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An Evaluation of Polymer Rotary Instruments' Ability to Remove Healthy, Non-carious Dentine

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Abstract - *The aim of this study was to confirm that Smartprep™ burs do not cut non-carious, healthy dentine. Twenty non-carious extracted molars were trimmed with a diamond bur to remove enamel and to create a flat dentine surface. A new Smartprep™ bur (RA # 4) was applied to each tooth for 30 seconds. As a control, a new number three round stainless steel bur was applied to each tooth. The mean dentine loss was 4.25 mg (range 1.4 – 9 mg) for Smartprep™ burs and 12.21 mg (range 7.6 – 16.5mg) for stainless steel burs. The Smartprep™ burs remove significantly less dentine than stainless steel burs.*

KEY WORDS: Smartprep, Polymer bur, Dental bur, Caries excavation

INTRODUCTION

The treatment of carious dentine is aimed at arresting progression of the lesion and to provide a sound restorative foundation[1]. Ideally, the treatment will remove the infected outer carious dentine layer, leaving the lightly infected (affected) inner carious dentine layer. The advantages of confining removal to the outer carious dentine have been summarised by Boston[2] as being painless excavation[3,4], a diminished pulpal response[5], significant reduction in numbers of viable bacteria with drier and harder remaining dentine[6,7] and lastly the reported ability of resin composite to bond to lightly infected or affected inner dentine, thus, eliminating the need for complete removal of carious dentine when planning resin composite restorations[8].

Despite the advocation of selective caries removal, complete removal of carious dentine is still routinely done and is still recommended[9]. Reasons for this practice include the lack of devices and/or chemicals to distinguish between infected/affected dentine or to selectively remove the outer layer in a fast and efficient manner[10].

In a study by Boston[2] milled polymer prototype and formed wire loop prototype burs were made and tested on normal and carious dentine. Both prototypes removed carious dentine but did not remove normal dentine in the extracted teeth used in this study.

Based on the work of Boston[2], a new polymer bur (SmartPrep™) has been developed for selective dentine removal. This unique rotary instrument is made of a specially designed polymer material, which, according to the manufacturers', selectively removes decayed dentine without cutting of healthy dentine. This property is based on the hardness of the instrument being lower than the hardness of healthy dentine. According to the manufacturers' the Vickers Knoop hardness number (KHN) of the instrument is 50, with that of healthy dentine ranging from 70-90 KHN and infected, carious dentine less than 30 KHN. Apparently the edges of the instrument start rolling and become dull as soon as it comes in contact with healthy tooth structure. This selective dentine removal will result in exposure of very few dentine tubules and thereby minimising contact with nerve endings in the pulp chamber and reducing patient discomfort**.**

Since the marketing of this new polymer bur, several studies have been performed to investigate the efficiency of the bur for excavating dentine caries in permanent and primary teeth[11,12], its ability to remove dentine caries painlessly without the need for local anaesthesia [13] and its efficiency in creating substance for dentine bonding[14].

Results from these studies showed that Smartprep™ burs, apart from its use without local anaesthetic being accepted by patients, performed less than satisfactorily and not according to the manufacturers' claims or expectations. Silva et al.[14] found that tooth surfaces prepared by polymer burs exhibited significantly lower bond strengths than carbide burs, with transmission electron micrographs showing areas of incompletely removed denatured caries-infected dentine in the polymer bur specimens. The authors suggested that these first generation polymer burs will be best utilised for deep caries removal when pulp exposure is a concern.

Dammaschke et al.[11] and Celiberti et al.[12] found that the polymer burs were less effective than stainless steel burs for removing carious dentine. In both studies a carious layer of thicker than 1 mm was left after Smartprep™ instrumentation. Dammaschke et al.[11] suggested a harder polymer to increase the efficiency of the burs while Silva et al.[14] suggested an increased hardness and/or modification of the shape of the bur.

Apart from the initial work by Boston[2] on the prototypes, no studies have been performed on sound dentine to test whether Smartprep™ burs are indeed selective with no, or limited, cutting of sound or caries affected dentine. As the manufacturers' are in the process of developing a new, more efficient polymer bur, information on the ability, or in-

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ability, of the currently available polymer burs to cut sound dentine, will be helpful to determine to which extend the hardness of the bur could be increased without loosing its selective cutting ability for carious dentine and rendering it no more selective than stainless steel burs.

The aim of this study was, to evaluate whether Smartprep™ burs cut healthy dentine.

