



COMPARATIVE EVALUATION OF EFFICACY OF MINIMALLY INVASIVE CARIES REMOVAL TECHNIQUES: AN SEM STUDY

Dental Science

Krishna Prasada L Department of Conservative and Endodontics, K.V.G Dental College and Hospital, Kurunjibagh, Sullia -574327.

Banashree Bhagawati* Department of Conservative Dentistry and Endodontics, K.V.G Dental College and Hospital, Kurunjibagh, Sullia -574327. *Corresponding Author

ABSTRACT

AIM The aim of the study is to evaluate and compare the efficacy and fracture resistance of the teeth restored with composite using minimally invasive caries removal techniques under a scanning electron microscope. **MATERIALS AND METHODS** 45 freshly extracted human permanent molars with Class I and II dentinal caries were selected. Diamond bur group (15): The carious lesion was excavated using round diamond bur until hard dentine were detected. Polymer bur group (15): Carious lesion were removed using polymer burs in circular motions. Carie-Care gel group (15): Carious lesion were covered with Carie-Care gel for 30 s and were scraped using a spoon excavator. The time required for the caries removal by each group was recorded. The effectiveness of caries excavation were verified using caries indicator dye. The smear layer removal were assessed using a scanning electron microscope. The cavities were restored with composite resin and fracture resistance of teeth was evaluated. All the data were tabulated and analyzed using Kruskal-Wallis test Kruskal-Wallis & by chi-square test. **Results** The mean value of time duration for caries removal by diamond bur group was less than polymer bur group and Carie-care gel group. The mean value of staining was more in polymer bur group and v-carie care gel group. There was minimal staining in the diamond bur group. SEM evaluation for the smear layer removal using different caries excavation methods showed Diamond bur low to moderate smear layer with visible dentinal tubules whereas Polymer bur showed dense smear layer with few visible dentinal tubules. Carie care gel showed dense smear layer with variable amount of dentinal tubules occlusion. the diamond bur group has shown highest fracture resistance. The polymer bur group, though exhibiting less amount of smear layer compared to cariecare gel group showing moderate fracture resistance. **Conclusion** According to this study, although Diamond bur method is most efficient in caries removal, carie care gel gives better result when compared to Polymer bur method in terms of efficacy as well as fracture resistance. The combined effect of carie care gel with diamond bur can reduce the risk of pulp exposure and post operative sensitivity.

KEYWORDS

Minimally Invasive, Carie-care, Polymer Bur, Scanning Electron Microscope.

INTRODUCTION

The field of operative dentistry is making remarkable strides in the direction of the minimally invasive approach. This methodology is founded on the principle of "Prevention of extension," in stark contrast to G. V Black's dictum of "Extension for prevention." The science of minimally invasive dentistry prioritizes the implementation of early detection, precise diagnosis, expeditious intervention, and microscopic treatment.¹

Treatment utilizing rotary instruments has exhibited a gradual improvement in terms of precision and efficacy with respect to the excavation of enamel and dentin. Nonetheless, said treatment can prove bothersome to a significant number of patients. Additionally, drilling has been known to induce pulp overheating, vibration, noise, and pain stimulation. Furthermore, such a procedure may necessitate the removal of an excessive amount of sound tissues, thereby reducing the degree of regenerative potential associated with the pulp-dentin complex.³ Recent advances in the field of restorative dentistry have been focused on the innovation of materials and minimally invasive techniques for the purpose of eradicating decay while simultaneously preserving the healthy dental tissue that remains prior to restoration. This has led to the introduction of less intrusive caries excavation procedures, including the use of polymer burs and gel.^{1,4}

The Knoop Hardness value of dentin affected by caries falls within the range of 10 to 40 kilograms per square millimeter, whereas healthy dentin exhibits a hardness ranging from 45 to 63 kg/mm². The Polymer burs, which are bur-like instruments, are single-use and composed of medical-grade polymer with a hardness lower than that of healthy dentin. They are designed for the purpose of selectively removing carious dentin by losing their cutting efficiency upon reaching the affected area.²

