

Evaluation of the Efficacy of Caries Removal Using Polymer Bur, Stainless Steel Bur, Carisolv, Papacarie – An Invitro Comparative Study

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ABSTRACT

Context: Dental caries continues to affect a significant portion of the world population and treatment of the decay is associated with pain by many patients. Intervention and application of rotary instruments for treatment of carious lesions has often resulted in considerable removal of tooth structure. Chemo-mechanical method, a minimal invasive technique for caries removal was developed to overcome these shortcomings. This innovative method seems to be efficient in removing infected dentine without altering the healthy dental tissue or harming the adjacent oral mucosa.

Aim: To evaluate the efficacy and efficiency of Caries removal Using Polymer Bur, Stainless Steel Bur, Carisolv and Papacarie.

Materials and Methods: A total of 120 sectioned specimens were obtained from 60 extracted teeth. Each tooth was sectioned mesiodistally in the center of the carious lesion so that two halves (buccal and lingual or palatal) having equal sized carious lesions are compared. The sectioned specimens were

subdivided into four groups (Polymer Bur, Stainless Steel Bur, Carisolv, Papacarie) allotting 30 specimens to each for caries excavation.

Results: One-way ANOVA, Chi-square test analysis was done for comparison between groups which showed significant results with Stainless Steel Bur excavation taking less mean time when compared to other agents and Polymer Bur showed more amount of bacterial remnants after excavation whereas Carisolv and Papacarie were efficient with less dentinal tubule destruction and bacterial remnants after excavation. Further inter comparison between groups was done using Paired t-test and Fischer's Exact-test.

Conclusion: The Mean time taken by Stainless Steel Bur excavation was found to be less and caused more amount of dentinal tubule destruction when compared to Polymer Bur, Carisolv and Papacarie. Chemo-mechanical methods found to be more efficient with lesser amount of bacterial remnants and dentinal tubule destruction after caries excavation when compared to conventional methods.

Keywords: Chemo-mechanical caries removal, Dental caries, Deciduous teeth, Efficacy, Infected dentine

INTRODUCTION

Dental caries characterized by cavitation of the enamel and penetration of microorganisms into the dentine is caused by disequilibrium in the process of demineralization of hard tissues induced by the proliferation of cariogenic bacteria and consequent increase in acid production, causing the saliva pH to drop to a critical level [1]. Takao Fusayama in 1980 distinguished two layers in caries lesions the first layer "outer carious dentine" is highly infected, acidic, demineralised, not sensitive to contact, can be removed without anaesthesia and fail to remineralize in a natural way and the second layer "inner carious dentine" is partially demineralised and slightly infected, but the collagen fibrils retained their natural structure around intact dentinal tubules. Because of this remaining structural integrity, the inner carious dentine was sensitive to removal without anaesthesia [2].

Presently, there is increasing move towards less invasive treatment and preventive dentistry in the current odontologic era [3]. Conventional caries removal and cavity preparation entail the use of burs on a high-speed handpiece to gain access to the carious lesion, and a low-speed handpiece to remove carious dentine [4]. Steel bur excavation and Conventional rotary techniques removes largest amount of sound tissue (over-preparation) leaving behind some amount of carious tissues (under-preparation) with the possibility of overextending the cavity, healthy tissue removal, pressure and heat on the pulp, vibration, noise, pain stimulus and the need of local anaesthetic, a procedure that causes aversion in many patients, especially children [5].

Recently, Boston in 2003 developed a possible alternative to conventional methods of dentine caries removal by introducing a new Polymer prototype bur. Self limiting polymer burs, the new version of SmartPrep™, the now called SmartBurs™ (SS White, Lakewood, N.J., USA) with reinforced blades have been introduced that is used with a slow-speed handpiece and intended to selectively excavate carious degraded dentine. These Polymer Burs presented the smallest area of over-preparation and the largest area of under-preparation [6,7].