MATERIAL AND METHODS

Twenty non-carious, extracted molars were trimmed with a diamond bur to remove the enamel and to provide a flat dentine occlusal surface[2]. Each tooth was weighed to the nearest tenth of a milligram[15,2]. As a positive control a new round stainless steel bur #3, was applied to one tooth each on its flat dentine surface for 30 seconds. An ATR Technika high torque motor was used at 500 revolutions per minute (rpm) and a maximum torque of 8 Newton per centimetre (N/cm). By using the motor we were able to standardise the rpm and to a certain extent the applied pressure. If too much pressure was applied to the surface of the tooth, the bur would stop rotating. The prepared tooth was then reweighed. One new Smartprep™ bur, (RA #4) of a similar size as the stainless steel bur, was applied to the dentine surface of the same tooth, 2 mm away from the previously instrumented area. The electrical motor settings were the same as those used for the stainless steel bur. The tooth was again reweighed. This procedure was repeated for all twenty teeth. In randomly selected cases the Smartprep ™ burs were applied first, followed by application of stainless steel burs, to exclude the possibility of drying of dentine to influence the results. Photographs of the tooth dentine surface were taken after application of both types of burs (Fig 1). Scanning electron micrographs were taken of the surfaces of new (Fig 2) and used (Fig 3) Smartprep ™ burs.

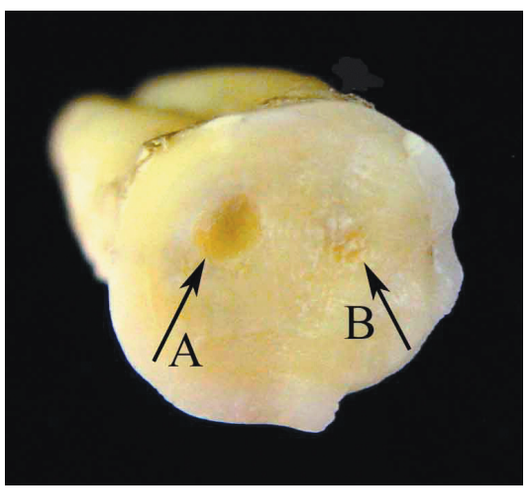

Figure 1. **A.** *Cavity made by a stainless steel bur.* **B.** *When using Smartprep™ burs little visual effect could be detected on the dentine surface*

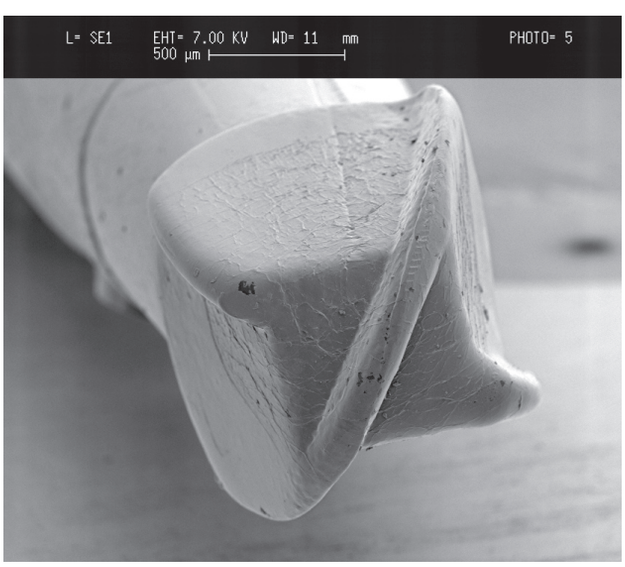

Figure 2. *A new Smartprep™ bur*

Figure 3. *Dulled blades of the used Smartprep™ bur*

DATA AND STATISTICAL ANALYSIS

The independent Student's *t* test or paired samples Student's *t* test was used to evaluate the statistical difference for each treatment. Significance was accepted at the 5% level. All statistical calculations were performed with a computer statistics program (SPSS.13 for Windows, SPSS Inc. Chicago, Illinois, USA).

RESULTS

Smartprep™ burs removed significantly less healthy dentine than stainless steel burs. The mean tooth loss was 4.25 mg (range 1.4-9 mg) after instrumentation with the Smartprep™ burs and 12.21 mg (range 7.6-16.5 mg) after instrumentation with the stainless steel burs (Table 1). The difference in ability to remove dentine between stainless steel and Smartprep™ burs was statistically significant ($p<0.05$). Visually, it was evident that the stainless steel burs were removing dentine with the production of dentine flaking and macroscopical indentation of the dentine surface (Fig.1). When using Smartprep™ burs, no dentine flaking occurred and little visual effect could be detected on the dentine surface (Fig 1). Dulling of the blades of used Smartprep™ burs (Fig 3) was evident, especially when compared with new, unused burs (Fig 2).

DISCUSSION

The Smartprep™ system includes three sizes of Smartprep™ instruments (burs) and a caries access block containing different carbide burs to gain access to the carious dentine through restorative material, enamel and/or healthy dentine. It is recommended that Smartprep™ instruments are used with a very slow rotation (500-800 rpm) and with a light touch into the suspected centre of the carious lesion working down and outwards to remove layer by layer throughout the lesion, thus avoiding contact with healthy dentine and prematurely dulling the instrument. The last action of the instrument will be to clean the cavity floor with more forceful strokes. The instrument is disposed of after use. Any contact of the Smartprep™ instrument with enamel, healthy dentine or restorative materials will result in premature wearing and failure of the instrument. The manufacturers claim that the instruments provide a greater tactile sense when encountering carious versus healthy dentine. It is suggested that it is normal to expect premature wear of the Smartprep™ instrument until such time that the operator has adjusted to the tactile difference between healthy and carious dentine.

