Original Article

Comparative Evaluation of Dentinal Caries in Restored Cavity Prepared By Galvanic and Sintered Burs

Abstract

Background: The occurrence of secondary caries is the most common reason for the restorations failures. **Aim:** The aim of the study was to evaluate and compare the anticaries effect of copper ions on the teeth restored with glass ionomer cement (GIC) and composite restorations in the cavity prepared by galvanic and sintered burs. **Materials and Methods:** A total of 40 premolars were divided into two halves buccolingually. Class V cavity was prepared with sintered diamond burs and galvanic diamond bur. Cavities were restored with either GIC or composite resin. The monospecies artificial microbial caries model was selected for induction of secondary caries. The lesions were measured at junction of restoration by confocal laser scanning microscope. **Results:** The results were statistically significant ($P < 0.001$) and suggested that the width of lesion was lowest in cavity prepared by sintered bur and restored with composite resin. **Conclusion:** The use of different burs in combination with various restorative materials influence the occurrence and width of caries lesion.

Keywords: *Composite restoration, confocal laser scanning microscope, glass ionomer cement, secondary caries, sintered bur*

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Introduction

Dental caries is defined as a local pathological process of the extrasomatic background, leading to enamel decalcification, decomposition of dental hard tissues, and in consequence to formation of a dental cavity (WHO).[1] Dental caries is the most common ailment in dentistry and current epidemiological studies suggest a steep rise in the prevalence to the extent of becoming a public health crisis.[2] The WHO has recommended reducing the incidence of caries to 30% of the children population of below or at the age of 6 years by the year 2000.[1]

The occurrence of secondary caries is the most common reason for the restorations failures.[3] Employment of comprehensive caries prevention protocol including a remineralizing and antimicrobial agent and fluoride-containing restorative materials are still insufficient to contain this secondary caries.[4] The primary reason for the formation of secondary caries are microgaps created between the restoration and the margins of the cavity leading to the microleakage and eventually secondary caries formation at restoration/tissue interface.[5]

The smear layer is composed of microcrystalline debris in denatured collagen fibrils and contaminated with microorganism and saliva.[6,7] The preparation of teeth forms a smear layer which is composed of bacteria, saliva, denatured collagen, cutting debris, hydroxyapatite crystals, and possibly bur particles.[6,8] The smear layer is inhabitated by the microorganism from the plaque in addition to the original flora. It flourished by the nourishment availed through the microgap and produced acid for demineralization at the tooth-restoration interface.[9] The studies were conducted on cavity disinfectants to eliminate the cariogenic flora. They either cause decrease in the bond strength of the restorative material a temporary result.[10,11]

Copper is a partial noble metal with antibacterial property in both aerobic and anaerobic conditions at low concentration.[12] It possesses property to resist demineralization of the tooth under acid attack.[13] The sintered copper bur contained copper ions which may be deposited on the tooth into the smear layer to provide antibacterial activity.[8,14]

The introduction of fluoridated restorative materials remineralized the incipient

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or arrested caries and resisted demineralization. The resistance to solubility and improved bond strength are the added advantage of composite over glass ionomer cement (GIC).[15]

The aim of the study was to evaluate and compare the anticaries effect of copper ions on the teeth restored with GIC and composite restorations in the cavity prepared by galvanic and sintered burs. The null hypothesis was that there is no anticaries effect of sintered copper bur on the cavity restored by GIC and composite restoration.

Materials and Methods

The sample size calculation was done using the software nMaster (version 2.0, Christian Medical College, Vellore, Tamil Nadu, India). The effect size taken was 0.4, which was calculated using the mean and standard deviation of the pilot study with an error probability of 0.05 and power (1-β error probability) of 0.80. Total sample size obtained was 9.78, and hence, a total of ten samples were considered for the study.

The study was conducted in Sharad Pawar Dental College, Wardha, after the approval of institutional ethical committee. Forty healthy human premolars, intact without any visible defect, were extracted for orthodontic treatment and collected. The teeth were stored at 4°C in 0.1% thymol solution after cleaning with 2.5% sodium hypochlorite and used within 30 days from the day of extraction. Two types of burs - sintered burs (n = 20) and galvanic burs (n = 20) were used to prepare the cavity for the restorations [Figures 1 and 2].

The teeth were divided into four groups. Group A consisted of teeth prepared by galvanic bur and restoration with GIC, Group B consisted of teeth prepared by sintered bur and restoration with GIC, Group C consisted of teeth prepared by galvanic bur and restoration with composite, and Group D consisted of teeth prepared by sintered bur and restoration with composite.

