cleaned after each run in an ultrasonic cleaner containing a powerful detergent: Microten (Unident, Swiss) after cutting each specimen [17].

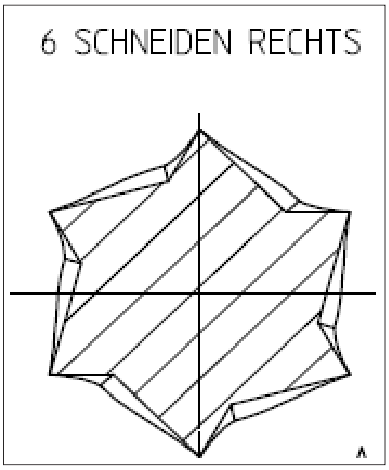

Figure 2: Smear layer Examination

Twelve unerupted human third molars teeth were collected after the patients' informed consent was obtained under a protocol approved by the UMKC adult health sciences institutional review board. The teeth were suspended in jars containing 12% solution of gelatin adjusted to pH 4 by adding 0.1 M lactic acid. The acidified gel was renewed after one week. Teeth were removed from the gel after two weeks, rinsed with water and air-dried. After complete removal of enamel, dentin slabs, of approximately 2 x 2 x2 mm, were obtained. Complete demineralization was ensured by the absence of Raman spectral features associated with the mineral component. The specimens were cut using ceramic bur, tungsten carbide bur and diamond stone respectively under the same conditions in terms of pressure, speed and time. Then, the dentin slabs were fixed at 23°C with 2.5% glutaraldehyde and 1% alcian blue 8GX (Sigma- Aldrich, St. Louis, MO, USA) in sodium phosphate buffer (pH 7). Fixation was continued in 1% OS04, and total fixation time was 16 hours. Specimens were air-dried and mounted on aluminum stubs. After sputtering with a 40 nm layer of gold in a Balzers SCD 050 apparatus, the cut surfaces were examined in a Jeol 6100 scanning electron microscope (Model Philips XL 30) operating at 10-15 kV, under magnification of X 500 to observe the smear layer ultramorphology.

Results

Cutting Efficiency Results

The mean and standard deviation values of weight loss after using ceramic bur were 0.18 ± 0.08 gm, 0.40 ± 0.07 gm after using carbide bur and 0.50 ± 0.07 gm after using stone.

ANOVA test showed that there was a statistically significant difference between the groups (P-value < 0.001). Pair-wise comparisons between the groups showed that there was no statistically significant difference between carbide bur and stone; both showed the highest weight loss. Ceramic bur showed the statistically significantly lowest mean weight loss.

Table 1: Mean, standard deviation (SD) values and results of comparison between weight loss in the three groups

Ceramic bur		Ceramic bur		Stone		P-value
Mean	SD	Mean	SD	Mean	SD	
0.18[b]	0.08	0.40[a]	0.07	0.50[a]	0.07	<0.001*

*: Significant at P ≤ 0.05, Different letters are statistically significantly different

Scanning Electron microscope Results

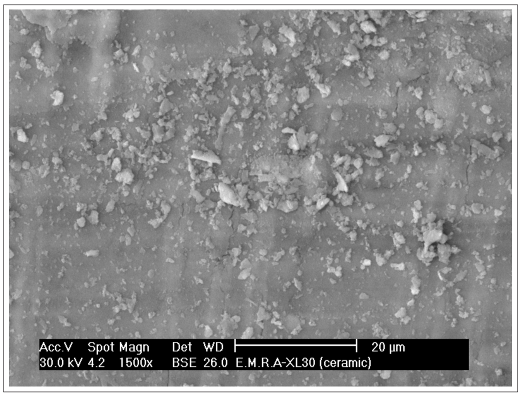

Figure 3: For the ceramic bur, the smear layer present on the dentin surface shows sporadic debris, scanty and non uniform layer

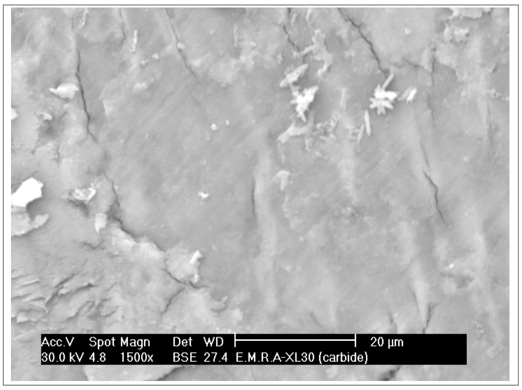

Figure 4: The carbide bur exhibited irregular, narrow grooves and dentin micro-particles deposited together with the smear layer. Several cracks were observed which might be due either the effect of the cutting with bur, or as due to dentin dehydration or specimen's preparation