The current study was exclusively designed to determine whether Smartprep™ instruments cut healthy dentine and did not address its ability to effectively remove carious dentine or its greater tactile sense to differentiate between healthy and decayed dentine.

According to Meredith et al.[16], dentine hardness ranges from 54 to 65 KHN with softer values closer to the dentino-enamel junction (DEJ) and the hardest values about two millimetres (mm) away from the DEJ. Sound dentine within twelve carious teeth showed a hardness range of 51 to 62 KHN varying by depth[17]. Yamada et al.[18], found that the most superficial layers of carious permanent dentine were less than 20 KHN. This softness gradually decreased until the unaffected dentine under the caries is around 60 KHN. Shimizu and Shibatani[19] found that KHN and the pH of carious dentine were positively correlated with a KHN of 35 for carious dentine with a pH of 7.0 while carious dentine with a pH of 6.0 had a KHN of 11. The hardness of dentine at the bacterial infection front also varied depending on the type of caries i.e. smooth versus fissure and chronic versus acute dentine caries[20]. These studies show a wide variation in KHN of dentine in the same teeth and

Table 1. *Weight in milligrams (mg)*

Sample	*Initial tooth weight*	*Weight after SS bur*	*Loss in weight*	*Weight after SP bur*	*Loss in weight*
1	1212.9	1204.5	8.4	1201.6	2.9
2	938.2	930.6	7.6	929.2	1.4
3	1277.3	1267.1	10.2	1265.2	1.9
4 *	1112.9	1098.3	10.8	1109.1	3.8
5	1367.2	1355.3	11.9	1350.9	4.4
6 *	1023.8	1009.2	11.2	1020.4	3.4
7	1610.4	1591.6	18.8	1582.5	9.1
8	1538.3	1524.1	14.2	1517.1	7.0
9	1780.6	1767.9	12.7	1764.3	3.6
10 *	1583.5	1567.0	9.8	1576.8	6.7
11	873.5	862.7	10.8	860.9	1.8
12	983.6	973.0	10.6	970.8	2.2
13	1023.5	1006.0	17.5	1000.0	6.0
14	1126.3	1112.0	14.0	1109.0	3.0
15	1628.8	1613.1	15.7	1609.0	4.1
16 *	1412.9	1398.4	11.0	1409.4	3.5
17 *	1612.3	1592.9	11.5	1604.4	7.9
18 *	1395.1	1379.0	12.8	1391.8	3.3
19	1759.8	1743.3	16.5	1736.1	7.2
20	778.2	770.0	8.2	768.3	1.7

SS = Stainless Steel bur, SP = SmartPrep™ bur
** = SP before SS (As a further control, a few samples were first prepared with the Smartprep™ burs followed by stainless steel burs)*

suggest that dentine from non-carious teeth may have a slightly higher KHN than dentine from carious teeth with further variations in hardness depending on pH and type and location of caries. These findings may explain to a certain extent the wide range in the amount of dentine removed in the current study when using Smartprep™ and stainless steel burs.

As the polymer burs were removing small amounts of sound dentine from non-carious teeth in the current study, it is possible that they may remove greater amounts of affected/sound dentine from carious teeth based on their reported lower KHN values.

CONCLUSION

Results from the current study suggest that the amount of sound dentine removed from non-carious teeth by the Smartprep™ instrument is negligible and significantly less than the amount of dentine removed by the stainless steel burs, currently used for rotary removal of carious dentine. Within the constraints of this study it thus appears as if Smartprep™ instruments may provide a fast and efficient means of selectively removing the infected outer carious dentine layer with preservation of the harder, affected inner layer of dentine. When interpreting the results from this study in combination with the results from recent studies, showing insufficient removal of carious dentine with the need to increase the polymer KHN value for more efficient cutting, it becomes clear that there is a very fine line between the polymer burs cutting carious dentine efficiently and loosing its selective properties. Manufacturers need to consider this when developing an improved generation of polymer burs.

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MANUFACTURERS' DETAILS

- Smartprep™ bur, SS White Burs, INC. lakewod, NJ, USA.
- Diamond burs, SS White Burs, INC. lakewod, NJ, USA.
- Stainless steel burs, Komet, Gerb. Brasseler GmbH, Lemgo, Germany.
- Scanning electron microscope, Cambridge S360, Cambridge, UK.
- High torque motor, ATR Technika, Dentsply Tulsa Dental, Tulsa, Oklahoma, USA.

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