The teeth were measured, marked with a marker, and divided into two halves buccolingually with double-sided diamond disk (DFS). The small hole was created with the help of small pear-shaped carbide bur no. 330 (SS White) to pass on the 23-gauge orthodontic wire for handling the samples aseptically during caries induction. Class V cavity of size 4 mm × 4 mm × 2 mm, 1 mm above the cervical line, was prepared with sintered diamond burs and galvanic diamond bur on buccal surface of Group A, Group B, Group C, and Group D under the distilled water irrigation of 50 ml/min and 35 psi compressed air pressure.

Ten cavities of Group A and B were conditioned with 10% polyacrylic acid for 10 s, rinsed with water, soaked and restored with Type IX GIC (GC Fuji, Japan). Teeth of Group C and Group D were selectively etched with 37% phosphoric acid (Scotchbond Total Etch, 3M ESPE) for 15 s, washed with water for 30 s, and soaked dried. The Scotchbond universal bonding agent (3M ESPE) was applied on the surface of the cavity for 20 s and light cured for 20 s. The cavities were dried with three-way syringe and restored with composite resin (Filtek Z 250, 3M ESPE, USA). The composite was cured with LED light cure unit for 20 s. The restoration was polished using soflex disc (3M ESPE). All teeth sample were collected and thermocycling (thermostatic water bath) was done for 500 cycles at 5° to 55°C, ±2°C with a dwelling time of 30 s. The layer of varnish was coated twice, 2 mm away from the margin of restoration. The samples were again sterilized in ethylene dioxide gas chamber for 6 h.

All the forty teeth samples were suspended in the broth stored in four 50-ml sterile glass test tube. These samples were fixed with the 26-gauge orthodontic wire by preparing a hole in the root with the help of carbide-tapered fissure bur (169 L).

The monospecies artificial microbial caries model was selected for induction of the secondary caries adjacent to the restorations. The *Streptococcus mutans* American Type Culture Collection (ATCC) 25175 (Himedia Laboratories Pvt Ltd, Mumbai, India) was grown in blood agar anaerobically for 24 h at 37°C. The grown colonies were transferred to the tubes containing brain–heart infusion broth with 5% sucrose and incubated further for 24 h at 37°C. The bacterial cell pellets were centrifuged (1500 rpm, 10 min, 37°C) and resuspended in brain–heart infusion broth to a cell density of McFarland 2 (6×10^8 colony forming unit/mL). Viable bacterial concentration was determined with the use of the standard spreading technique at various opacities. Inoculation was done on the 1st day of experiment, but the renewal of culture media was done for 21 days at the interval of every

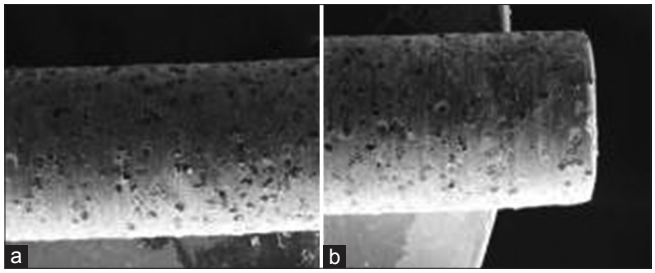

Figure 1: Scanning electron microscope images of sintered bur (a) before and (b) after tooth preparation at × 50 magnification

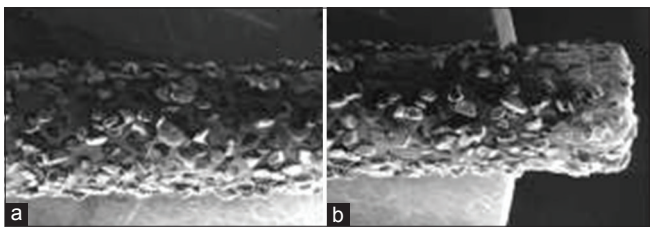

Figure 2: Scanning electron microscope images of galvanic bur (a) before and (b) after tooth preparation at ×50 magnification

48 h. Contamination of the culture was verified in every 48 h by means of gram staining.

All the teeth samples were stored in 100% humidity. The teeth samples were divided into two equal halves labiolingually using double-sided diamond disc (Biomet, Muehler) in the center parallel to long axis of tooth. The samples were flattened from the proximal surfaces. The restoration surfaces were polished with 100, 200, 400, 600, and 1200 grit wet sandpaper. Each sample was placed under the eyepiece for the measurement of width of carious lesion by confocal laser scanning microscope (Olympus, Fluoview FV1000, Japan) software version 4.1.2.2 with observation mode LSM, objective lens ×10 and the argon gas laser source of excitation band of 405 nm wavelength and 450 nm longpass filter was used to detect the autofluorescence. The lesions were measured by triplicating the lesion width at the junction of restoration and dentin below the dentinoenamel junction. The measurements were taken for three widest lesions above the floor of the cavity. The histotomographic images were recorded with the measurements. The mean of the lesion readings for each sample was calculated based on the fluorescence difference of mineralized and demineralized dentin.