Chemomechanical caries removal technique is another non-invasive hand excavation method which removes only the infected dentine maintaining the demineralised portion for repair and remineralization [8]. Habib et al., used Sodium hypochlorite for the removal of carious dentine [1]. Carisolv™ introduced to the European market in 1998 containing three amino acids-lysine, leucine, and glutamic acid was found to be more effective and easy to manipulate but used by few professionals due its high cost and requirement of customized instruments [9]. In 2003, a Brazilian gel was developed based on papain, chloramines, and toluidine blue called Papacarie gel (Formula & Acao, Sao Paulo, Brazil) having antibiotic, bacteriostatic, and anti-inflammatory properties enhancing its use in Special Health Care Needs (SHCN) patients and phobic adults in paediatric dentistry and public health sectors [10].

Currently, research in dentistry has concentrated its efforts on the quality of treatment given and the goal is to preserve the potentially remineralizable inner layer of the carious lesion as much as possible. As each technique entails a specific caries removal endpoint,

the extent of carious dentine excavation, the time taken by each caries excavation technique needs to be evaluated including the microbiological aspect. Hence, the present in-vitro study was designed with an objective to evaluate the efficacy of caries removal using Polymer Bur, Stainless steel bur, Carisolv and Papacarie to compare the effectiveness of caries removal among all the agents used.

MATERIALS AND METHODS

The present in vitro study was carried out in the Department of Pedodontics and Preventive Dentistry in association with the Department of Oral and Maxillofacial Pathology, St. Joseph Dental College, Eluru, Andhra Pradesh, India.

Experimental design

In this experiment, method of carious dentine removal is the independent variable and time (in seconds) required to remove dentine (Efficiency) and the detection of bacteria after carious removal and dentinal tubule destruction (Efficacy) are the response or dependent variables.

Sample selection

A total of 60 extracted primary molars [Table/Fig-1] were collected. The teeth included were selected based on modified caries classification of Mount and Hume given by Lasfargus et al., in which caries distribution is done according to site and stage of progression of the lesion [11]. Teeth with deep carious lesion and with pulp exposure or potential for pulp exposure are excluded. All the extracted teeth were stored in Normal Saline.

Materials used in the study [Table/Fig-2]:

1. Polymer bur (SmartPrep, SS White Burs, Inc., Lakewood, NJ, USA)
2. Stainless steel bur (S.S. White Company)
3. Carisolv™ (Mediteam, Sweden)
4. Papacarie (Formula & Acao, Sao Paulo, Brazil)



[Table/Fig-1]: Tooth samples [Table/Fig-2]: Materials used in the study

Specimen preparation

Specimens were prepared by sectioning each tooth mesiodistally in the centre of the carious lesion using diamond discs so that the two halves (buccal and lingual or palatal) having equal sized carious lesions are evaluated for four caries excavation methods.

Caries removal procedure

1. **Polymer bur method:** Carious tissue was removed with circular movements starting from the centre of the lesion to the periphery as recommended by the manufacturer. Excavation was stopped when the instrument became macroscopically abraded and blunted and was no longer able to remove tissue. The presence of hard tissue was also checked with a probe.
2. **Stainless steel bur method:** Burs were used in a slow-speed handpiece, according to the size of the lesion. Dentine

excavation was stopped when hard dentine was detected using a non-flexible dental probe. Dentine was considered hard when, in applying a firm pressure the probe was not able to penetrate into dentin [12].

3. **Carisolv method:** Carious dentine was covered with Carisolv gel for 30 seconds and was scraped with the specially designed hand instrument to remove softened carious tissue. The procedure was repeated until the gel became clear and a sharp explorer was used to confirm that the cavity was free of caries and the remaining gel is removed with a cotton pellet soaked in water.
4. **Papacarie method:** Carious lesion was covered with Papacarie gel for 30 seconds and was scraped gently with a spoon excavator once the gel becomes cloudy. Removal of carious dentine was continued until the gel was no longer cloudy.