Carie-Care is a more recent, minimally invasive method for chemo-mechanical dentine caries removal. Carie-care gel is a chemo-mechanical agent utilized for caries removal which relies on the presence of papain and chloramines. The key active ingredient is the endoprotein present in Carie's Care, which is comprised of chloramines and colour extracted from papaya. Papain, a papaya extract, serves as a debrillant and possesses antibacterial and anti-inflammatory properties. It solely targets carious tissue that lacks the plasmatic protease inhibitor alpha-1 antitrypsin and promotes tissue

healing. Healthy tissue is safeguarded from its proteolytic action owing to the presence of this molecule. By means of chlorination of partially damaged collagen, chloramines expedite the process of tissue repair and serve as an aid in the healing of wounds. Furthermore, they possess the capability of dissolving carious dentin. This is achieved through the breakdown of hydrogen bonds, thereby facilitating tissue clearance and disruption of collagen structure. To add to its therapeutic properties, the medication comprises specific proportions of essential oils obtained from plant sources. These oils, including clove oil, exhibit anti-inflammatory and moderate anaesthetic effects⁵. Presently, all chemomechanical caries removal gels employ a combination of sodium hypochlorite and three amino acids as their primary active ingredients. This facilitates the softening of carious dentine, which is subsequently excavated manually, whilst ensuring that the healthy affected dentine remains unaffected. Moreover, Carie-Care offers the added benefit of anti-inflammatory activity and aroma, in addition to softening infected dentine.⁵

METHODOLOGY

45 extracted human permanent molars extracted for various reasons were collected from the department of oral and maxillofacial surgery (kvg dental college & sullia), cleaned, and stored in 10% formalin. The teeth with Class I and II coronal caries extending midway through the dentin, were selected for the study. The Class V caries, pulp exposure, or potential for pulp exposure were excluded from the study. The samples which fulfilled the inclusion criteria were mounted.

The specimens were numbered and randomly divided into three experimental groups:

- Group 1: 15 samples – Diamond burs (control group)
- Group 2: 15 samples – Polymer burs
- Group 3: 15 samples – Carie-care gel

The method followed in our study for excavation of carious lesion was similar to that of the method given by Divya et al⁶.

Diamond Bur Method

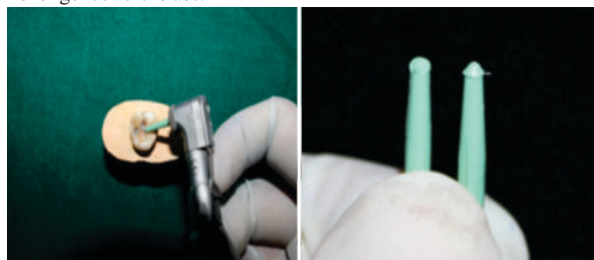
The process of extracting a variety of lesions was executed through the utilization of a round diamond bur, specifically ISO 001/016 (DiaBurs, Mani Medical India,) in conjunction with a gradual speed aerotor handpiece (waldent). The aforementioned procedure was continued until the entirety of the soft dentin was eliminated, and till hard dentin was confirmed.



Caries removed by diamond bur method

Polymer Bur Method

The excavation of a carious lesion was done using polymer burs (SmartPrep, SS White Burs) in circular movements from the center of the lesion to periphery till the instrument becomes blunted and should no longer be able to use.



Caries removed by polymer bur polymer bur method

Chemomechanical Method

Carie Care, a therapeutic agent, is administered to the site of dental decay using a disposable applicator tip. Following a brief interval of one minute, the gel is extracted alongside the dissolved carious lesion with the aid of a Sharp Spoon Excavator. This product is presented in a unitary form that can be maintained at a temperature of 4°C for a period exceeding six months.



