ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 4, Issue – 5, October - 2021, Page No. : 320 - 329

Comparative evaluation of the efficacy of sdf with that of various caries excavating methods- an in-vitro study

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Citation of this Article: Dr Hridya V G, Dr Shipra Jaidka, Dr Rani Somani, Dr Aiswarya Madhu, Dr Muhamed Sabin A P, Dr Layeeque Ahmad, "Comparative evaluation of the efficacy of sdf with that of various caries excavating methods- an in-vitro study", IJDSIR- October - 2021, Vol. – 4, Issue - 5, P. No. 320 – 329.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Background: SDF is a novel means of caries prevention with minimal intervention which mainly focuses on the remineralization of lesion. If it could achieve the same microhardness after caries management as that of conventional caries removal techniques then this atraumatic method can be a boon to pediatric dentistry.

Aim: Comparative evaluation of the efficacy of Silver Diamine Fluoride (SDF) without removal of caries with that of various caries excavation methods.

Material and methods: Present study was conducted on 48 extracted molars with caries involving dentin and these were further divided into 4 categories. Group A - 38% SDF solution application; Group B - caries removal using spoon excavator; Group C- using smart burs and Group D- using diamond burs. All teeth were sectioned mesiodistally into two samples with disc bur creating 96 sections. One half of the sectioned tooth was used to evaluate the baseline microhardness and to the other half was experimental where caries was removed according to respective groups. Microhardness was again measured post-operatively.

Statistical Analysis: Statistical analysis was done by Analysis of Variance (ANOVA) and Post-Hoc Test (Tukey-HSD) using SPSS Version 19.0.

Results: The differences in the mean values of baseline microhardness of remaining dentin thickness before caries removal was statistically insignificant in all groups ($p>0.05$). The mean values of microhardness as well as percentage increase in microhardness after caries removal was highest in Group D(60.35) and lowest in Group B (30.24)

Conclusion: SDF can be used as an efficient atraumatic adjunct in caries management especially in paediatric patients

Keywords: Caries excavation, Dentin thickness, Microhardness

Introduction

Dental caries is a global pandemic and is the most common disease afflicting mankind. Its treatment in children is virtually non-existent in rural areas having prevalence of 92.4% with the untreated caries.[1] the reason for the same can be attributed to the less knowledge regarding the factors associated with caries, dental care needs and also due to less accessibility to healthcare services.[2,3] Inspite of the increase in the number of dental professionals, the dentist population ratio is still 1: 1.5 lakh people in the rural areas of India whereas India has one dentist per 10000 people in urban areas [2] So it becomes virtually important to have a technique of caries prevention/management which is cost effective, less time consuming and can be applied without adequate armamentarium.

Conventional caries excavation involved the use of drill in a highspeed handpiece with diamond burs to gain access to carious lesions. This method requires proper armamentarium and at times can be traumatic to the pulp due to pressure, thermal changes and vibration. But it is the best available method for complete caries removal.

An alternative for diamond burs, is the use of polymer burs(smart burs). These were first introduced by SS White Co for selective removal of caries. The material has a knoop hardness number greater than carious dentin and less than normal dentin.[4] Thus it only removes infected dentin and less affected dentin, which has the capacity of remineralisation.

The search of simpler, effective methods resulted in the introduction of Alternative Restorative Treatment (ART) in India in 1988.[5] It involves the removal of soft demineralised tooth structure using hand instrument alone, followed by restoration with an adhesive restorative material, routinely glass sionomer. It was initially developed to provide effective restorative treatment in developing countries where electricity may not be available. The initial anxiety of preschool children was greatly decreased, and high acceptability rate for the ART procedure was found in young children.[6]

Further a Chemomechanical caries removal system involving the application of a gel, which is applied, to the caries affected area of the dentin, softening the diseased portion of the tooth, while healthy tissue is preserved. The softened carious dentin is removed with special instruments and the treatment is quiet effective. The remaining dentin is sound, properly mineralized and well suited for restoration and bonding to modern restorative materials. But studies have indicated the complete removal of carious dentin is difficult with the treatment and that the possibility of remaining caries following the treatment is a major concern.