Evaluation of Efficiency (Time taken to remove caries) and Efficacy (The detection of bacteria after carious removal and Dentinal tubule destruction): The time taken was measured and recorded from start of caries removal till the cavity was confirmed to be caries free with the help of a stop.

After caries removal the specimens were stored in individual plastic containers and decalcified with 10% Formic acid [Table/Fig-3] at room temperature [13]. They were dehydrated in ascending degrees of Ethanol, cleared in Xylene and embedded in Paraffin [Table/Fig-4] and cut into 5µm sections for staining with Eosin and Hematoxylin to evaluate the presence of bacterial deposits and dentinal tubule destruction using conventional light microscope.



[Table/Fig-3]: Decalcification of tooth Samples [Table/Fig-4]: Paraffin Embedding

RESULTS

The results were statistically evaluated. The data obtained from the four groups was subjected to following statistical analysis using One-way Analysis Of Variance (ANOVA) to determine significant differences in time taken for caries removal and Chi-square test to calculate values of bacterial deposits and dentinal tubule destruction after excavation of caries in each group.

The mean time taken for caries removal using Stainless Steel Bur, Polymer Bur, Carisolv and Papacarie was found to be 151 seconds, 344.80 seconds, 461.60 seconds and 359.60 seconds respectively. The time taken is more for Carisolv when compared with other agents and less for Stainless Steel Bur [Table/Fig-5]. A significant difference in the amount of bacterial deposits among all agents was found with Polymer Bur 29(96.7%) containing the maximum and less with the other agents after caries removal [Table/Fig-6-8]. Samples excavated with Stainless Steel Bur, Polymer Bur, Carisolv and Papacarie showed dentinal tubule destruction in 24 (80%), 6 (20%), 3 (10%) and 3 (10%) teeth respectively. The results are significant with Stainless Steel Bur causing more amount of dentinal tubule destruction when compared with other groups [Table/Fig-9-10].

Further inter-comparison between the groups was done using Paired t-test and Fisher's exact-test. Significance for all statistical tests was predetermined at $p < 0.05$. The observations made were the mean time taken for caries removal was found to be more for Carisolv when compared to others. More amount of bacterial remnants were present after excavation with Polymer Bur. Excavation with Polymer

VARIABLES	SAMPLE SIZE	MIN	MAX	MEAN ± SD
Stainless Steel Bur	30	102	228	151.00 ± 31.89
Polymer Bur	30	288	438	344.80 ± 35.99
Carisolv	30	414	526	461.60 ± 25.65
Papacarie	30	312	408	359.60 ± 28.39

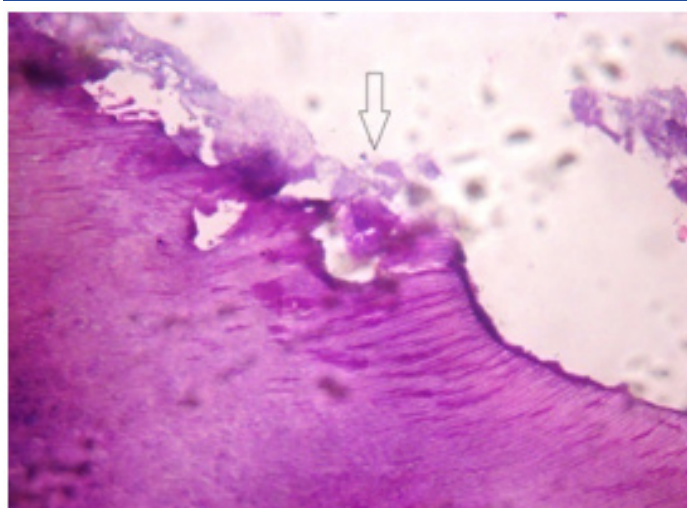
ANOVA : Overall comparison between variables

Source of Variation	Sum of squares	Degrees of freedom	Mean sum of squares	F	p-value
Between Groups	1513575.3	3	504525.1	534.4097	0.001 S
Within Groups	109513.2	116	944.0793103		
Total	1623088.5	119			