Caries removed by Carie Care

The duration necessary for the comprehensive excavation of caries from all specimens will be recorded in seconds via the utilization of a stopwatch. The verification of the presence of infected dentin will be performed by means of caries detecting dye (neodetect dye) for a duration of 10 seconds, succeeded by a 10-second water rinse. The presence of infected dentin was detected by using neodetect which contains micronized methylene blue solution which helps in visual demarcation between infected carious dentin and remineralizable sound dentin by its capability to selectively stain the carious dentin. The effectiveness was subject to a numerical grading system ranging from 0 to 5, as proposed by Prabhakar A et al². In order to replicate the conditions of the oral environment, the specimens were immersed in artificial saliva for a duration of 14 days. Upon completion of the decoding process, scanning electron microscope set at magnifications of 5000 to evaluate the efficacy of various caries excavation techniques in removing the smear layer. The grading system employed was the one that was established by Somani R et al⁷. The cavities were subjected to etching through the use of 37% phosphoric acid, followed by a rinsing period of 15 seconds. A bonding agent was then applied and subsequently cured for an additional 15 seconds. The composite build-up, specifically the 3M Filtek, was applied and cured. The restored cavities were then subjected to a universal testing machine at a crosshead speed of 1 mm/s to determine the fracture resistance of the teeth. The scores pertaining to the time required for complete caries

removal, confirmation of the presence of infected dentin using dye, efficacy of smear layer removal, and fracture resistance will be subjected to statistical charting and analysis using Kruskal-Wallis & by chi-square test.

RESULTS:

The data were analyzed between all the groups to determine the significant difference between them. The mean value of time duration for caries removal by diamond bur group (1.2 minutes) was less than polymer bur group (3.5 minutes) and Carie-care gel group (6.8 minutes). The mean value of staining was more in polymer bur group and carie care gel group, as only infected dentin was removed preserving affected dentin. There was minimal staining in the diamond bur group as both infected and affected dentin were removed. SEM evaluation at 4.5 kV and 10 Pa vacuum viewing status at a magnification of $\times 2500$ and $\times 5000$ was assessed for the smear layer removal using different caries excavation methods. Diamond bur (group 1) showed low to moderate smear layer with visible dentinal tubules whereas Polymer bur (group 2) showed dense smear layer with few visible dentinal tubules. Carie care gel (group 3) showed dense smear layer with variable amount of dentinal tubules occlusion. The diamond bur group has shown highest fracture resistance. The polymer bur group, though exhibiting less amount of smear layer compared to cariecare gel group showing moderate fracture resistance.

Table 1: Comparison Of Time Taken For Complete Caries Removal Between The 3 Groups By Kruskal-wallis Test

Group 1,2,3 (minutes)					
GROUPS	N	MEAN	STD. DEVIATION	CHI-SQUARE	SIGNIFICANCE
Group 1	15	1.2640	.23922	39.192	0.00
Group 2	15	3.5307	.46816		
Group 3	15	6.8167	.66607		
Total	45	3.8704	2.35449		

Table 2: Comparison Of For Complete Caries Removal Between The 3 Groups By Chi-square Test

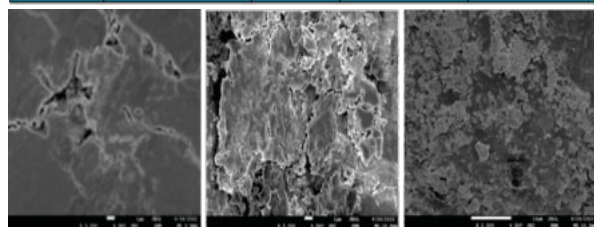
CHI-SQUARE Test Ranks				
Method	N	Mean Rank	CHI-SQUARE	SIGNIFICANCE
1	15	8.70	31.161	0.000
2	15	34.20		
3	15	26.10		
Total	45			

Table 3: Comparison Of Efficacy Of Smear Layer Removal Between The 3 Groups By Chi-square Test

CHI-SQUARE TEST					
	PARAMETER 3	N	MEAN RANK	CHI-SQUARE	SIGNIFICANCE
Groups	1	15	8.00	44.000	0.000
	2	15	23.00		
	3	15	38.00		
	Total	45			