The latest addition to the caries prevention armamentarium is Silver Diamine Fluoride (SDF). SDF being first introduced in market for hypersensitivity and became the first dental product to get the breakthrough therapy status for dental caries by Food and Drug Administration (FDA) recently in 2016. SDF is currently considered an effective preventive and therapeutic agent for caries management in preschool children due to its safe, simple, low-cost and effective treatment.[7] In Silver Modified Atraumatic Restorative Treatment (SMART), it is reported that removal of infected lesion is not required prior to restoration with glass ionomer cement(GIC), thus it can be applied to large number of people with minimum armamentarium. The antibacterial and remineralizing effects of SDF results in the caries

arrest[8]. A review concluded SDF as an effective, efficient, equitable and safe caries-preventive agent appearing to meet the World Health Organization's Millennium Goals for 21st century dental care.

Conventionally the tooth is considered caries free only when hard dentinal structure is reached. So the recent non caries removal technique can be accepted only if the remaining dentin hardness is comparable with that of conventional caries removal techniques.

Thus, the present study was carried out to comparatively evaluate the efficacy of SDF without removal of caries with that of various caries excavation methods.

Material and methods

This present study was conducted in the Department of Paediatric And Preventive Dentistry at DJ College of Dental Sciences & Research in collaboration with the Cosmo Anaytical Lab, Noida. 48 extracted molars with caries involving dentin up to varying degree fulfilling the inclusion criteria were collected from the Department of Oral and Maxillofacial Surgery(Figure 1). Informed consent was taken from the patients before using the teeth.

Preparation of samples

All the samples were autoclaved (121 degree Celsius, 15 lbs. for 15 min.) and cleaned using ultrasonic scaler to remove the debris. All the selected teeth were used within 3 month of collection as per recommendations of Occupational Safety and Health Administration (OSHA). Prior to treatment, each caries lesion was analyzed according to Erickson's criteria checking the color (brown- to- black), hardness of the lesion i.e., medium consistency (resistance to probing but readily penetrated when tested with a sharp probe).

To prevent dehydration of the samples, they were stored in saline, marked and labelled. All the sample teeth were taken out with a tweezer and sectioned through the middle of the carious lesion mesiodistally into two samples with disc bur using micromotor with constant irrigation with saline.

Division of samples

One of the sectioned halves of each tooth were marked with blue color and was used to evaluate the baseline (pre-op) microhardness level, and the other half of the section was used as experimental group from which caries was removed utilizing various means. Thus the collected 48 molars gave 96 sections and these were further divided into 4 categories and color coded accordingly(group a- brown, Group B- purple, Group C-red and Group D- pink). (Figure 2) A single line of the respective color was drawn around the neck of each section. The sections obtained from each tooth were kept separately in Ziplock covers.

Evaluation of Pre-Op Microhardness

The evaluation of pre-op surface microhardness of carious dentine of all the samples of the groups (A_1, B_1, C_1, D_1) were measured by means of a Vickers Microhardness Tester Machine one by one. The pointer of the machine made an indentation on it with 100 grams of force for 15 seconds using a diamond indenter with square base having an angle of 136 degree between the opposite sides. (Figure 3) . Upon completion of indentation, the two diagonals were measured and average value was considered. Four indentations per test was performed on each sample during each experiment and the mean value derived represented the microhardness. These results served as baseline for the comparison for the increase in post-op microhardness.

Methodology

Each section was removed from saline using tweezer and washed under water for 1 minute and section was held in hand during the caries removal. The following procedures were used for the caries removal in respective groups.

D1. Caries Removal in Each Group:

Group A_2 - 38% SDF solution was applied on the carious lesion using microtip for 3 minutes. The excess solution was removed using cotton pellets.

Group B_2 - the caries were removed using spoon excavator until all the soft caries were removed.

Group C_2 - caries were removed using smart burs using micromotor with slow and intermittent speed.

Group D_2 - caries were removed using diamond burs. An assistant was appointed to irrigate the sample throughout the procedure.

The completion of caries removal was checked using Erickson's criteria [optical (colour) and tactile (hardness)]. The colour was checked visually and hardness of the lesion was checked by the dental explorer until a leather-hard texture and sharp scratching sound was heard. Once the caries removal was confirmed, sample (post-op) was kept in an empty bottle and was evaluated for hardness removal within half an hour.

Microhardness Evaluation

Samples of all the groups were smoothened with 500 and 600 grit sandpapers. Standardized blocks for determination of microhardness were prepared using blacklite powder by the laboratory technician. The samples were mounted in such a way that the cavitated part was exposed to external environment. (Figure 4) Samples were tested one by one in the Vickers Microhardness Tester Machine similar to baseline measurement(figure 5).