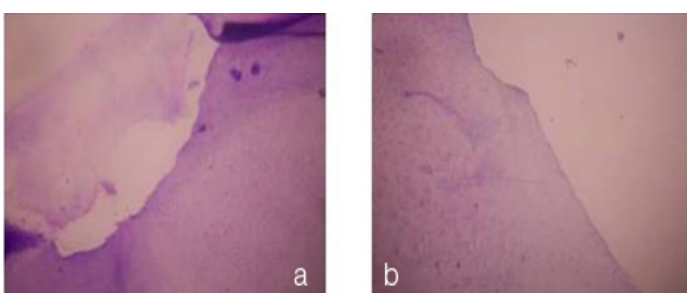
[Table/Fig-5]: Comparison of time taken in seconds between different groups Statistical Analysis: ANOVA one-way analysis. Statistically significant at p<0.05

Comparison between variables	YES n (%)	NO	TOTAL	Chi-square test p-value
Stainless Steel Bur	3 (10)	27 (90)	30 (100)	0.001 Significant
Polymer Bur	29 (96.7)	1 (3.3)	30 (100)	
Carisolv	13 (43.3)	17 (56.7)	30 (100)	
Papacarie	7 (23.3)	23 (76.7)	30 (100)	

[Table/Fig-6]: Comparison of bacterial deposits in different groups Statistical Analysis: Chi-square test. Statistically significant at p<0.05



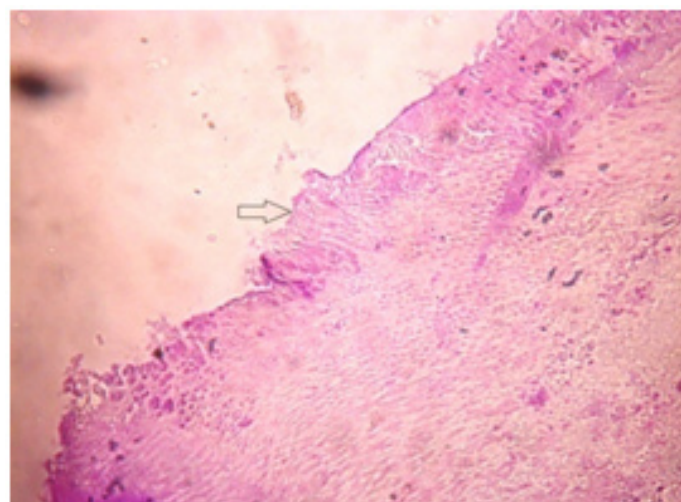
[Table/Fig-7]: Stained sections showing bacterial remnants after excavation with Polymer Bur (arrow)



[Table/Fig-8a,b]: Stained sections showing less or no bacterial remnants after excavation with (a) Carisolv and (b) Papacarie

Comparison between variables	YES n (%)	NO	TOTAL	Chi-square test p-value
Stainless Steel Bur	24 (80)	6 (20)	30 (100)	0.001 Significant
Polymer Bur	6 (20)	24 (80)	30 (100)	
Carisolv	3 (10)	27 (90)	30 (100)	
Papacarie	3 (10)	27 (90)	30 (100)	

[Table/Fig-9]: Comparison of dentinal tubule destruction in different groups Statistical Analysis: Chi-square test. Statistically significant at p<0.05



[Table/Fig-10]: Stained sections showing dentinal tubule destruction after excavation with stainless steel bur (arrow)

Comparison Variables	Mean Time Taken	Bacterial Deposits			Dentinal tubule destruction		
		Y	N	Total	Y	N	Total
Polymer Bur	334.20	10	0	10	1	9	10
Stainless Steel Bur	135.00	1	9	10	7	3	10
p-value	p*= 0.001 S*	p**= 0.001 S			p**= 0.020 S		

[Table/Fig-11]: Comparison of Time taken, Bacterial deposits and Dentinal Tubule Destruction after excavation with Polymer Bur and Stainless Steel Bur Statistical Analysis: Paired t-test. Statistically significant at p<0.05 Fisher's Exact-test. Statistically significant at p** < 0.05. S*: Significant

