Comparison of cutting efficiency with different diamond burs and water flow rates in cutting lithium disilicate glass ceramic

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ABSTRACT

Background. This study compared different diamond burs and different water flow rates on the cutting efficiency of sectioning through lithium disilicate glass ceramic.

Methods. The authors used a standardized cutting regimen with 4 brands of diamond burs to section through lithium disilicate glass ceramic blocks. Twelve diamonds of each brand cut through the blocks in randomized order. In the first part of the study, the authors recorded sectioning rates in millimeters per minute for each diamond bur as a measure of cutting efficiency. In the second part of the study, the authors compared sectioning rates using only 1 brand of diamond bur, with 3 different water flow rates.

Results. The authors averaged and compared cutting rates of each brand of diamond bur and the cutting rates for each flow rate using an analysis of variance and determined the differences with a Tukey honest significant difference test. One diamond bur cut significantly slower than the other 3, and one diamond bur cut significantly faster than 2 of the others. The diamond bur cutting efficiency through lithium disilicate glass ceramic with a 20 mL/min water flow rate was significantly higher than 15 mL/min.

Conclusions. There are differences in cutting efficiency between diamond burs when sectioning lithium disilicate glass ceramic. Use a minimum of 20 mL/min of water coolant flow when sectioning lithium disilicate glass ceramic with dental diamond burs to maximize cutting efficiency.

Practical Implications. Recommendations for specific diamond burs with a coarse grit and water flow rate of 20 mL/min can be made when removing or adjusting restorations made from lithium disilicate glass ceramic.

Key Words. Lithium disilicate; ceramics; dental diamond burs; water flow rates.

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Continued and increasing demand by dentists for highly esthetic materials has motivated manufacturers to develop newer and stronger ceramic biocompatible materials.[1] Dental practice, at one time, based on metal ceramic restorations is changing. The price of noble alloys has increased tremendously in the past few years. In particular, the price of gold has increased from $600 per troy ounce in 2006 to its value in 2015 of $1,164 a troy ounce.[2] These economic factors—in addition to increased patient demand for and knowledge regarding highly esthetic restorations—are moving dental practice increasingly toward computer-aided design and computer-aided manufacturing (CAD-CAM) restorations. Our convenience-oriented society also moves the demand toward these types of restorations so that crowns are delivered in a single appointment.[3]

Ceramic materials are increasingly used in dental practices. Laboratories report that more than 50% of single crown restorations requested are all-ceramic crowns.[4] Survival rates of all-ceramic crowns are reported to be higher than 95%.[5] As newer ceramic materials have evolved, manufacturers have developed higher-strength materials that have properties that are different from traditional metal alloys.

The CAD-based ceramics are reported to have greater toughness, resiliency, as well as higher strength as compared with conventional ceramics. Lithium disilicate glass ceramic (LDGC) (IPS e.max, Ivoclar Vivadent) is one of the newer CAD-CAM materials dentists are incorporating into their dental practices. This material has a flexural strength of 360-400 megapascals, a Vickers hardness number (VHN) (standard deviation

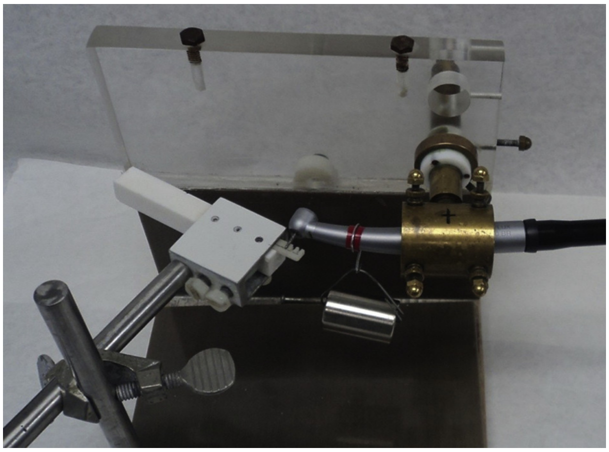

Figure 1. Testing regimen. *Image of the GENTLEforce LUX 6000B high speed handpiece reproduced with permission of KaVo America.*