Results

The comparison of mean scores of carious lesion extension after cavity preparation with galvanic and sintered bur and restored with GIC was done utilizing Mann–Whitney test. The mean scores of carious wall lesion extension (μm) after cavity preparation with diamond bur and restoration with GIC was 64.00 ± 20.35, while the mean carious lesion extension (μm) after cavity preparation with sintered bur and restoration with GIC was 24.73 ± 9.95, and this difference was found to be statistically highly significant ($P < 0.01$) [Table 1]. This result indicated that cavity preparation with sintered bur had a higher ability to inhibit carious lesion extension than diamond bur.

The comparison of mean scores of carious lesion extension after cavity preparation with galvanic and sintered bur and restored with composite was done utilizing Mann–Whitney test. The mean scores of carious wall lesion extension (μm) after cavity preparation with diamond bur and restoration with composite was 28.73 ± 12.22, while the mean carious lesion (μm) after cavity preparation with sintered bur and restoration with composite was 19.83 ± 9.95, and this difference was found to be statistically highly significant ($P < 0.01$) [Table 2]. These results indicate that cavity preparation with sintered bur had a higher ability to inhibit carious lesion extension than diamond bur.

The comparison of the means of caries wall lesion extension (μm) after cavity preparation with galvanic and sintered burs and restored with GIC and composite restorations was done using ANOVA test. The results were statistically significant ($P < 0.001$) and suggested that the carious wall lesion extension was highest in the cavity prepared by galvanic bur and restored with GIC followed by cavity prepared by galvanic bur and restored with composite, cavity prepared by sintered bur restored with GIC and cavity prepared by sintered bur and restored with composite, respectively [Table 3].

The comparison of the means of caries wall lesion extension (μm) after cavity preparation with galvanic and sintered burs and restored with GIC and composite restorations was done using *post hoc* test. The mean difference between Group A and Group B was 39.26, mean difference between Group A and Group C was 35.26, and mean difference between Group A and Group D was 44.16. The results were statistically significant between Group A and Groups B, C, and D. The results were statistically insignificant between all the remaining intergroup comparisons [Table 4].

Discussion

The replacement and repair of the older restoration comprised to 50%–70% of the total operative procedures. The most common reason of fracture of the restoration was the incidence of the secondary caries.[3] The smear layer formed during the tooth preparation comprised of bacteria, denatured collagen, saliva and bur debris in the microgap at a tooth restoration interface. The microorganism of the plaque harbor into the smear layer and caused demineralization.[6,8,16]

Diamond burs are produced by various methods, mainly, electrodeposition, microbrazing with sintering, sintering with binder, and sintering under vacuum. The galvanic burs are formed by depositing single or multiple layer of diamond particle on the steel shank into a nickel sulfamate solution containing diamond particle under controlled pH and temperature.[17] The vacuum sintered burs were manufactured by compressing the copper binder undertones of pressure and high temperature under vacuum for hours

Table 1: Comparison of carious wall lesion after cavity preparation with different burs and restoration with glass ionomer cement

Bur	*n*	Mean±SD (μm)	SEM	Significant
Galvanic	10	64.00±20.35	6.43	*P*<0.001*
Sintered	10	24.73±8.39	2.65	

**P*<0.01 highly significant. SD: Standard deviation; SEM: Standard error of mean

Table 2: Comparison of carious wall lesion after cavity preparation with different burs and restoration with composite

Bur	*n*	Mean±SD (μm)	SEM	Significant
Galvanic	10	28.73±12.22	3.86	*P*<0.001*
Sintered	10	19.83±9.95	3.14	

**P*<0.01 highly significant. SD: Standard deviation; SEM: Standard error of mean

Table 3: Comparison of caries wall lesions after cavity preparations with different burs and restorations

	n	Mean±SD (μm)	SE	95% CI for mean		*F*	*P*
				Lower bound	Upper bound		
1	10	64.00±20.35	6.43	49.43	78.56	22.07	0.001*
2	10	24.73±8.39	2.65	18.72	30.73		
3	10	28.73±12.22	3.86	19.99	37.47		
4	10	19.83±9.95	3.14	12.71	26.95		
Total	40	34.32±21.91	3.46	27.31	41.33		

*P<0.001 highly significant. SD: Standard deviation; SE: Standard error; CI: Confidence interval