Comparison Variables	Mean Time Taken	Bacterial Deposits			Dentinal tubule destruction		
		Y	N	Total	Y	N	Total
Polymer Bur	334.80	9	1	10	2	8	10
Carisolv	465.60	4	6	10	1	9	10
p-value	p*= 0.001 S*	p**= 0.057 NS**			p**= 1.00 NS		

[Table/Fig-12]: Comparison of Time taken, Bacterial deposits and Dentinal Tubule Destruction after excavation with Polymer Bur and Carisolv Statistical Analysis: Paired t-test. Statistically significant at p<0.05 Fisher's Exact-test. Statistically significant at p** < 0.05. S*: Significant NS**: Not Significant

Comparison Variables	Mean Time Taken	Bacterial Deposits			Dentinal tubule destruction		
		Y	N	Total	Y	N	Total
Polymer Bur	365.40	10	0	10	3	7	10
Papacarie	362.60	0	10	10	1	9	10
p-value	p*= 0.856 NS**	p**= 0.001 S*			p**= 0.582 NS		

[Table/Fig-13]: Comparison of Time taken, Bacterial deposits and Dentinal Tubule Destruction after excavation with Polymer Bur and Papacarie Statistical Analysis: Paired t-test. Statistically significant at p<0.05 Fisher's Exact-test. Statistically significant at p** < 0.05. S*: Significant NS**: Not Significant

Comparison Variables	Mean Time Taken	Bacterial Deposits			Dentinal tubule destruction		
		Y	N	Total	Y	N	Total
Stainless Steel Bur	155.40	1	9	10	8	2	10
Carisolv	451.40	4	6	10	0	10	10
p-value	p*= 0.001 S*	p**= 0.303 NS**			p**= 0.001 S		

[Table/Fig-14]: Comparison of Time taken, Bacterial deposits and Dentinal Tubule Destruction after excavation with Stainless Steel Bur and Carisolv Statistical Analysis: Paired t-test. Statistically significant at p<0.05 Fisher's Exact-test. Statistically significant at p** < 0.05. S*: Significant NS**: Not Significant

Bur, Carisolv, Papacarie is more conservative with the least amount of Dentinal tubule destruction when compared to Stainless Steel Bur [Table/Fig-11-16].

DISCUSSION

The conventional carious tissue removal method using high and low speed burs, allows fast treatment with unnecessary structure

Comparison Variables	Mean Time Taken	Bacterial Deposits			Dentinal tubule destruction		
		Y	N	Total	Y	N	Total
Stainless Steel Bur	162.60	1	9	10	9	1	10
Papacarie	357.80	5	5	10	1	9	10
p-value	p*= 0.001 S*	p**= 0.141 NS**			p**= 0.001S		

[Table/Fig-15]: Comparison of time taken, bacterial deposits and dentinal tubule destruction after excavation with stainless steel bur and papacarie
 Statistical Analysis: Paired t-test. Statistically significant at p* < 0.05
 Fisher's Exact-test. Statistically significant at p** < 0.05. S*: Significant NS**: Not Significant

Comparison Variables	Mean Time Taken	Bacterial Deposits			Dentinal tubule destruction		
		Y	N	Total	Y	N	Total
Papacarie	358.40	2	8	10	1	9	10
Carisolv	467.80	5	5	10	2	8	10
p-value	p*= 0.001 S*	p**= 0.350 NS**			p**= 1.00 NS		

[Table/Fig-16]: Comparison of time taken, bacterial deposits and dentinal tubule destruction after excavation with papacarie and carisolv
 Statistical Analysis: Paired t-test. Statistically significant at p* < 0.05
 Fisher's Exact-test. Statistically significant at p** < 0.05. S*: Significant NS**: Not Significant

removal and consequent weakening of the tooth remainder, causing pulp injuries as well [6].