TABLE 1

Dental diamond burs tested.*

BUR NAME, MANUFACTURER	DIAMETER AT TIP (MILLIMETERS)	DIAMETER AT SHANK (mm)	DIAMOND TYPE	GRIT SIZE (MICROMETERS)
DuraCut, Brasseler USA	1.26	1.59	Synthetic	151
Great White Z, SS White Dental	1.22	1.77	Synthetic	64-74
Two Striper TSZtech, Premier Dental Products	1.11	1.59	Natural brazed	Proprietary (fine)
ZR-Diamonds, Komet USA	1.58	1.61	Synthetic	126

* Information provided from the manufacturers.

[SD]) of 621 (6) VHN and a fracture toughness of 3.0 K_{Ic} (MPa × meters$^{1/2}$)[6-8] in comparison with conventional ceramics that have a flexural strength of 65-100 MPa, a VHN (SD) of 508 (10), and a fracture toughness of 1.2-1.5 K_{Ic} (MPa × m$^{1/2}$).[9,10] The difficulty for the dental practitioner is that adjusting very high-strength LDGC materials is time consuming and demanding with a need to accomplish the task in an efficient manner.

Adjusting these strong ceramic materials includes occlusal adjustment, endodontic access, or crown removal. Using improved burs to maximize the time efficiency of this process will benefit the clinician in minimizing the time required for the process. Several bur manufacturers have newly designed burs or recommendations for these procedures. To date, there are few studies reported in the literature that have quantitatively analyzed cutting efficiency of burs to cut through or adjust LDGC.[11,12] There are no studies comparing rotary instruments that manufacturers have specifically designed to section these higher-strength glass ceramics.

Studies have shown that increased water coolant spray improves cutting efficiency of titanium, gold, and material simulating tooth structure (MACOR, Corning).[13-15] No study to date has compared the cutting efficiency of diamond burs on the newer ceramic materials using varying amounts of water coolant flow rates.

The purpose of this research was 2-fold. First, the study compared the cutting efficiency of 4 dental diamond burs to section through LDGC. Second, we evaluated the effect of 3 different water coolant flow rates using 1 type of dental diamond bur on LDGC (IPS e.max).

METHODS

In the first part of this study, we used a cutting apparatus (described in a previous article[16]) with a freely rotating arm and a high-speed handpiece (GENTLEforce LUX 6000B, KaVo America) (Figure 1) under constant air pressure of 55 pounds per square inch (translated to 33 psi at the handpiece). We did standardized sectioning under a water coolant flow rate of 20 milliliters per minute and an applied load at the bur tip of 1.46 newtons (149 grams). We used distilled water for all cutting studies. We used 4 dental diamond burs from different manufacturers (Great White Z, SS White Dental; Two Striper TSZtech, Premier Dental Products; ZR-Diamonds, Komet USA; DuraCut, Brasseler USA; Table 1) to section through sintered 18 × 6 × 3–millimeter blocks of LDGC. We used blocks that were specifically manufactured to the aforementioned specifications for this study. The manufacturer rigorously ensured that the thickness of all blocks was precise to 3.0 mm using an electronic caliper accurate to 0.01 mm.

We used 12 diamond burs from each of 4 manufacturers and randomized their order of cutting so that each block of LDGC had 1 diamond bur from each company section cut through its 4-mm length and 3-mm depth. Each cut was performed with a brand new diamond bur. A single operator supervised all cutting and was masked to the bur type.

In the second part of the study, we compared differences in cutting efficiency using different water flow rates. We used the aforementioned cutting protocol in this part of the study, with the exception that only 1 type of diamond bur (DuraCut) was used for all cuts. We used 3 different water flow rates (15 mL/min, 20 mL/min, and 25 mL/min) to section through sintered blocks of LDGC measuring 18 × 6 × 3 mm (Figure 1). We performed the cutting so that 12 cuts were made using a new diamond

ABBREVIATION KEY. CAD-CAM: Computer-aided design and computer-aided manufacturing. **LDGC:** Lithium disilicate glass ceramic. **VHN:** Vickers hardness number.