Table 4: Comparison of caries wall lesions after cavity preparations with different burs and restorations

Multiple comparisons						
VAR00001 LSD						
VAR00002 (I)	VAR00002 (J)	Mean difference (I−J)	SE	Significant	95% CI	
					Lower bound	Upper bound
1	2	39.26*	6.05	0.001*	26.98	51.54
	3	35.26*	6.05	0.001*	22.98	47.54
	4	44.16*	6.05	0.001*	31.88	56.44
2	3	−4.00	6.05	0.51	−16.27	8.27
	4	4.90	6.05	0.42	−7.37	17.17
3	4	8.90	6.05	0.15	−3.37	21.17

*The mean difference is significant at the 0.05 level. SE: Standard error; CI: Confidence interval; LSD: Least significant difference

together. The finished bur was trued to required shape with computer-aided method.[14]

The bur particles and the adjoining matrix tend to abrade and get partly deposited over the tooth surface.[8] The copper from the matrix of the sintered bur might be deposited on the tooth and could possibly be assimilated in the smear layer and plug. Copper is a known antibacterial agent in both aerobic and anaerobic conditions.

The caries was induced artificially by cutting *Streptococcus Mutans* ATCC 25175 in Brain Heart Infusion agar for 21 days under anaerobic condition in anaerobic gas jar. The biological model of caries was more aggressive as compared acid model of caries induction.[18] The microbial model of caries mimic closely to natural caries lesion of the teeth.[19] The histologic structure of caries induced by pH cycling and acidified gel simulated the affected dentin after caries removal and the microbiological model of caries induction was more similar to dentin caries lesion with an infected layer before caries removal.[20] Hence, the restoration aging was done by storing the samples in the phosphate buffer moistened cotton which was changed in every 48 h.[21]

Confocal laser scanning microscope analyzed the caries lesion in the dentinal wall. The acid produced by *Streptococcus mutans* interacted with the multiple components of the tooth, unmask the fluorophores and induced strong fluorescence signals in the red spectrum.[22] The mineral changes are significantly evident in blue light in the wavelength of 408 nm.[23] In the present study, the lesions were visualized with three different excitation band wavelengths of 405 nm, 488 nm and 559 nm, and the filter wavelength of 420–470 nm, 490–550 nm, and 575–675 nm, respectively. The fluorescence of caries was more evident in the excitation band 405 nm and longpass filter of 420–470 nm at the magnification of ×10.

The secondary caries lesion was formed at the tooth restoration interface. The inner wall lesion at the dentinal surface was assessed by confocal laser scanning microscope. The caries lesion width with GIC restorations was higher as compared to the composites. Lai *et al*. investigated the caries lesion by microbiological model and stated that secondary wall lesion in dentin is more in GIC as compared to composite and amalgam, respectively.[24]

This is in contrast to the studies which proved that GIC were resistant to larger caries lesion. The teeth were exposed to caries after aging of 4 months after restorations. The aging of the restoration is beneficial to nullify the temporary beneficial effect of the restorative materials possessed for small duration. The dissolution of cement in the acid in monospecies batch caries model do not provide the possibility of remineralization. The aging of restoration also preluded the chance of benefit of fluoride and the maximum amount of fluoride is lost in the first 3 days.[25] The cariostatic effect of the combination of fluoride of GIC with copper is always better than fluoride or copper alone.[26] The sintered copper deposited the copper in smear layer and the fluoride from the GIC proved beneficial for prevention of incidence of secondary caries lesion.

The caries lesions were more in the composite restorations of galvanic burs as compared to the sintered burs. This may be due copper ions impregnated in the dentinal tubules in smear layer and plug which persisted even after etching the tooth. The copper ion on the tooth wall reduced the lesion as compared to restoration without it.[27]

Dentinal caries lesion was more in the cavities prepared by galvanic burs and restored with composite as compared to cavities prepared by sintered burs and restored with GICs. The anticaries effect of copper ion and its property to inhibit the mineral changes are the vital factors to control the progression of caries.[12,13,28]

The results of the study suggested that the smear alteration of the cavity prepared in teeth is possible with the bur of the desired matrix. This alteration could bring a paradigm shift in the formation of the biofilm at the tooth-restoration interface. Further *in vivo* studies are recommended for the finding the details outcome of the utility of the copper sintered burs in the dentistry.

Conclusion

The use of different burs in combination with various restorative materials influences the occurrence and width of caries lesion. The copper containing sintered burs are effective in reducing the caries with fluoridated and non fluoridated restorative materials.

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Conflicts of interest

There are no conflicts of interest.

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