As an alternate to chemomechanical caries removal technique, the concept of preserving sound tooth structure showing much interest among dental researchers. This technique preserves remineralizable tissue and prevents over-excavation of the cavity [14].

The present in-vitro study was conducted with the objective to evaluate the efficacy (Bacterial remnants and Dentinal tubule destruction) and efficiency (time taken) of caries removal using Stainless Steel Bur, Polymer Bur, Carisolv containing active gel (Glutamic acid, Leucine and Lysine), fluid (Hypochlorite) effective in removing infected dentine and preserving affected dentine [15] and Papacarie containing active ingredient papain which is an specific enzyme endoprotein with bactericidal, bacteriostatic and anti-inflammatory action and chloramines as disinfectant [16,17]. The extracted teeth selected based on the modified classification of Mount and Hume proposed by Lasfargues et al., were considered as it helps minimizing differences in the excavation results due to the different extension, depth, localization and structure of the caries.

In the study, 10% Formic acid was used as dehydrating agent as it causes minimal soft tissue shrinkage and minimal loss of tissue when compared to Nitric acid which showed crumbling of tissue as reported by Zappa et al., [18].

As found in this in-vitro investigation, among the four agents the time taken for caries removal was less with Stainless Steel Bur (151 seconds) when compared to Polymer Bur (344.80 seconds), Papacarie (359.60 seconds) and Carisolv (461.60 seconds) which is similar to the studies performed by Banerjee, Kidd & Watson, Dammaschke and others, Yazici & others [19]. Carisolv needs prolonged time for excavation compared to rotary instruments which may be due to little experience and training of operators in working with it [20]. Papacarie exerts an inhibitory action on cariogenic bacteria and the time taken for removal of caries was about six minutes which is in accordance with the study conducted by Motta et al., Pandit et al., evaluated various methods of caries removal and reported that the time needed for caries removal using traditional method was about four to five minutes and using Carisolv was about eight minutes [1]. Hegde AM & others in their clinical evaluation reported that though chemomechanical technique is time consuming it was found to be more comfortable and is definitely superior compared to conventional technique in paediatric dentistry, provided we use a lesser technique sensitive restoration which retains in the oral cavity for longer period of time [21]. Among the four agents used, the presence of bacterial remnants after caries

excavation resulted in a significant difference with 43.3% samples of Polymer bur containing more amount of bacterial deposits and least with Stainless Steel Bur accounting only 10% of the samples. This is similar to the studies reported by Scheutzel, Dammaschke & others.

Similar results were shown by El-Habashy L et al., who concluded that Papacarie is significantly more efficient in reducing the residual cariogenic bacteria in the dentin of primary teeth when compared to Carisolv [22].

In the present study, Stainless Steel bur excavation resulted in a large amount of dentinal tubule destruction which accounted for 80% of the samples when compared to that of chemomechanical methods (Carisolv and Papacarie) which accounted for only 3% of the samples each which is in accordance with the study done by Hauman and Kuzmanovic. Stainless Steel Burs tends to be a fast and rather non-conservative method for dentine caries removal as these burs present a negative rake angle which leads to a less controlled movement of the instrument through the surface with over preparation [5].

The present investigation was an in vitro study and the results may not necessarily be the same as those that would be obtained in the oral environment. Application of CMCR approach makes it feasible to the operator in providing a cost effective treatment for large populations. Therefore, more research is needed to prove the clinical reliability of these products. Long term clinical studies are required to confront or corroborate these outcomes and the quality of bonding to the affected dentine needs to be ascertained.

CONCLUSION

Among the four agents (Stainless Steel Bur, Polymer Bur, Papacarie, Carisolv) following conclusions were drawn from the study-

1. The mean time taken for caries removal was found to be more for Carisolv when compared to others.
2. More amount of Bacterial remnants were present after excavation with Polymer Bur.
3. Excavation with Polymer Bur, Carisolv, Papacarie is more conservative with the least amount of Dentinal tubule destruction when compared to Stainless Steel Bur.

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