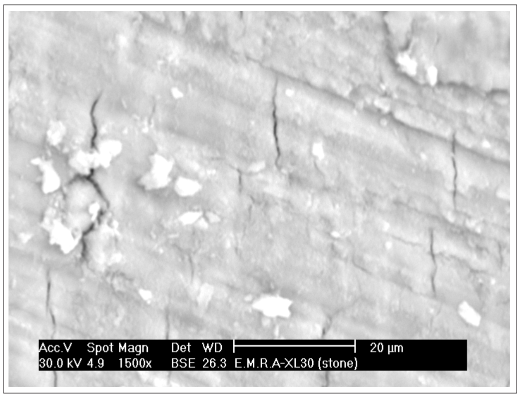

Figure 5: The diamond bur created a thicker smear layer than other burs, and formed a rough dentin surface with deeper and uniform grooves. Smear layer is condensed, compact and thick

The thicknesses of smear layer and irregularity on dentin surfaces treated with diamond burs were higher than those observed with carbide burs. The smear layer seems to be well burnished to the underlying structure.

Discussion

There has been continuous interest and research in dental cutting studies guided by the vast developments in modern dentistry. One of these is the invention of advanced cutting technologies such as laser cutting and air abrasion. Although such advanced technologies have proven their efficiency and applicability in many fields of dentistry, the dental hand piece and bur still remains the favorite tooth preparation tool for the general dentist [18]. The second development has been the introduction of different types of burs with wide variety of finishing instruments and burs designed for specific purposes [15]. Among these inventions is the introduction of tools, which are capable of removing infected dentin, and sparing of dentin capable of remineralization [9]. Clinicians have used caries removal techniques such as chemo-mechanical treatment and hand excavation, but these techniques are not in general use. A rotary instrument that can be used with limited cutting has conceptual appeal. In addition to the conservation of tooth structure such rotatory cutting tool will enable dentists to perform cutting procedures without damaging the health of the vital tooth [10,19].

The testing protocol used in this study is a reproducible and simple test method with good control of operating variables [20]. The authors simulated the clinical situation by moving the handpiece toward the substrate where Cutting was done under a controlled rate of water spray, and the load on the handpiece, which simulated that in clinical situation, was always placed in the same location [21]. The position of the bur was constant for each run-that is, parallel to the substrate and pulled perpendicularly down onto it simulating clinical practice [22].

Since handpiece reliability and consistency of operation are significant factors in cutting studies, the same handpiece was used during all testing procedures together with the recommended lubrication, to ensure consistent operation. Air pressure was controlled to be fixed all over the study, thus eliminating the need for external measurement or control of rotational speed [23].

Substrate selection is crucial to any cutting study. Ideally, dental cutting studies should be performed on enamel, but a suitable size single mass of enamel is relatively unavailable. In addition, enamel has numerous and well-established inconsistencies in physical properties and morphology that would introduce uncontrolled variables into a research protocol [2,8].

Glass ceramics have been used in many studies to take advantage of their consistent density, absence of porosity and availability; for these reasons, the authors used a glass-ceramic substrate in this study [19,18,23,24].

It is well established that debris accumulation may be more detrimental to cutting efficiency than are wear and chipping from the bur surface.13 For this reason each bur was cleaned after each run in an ultrasonic cleaner containing a powerful detergent.25 The ultrasonic cleaner has been chosen for debris removal it was proven to be a reliable method to be used for decontamination of infected dental instruments, specially the ceramic ones as they are free of metal, therefore biocompatible and corrosion-free [26,27].

In addition, the authors used a new bur after each testing to ensure that none of the burs was chipped which may affect their cutting efficiency.

The results of this study showed statistically significant differences in cutting efficiency between the ceramic bur and conventional diamond and carbide burs. However, these study results showed no significant differences in the cutting efficiencies between the diamond bur and the carbide one. The lower cutting efficiency observed with the ceramic bur maybe regarded to its design (Special blade design for smooth cutting), figure 2, that has been developed for minimal invasion and reduced cutting capacity thus providing a minimal reduction of the sound, hard tooth substance.

Scanning electron microscope was performed to study the substrate surface left after cutting by each of the used instruments. It is well established in literature that the composition and properties of the smear layer as shown in figures 3, 4, and 5 are related to the substrate, type of the cutting instruments as well as the cutting speed. The results of the present study showed that the use of the diamond bur yielded a more compact uniform and dense smear layer, the carbide bur resulted in a less compact smear layer while the ceramic bur resulted in a non uniform dispersed smear layer as shown in figure 3 [12].

However, the results of the current study conflict with other that showed that the carbide burs have higher cutting efficiency than the diamond burs. This conflict may be regarded to the difference in testing parameters [19].

Conclusion

The new tapered fissure ceramic bur can be considered a promising tool for minimally dentistry, while providing a minimal reduction of the sound, hard tooth substance.