Table 4: Comparison Of Fracture Resistance Between The 3 Groups By Chi-square Test

CHI-SQUARE TEST				
	PARAMETER 4	N	MEAN RANK	SIGNIFICANCE
Groups	1	15	1.43	0.000
	2	15	0.95	
	3	15	1.32	
	Total	45		



Group 1

Group 2

Group 3

DISCUSSION:

The introduction of the concept of minimally invasive dentistry (MID) has been spurred by an improved comprehension of the dental caries process and the recognition that restorative procedures are not a panacea for decayed teeth. This approach is characterized by the utilization of biological methods to manage dental caries while conserving as much healthy tooth tissue as possible, as opposed to conventional invasive operative dental techniques.⁸ Hence, the primary objective of the present investigation was to assess the efficacy of minimally invasive caries removal techniques, including polymer burs and **Carie-care** gel, in terms of smear layer removal and fracture resistance of teeth that have been restored with composite. A comprehensive experiment was conducted in order to achieve a higher degree of correlation between various factors that influence caries excavation methods & ultimate longevity including the duration of time for caries excavation, verification of affected dentin through staining with dye, as well as the evaluation of residual smear layer and fracture resistance.

As per the results obtained, the mean time duration for complete caries removal by **Group 1** (diamond bur group – Avg=1.2 minutes) was less. The reason for the observed effect may be attributed to the high rotational speed of the diamond bur, which exceeds 20,000 rpm. This high speed creates a frictional force that presents a negative rake angle and results in the abrading of the tooth surface, rather than the cutting of the tooth structure during cavity preparation. This phenomenon has been documented in previous research studies. Conversely, in the **Group 2** (polymer bur group- Avg= 3.5 minutes), the time duration for excavation of carious lesion was more prolonged due to the much lower rotational speed of the bur, which ranged from 500 to 800 rpm. Furthermore, the path taken by the instrument while removing the infected dentin was different, and the polymer bur was less hard than healthy dentin, with a hardness of only 50 KHN as compared to the healthy dentin's 66-80 KHN. These results are in line with those obtained in a study by Kittur M et al.¹ Likewise, the length of time required for complete excavation of caries with **Group 3** (Cariecare gel group- Avg= 6.8 minutes) is greater in comparison to the other two groups due to the involvement of multiple steps in the caries removal procedure, which is akin to the investigation conducted by Ashish, Katiyar et al.⁹

The presence of infected dentin was detected by using neo-detect which contains Micronized Methylene Blue Solution which helps in visual demarcation between infected carious dentin and remineralizable sound dentin by its capability to selectively stain the carious dentin. The staining was more in polymer bur group and carie care gel group. The staining was more in polymer bur group (**Group 2**) and v-carie care gel group (**Group 3**), as only infected dentin was removed preserving affected dentin. There was minimal staining in the diamond bur group (**Group 1**) as both infected and affected dentin were removed. There was minimal or no staining in the diamond bur group as both infected and affected dentin were removed.

Assessment of the smear layer removal using different caries excavation methods and graded them as reported by somani R et al.⁷ was done. It was found that the diamond bur group showed very few occluded dentinal tubules, indicating presence of less amount of smear layer. The reason could be due to very high rotational speed of the bur with a continuous water jet that flushes away the smear layer. Polymer bur (group 2) showed dense smear layer with few visible dentinal tubules whereas Carie care gel (group 3) showed dense smear layer with variable amount of dentinal tubules occlusion.⁸ The probable reason attributed could be non involvement of rotary instrumentation¹ in case of Carie care gel (group 3). The hypochlorite present in other Cmer is responsible for the smear layer removal due to amino acid degradation and hydrolysis of the collagen. Thus, smear layer can be easily washed away while toileting of the cavity.¹ However, the mechanism of action for cariecare differs. It consists of papain but, it lacks in the hypochlorite and hence the aggressive effect of sodium hypochlorite-based chemomechanical caries removal agent is not present.