References

1. Harnirattisai C, Inokoshi S, Shimada Y, Hosoda H. Interfacial morphology of an adhesive composite resin and etched caries-affected dentin. Oper Dent. 1992. 17: 222-228.
2. Nakabayashi N, Kojima K, Masuhara E. The promotion of adhesion by the infiltration of monomers into tooth substrates. J Biomed Mater Res. 1982. 16: 265-273.
3. Banerjee A, Kidd EA, Watson TF. Scanning electron microscopic observations of human dentine after mechanical caries excavation. J Dent. 2000. 28: 179-186.
4. Banerjee A, Watson TF, Kidd EA. Dentine caries excavation: a review of current clinical techniques. Br Dent J. 2000. 188: 476-482.
5. De Almeida Neves A, Coutinho E, Cardoso MV, Lambrechts P, Van Meerbeek B. Current concepts and techniques for caries excavation and adhesion to residual dentin. J Adhes Dent. 2011. 13: 7-22.
6. Yip HK, Samaranayake LP. Caries removal techniques and instrumentation: a review. Clin Oral Invest. 1998. 2: 148-154.
7. Norling BK, Stanford JW. Evaluating the performance of dental rotary cutting instruments. In: The cutting edge: interfacial dynamics of cutting and grinding. Washington,D.C.: U.S. Department of Health, Education,and Welfare, 1976. DHEW publication no. (NIH) 76-760:203-20.
8. Li H, Wang WM, Yu SL, Wen Q. Morphological and microtensile bond strength evaluation of three adhesive systems to caries-affected human dentine with chemomechanical caries removal. J Dent. 2011. 39: 332-339.
9. Bleiholder R, Rosenstiel S, Gegauff A,Martello J, McCafferty R. A laboratory performance test for dental rotary instruments J Dent Res. 1987. 66: 1746.

10. Dammaschke T, Vesnic A, Schafer E. In vitro comparison of ceramic burs and conventional tungsten carbide bud burs in dentin caries excavation. Quintessence Int. 2008. 39: 495-499.
11. Eick JD, Johnson LN, Fromer JR, Neumann AW. Surface topography: its influence on wetting and adhesion in a dental adhesive system. J Dent Res. 1972. 51: 780-788.
12. Dina W Elkassas, Ahmad Z Elhoshy, Ali I Abdalla. Effect of caries removal using ceramic bur on the microtensile bond strength of etch and rinse and self etch adhesive systems. International Journal of Clinical Dentistry. 2011. 4: 11-20.
13. Wilwerding T, Aiello A. Comparative efficiency testing 330 carbide dental burs utilizing Macor substrate.Pediatr Dent. 1990. 12: 170-171.
14. Sharon crane siegel, Anthony von Fraunhofer J. Cutting efficiency of three diamond bur grit sizes. J Am Dent Assoc. 2000. 131: 1706-1710.
15. Prabhakar A, Kiran NK. Clinical evaluation of polyamide polymer burs for selective carious dentin removal.J Contemp Dent Pract. 2009. 10: 26-34.
16. Siegel SC, von Fraunhofer JA. The effect of handpiece spray patterns on cutting efficiency. J Am Dent Assoc. 2002. 133: 184-188.
17. Sanchez E, Macdonald G. Decontaminating dental instruments: testing the effectiveness of selected methods. J Am Dent Assoc. 1995. 126: 359-362.
18. Howard E. Strassler, DMD. Caries removal using polymer burs. Inside Dentistry. 2011. 7.
19. Ercoli C, Rotella M, Funkenbusch PD, Russell S, Feng C. In vitro comparison of the cutting efficiency and temperature production of ten different rotary cutting instruments. Part II: electric handpiece and comparison with turbine. J Prosthet Dent. 2009. 101: 319-331.
20. Doerr RE. Principles associated with the use of high speed rotary instruments. Dent Clin North Am. 1967. 11: 22-25.
21. Naylor WP. NB Nova disposable diamond instruments: final project report. San Antonio, Texas: USAF Dental Investigation Service, USAF School of Aerospace Medicine, 1990. 90-39U: 1-13.
22. Semmelman JO, Kulp PR, Kurlansik LR. Cutting studies at air-turbine speeds. J Dent Res. 1961. 40: 404-410.
23. Price RB, Sutow EJ. Micrographic and profilometric evaluation of the finish produced by diamond and tungsten carbide finishing burs on enamel and dentin. J Prosthet Dent. 1988. 60: 311-316.
24. Watanabe L, Soelberg KB, Peizner RB. Diamond stones. In: Reports from product evaluation laboratory. Newtown, Pa.: Dent-E-Val Inc. 1987. 4: 17-24.
25. Tanaka N, Taira M, Wakasa K, Shintani H, Yamaki M. Cutting effectiveness and wear of carbide burs on eight machinable ceramics and bovine dentin. Dent Mater. 1991. 7: 247-53.
26. Gureckis KM, Burgess JO, Schwartz RS. Cutting effectiveness of diamond instruments subjected to cyclic sterilization methods. J Prosthet Dent. 1991. 66: 721-726.
27. Nakajima M, Ogata M, Okuda M, Tagami J, Sano H, et al. Bonding to caries-affected dentin using self-etching primers. Am J Dent. 1999. 12: 309-314.