Fracture resistance is directly associated with the amount of smear layer present on the surface of dentin which ultimately contributes to development of resin-dentin interdiffusion zone. The diamond bur group has shown highest fracture resistance as the retention of smear layer was minimal leading to stronger resin-dentin inter-diffusion zone. The polymer bur group, though exhibiting least amount of smear

layer compared to cariecare gel, forms a weak resin-dentin interdiffusion zone. The teeth under cariecare gel group have shown **moderate fracture resistance which could be due to** effect of storage medium and sterilization.¹⁰

CONCLUSION

According to this study, although Diamond bur method is most efficient in caries removal, carie care gel gives better result when compared to Polymer bur method in terms of efficacy as well as fracture resistance. The combined effect of carie care gel with diamond bur can reduce the risk of pulp exposure and post operative sensitivity. Further studies need to be done in order to evaluate the effect of using carie care gel with diamond bur.

REFERENCES

1. Kittur M, Ghivari S, Pujar M. Comparative evaluation of efficacy of two minimally invasive caries removal techniques on fracture resistance of the teeth restored with composite: An SEM study. *Journal of Conservative Dentistry: JCD*. 2021 Mar;24(2):204.
2. Prabhakar A, Kiran NK. Clinical Evaluation of Polyamide Polymer Burs for Selective Carious Dentin Removal. *J Contemp Dent Pract* 2009 July; (10)4:026-034
3. Ismail MM, Al Haidar AH. Evaluation of the efficacy of caries removal using papain gel (Brix 3000) and smart preparation bur (in vivo comparative study). *Journal of Pharmaceutical Sciences and Research*. 2019 Feb 1;11(2):444-9.
4. Silva Júnior, Z. S. et al. Papain gel containing methylene blue for simultaneous caries removal and antimicrobial photoinactivation against *Streptococcus mutans* biofilms. *Sci. Rep.* 6, 33270; doi: 10.1038/srep33270 (2016).
5. Sontakke P, Jain P, Patil AD, Biswas G, Yadav P, Makkar DK, Jeph V, Sakina BP. A comparative study of the clinical efficiency of chemomechanical caries removal using Carie-Care gel for permanent teeth of children of age group of 12–15 years with that of conventional drilling method: A randomized controlled trial. *Dental research journal*. 2019 Jan;16(1):42.
6. Divya G, Prasad MG, Vasa AA, Vasanthi D, Ramanarayana B, Mynampati P. Evaluation of the efficacy of caries removal using polymer bur, stainless steel bur, carisolv, papacarie – An in vitro comparative study. *J Clin Diagn Res*. 2015;9:ZC42–6.
7. Somani R, Jaidka S, Jawa D, Mishra S. Comparative evaluation of smear layer removal by various chemomechanical caries removal agents: An in vitro SEM study. *J Indian Soc Pedod Prev Dent*. 2015;33:204–7
8. Nada, a., Alsufayan., David, Patrick. Minimally invasive dentistry and dental caries management: a scoping review. (2021);10(2):575-587. doi: 10.46344/ JBINO. 2021. V10I02.22
9. Ashish, Katiyar., Sukriti, Gupta., Kirtija, Gupta., Karuna, Sharma., Bhoomika, Tripathi., Nitin, Sharma. (2021). Comparative Evaluation of Chemo-mechanical and Rotary-mechanical Methods in Removal of Caries with Respect to Time Consumption and Pain Perception in Pediatric Dental Patients.. *International Journal of Clinical Pediatric Dentistry*, Available from: 10.5005/JIP-JOURNALS-10005-1896
10. Lee JJ, Netter-Marbell A, Cook AJr, Pimenta LA, Leonard R, Ritter AV. Using extracted teeth for research: the effect of storage medium and sterilization on dentin bond strengths. *J Am Dent Assoc*. 2007 Dec;138(12):1599-603. doi: 10.14219/jada. archive. 2007.0110. PMID: 18056105.