Statistical analysis

After the data collected, it was tabulated and then the statistical analysis was done using SPSS Version 19.0. The Analysis of Variance (ANOVA) used in the study to analyze the difference between the means of more than two groups and one way ANOVA was choosed because here only one independent variable is used. Since an overall statistically significant difference in group means was obtained, a Post-Hoc Test (Tukey-HSD) were performed to confirm where the differences occurred between groups, to know the effect of each variable and to reveal the statistical significance. For the purpose of statistical interpretation p value of 0.05 was considered statistically significant.

Results

The mean values of baseline microhardness of remaining dentin thickness before caries removal by Group A(SDF), Group B(ART), Group C(Smart Burs), Group D(Diamond Burs) were 20.23, 20.67, 20.6 and 21.68 respectively. It was noted that the mean score of microhardness of remaining dentin removal was higher in group D and approximately in similar range in group A, group B and group C but these differences were not found statistically significant when subjected for Tukey's post hoc analysis. (Table 1).

The mean values of microhardness of remaining dentin thickness after caries removal was again highest in Group D (60.35) followed by Group A (54.38), Group C(35.64), and lowest in Group B (30.24). Intergroup comparison of postop microhardness found all the groups were statistically significantly different.(Table 2)

The mean values of the percentage increase in microhardness of remaining dentin thickness after caries removal (post-op) was highest in Group D(178.6), followed by Group A(168.9S), followed by Group C (73.2) and least in Group B(46.38). The intergroup comparison of percentage increase found that almost all the groups showed statistically significant difference (except for group A and group D) at p value <0.05. (Table 3)

Discussion

World Health Organization (WHO) recognizes dental caries as a pandemic and reports that the prevalence of dental caries among school children is 60 to 90%. According to National Oral Health Survey caries

prevalence in India was 51.9% at age 5 years(yrs), 53.8% 12 yrs and 63.1% at 15 yrs respectively.[9] In paediatric population, dental carries affect general health, nutrition and psychological attitude so it is advisable to find a way to combat this in childhood itself and prevent it. so we need to device various ways beneficial to provide faster and better treatment

The use of various instruments which are available for removing carious lesion, is always questionable in rural areas and camps because of lack of appropriate resources like electricity, water, drainage etc. Moreover these instruments at times lead to the removal of sound dentine too along with the carious dentine which lead to the weakening of the remaining tooth structure along with pain and sensitivity because of the exposed dentinal tubules. The method without affecting the remaining dentin thickness and capable of remineralization is the ultimate goal of restoration.

The findings of this research showed that the conventional diamond burs in group four showed the maximum increase in microhardness after caries removal when compared to all the other three groups. This can be because of the high knoop hardness 7000KHN of diamond burs when compared to the KHN of sound dentin 70-90KHN thus has greater cutting efficiency ,and it removes both affected and infected dentin. Also the bur method of excavation tended to overprepare cavities due to lack of sensitivity of the tactile feedback. According to AnwarAS(2017) the operator could not identify the true clinical end point, so the excavation procedure continued into healthier dentin leading to microhardness comparable to hard dentin.[4]

Increase in microhardness after caries removal by SDF treatment was found to be statistically significant when compared to ART and Smart burs while was non-significant when compared to carious removal by diamond burs. The non-significant results when compared to diamond burs can be substantiated by the ability of SDF to promote the remineralisation of hydroxyapatite in dentine and this was concurred with a previous study.[10] In a study by M.L. Mei (2013) it was concluded that SDF at 38% has high fluoride content of 44600ppm, which promotes the formation of insoluble calcium fluoride, and its high alkalinity creates ideal conditions for ion exchange releases fluoride ions.[11] Fluoride effectively prevents dental caries by inhibiting demineralization and promoting remineralization thus improving its microhardness drastically.[12] Moreover with SDF it was reported to even leave the organic part of caries intact (infected dentin) before application. According to Firouzmandi M(2020) application SDF Forms silver-protein conjugate on decayed dentin, thus increasing resistance to acid dissolution and SDF also preserves collagen by the release CaF which then gets deposited as a dense layer of clustered granular structure on the collagen fibers of tubular wall dentin. In addition to it, SDF in oral environment will also inhibit proteins that break down exposed dentin organic matrix like collagenases, MMP 2, MMP 8, MMP 9 and Cathepsins and thus prevents demineralization due to carious activity.[13]

In group three, the caries excavation was done with smart burs and the percentage increase in microhardness after caries removal was found to be significantly lower when compared to SDF and diamond bur. Smart burs being made with polyamide ketone has knoop hardness number of 50KHN. Since the KHN of smart bur is less than sound dentin (70-90 KHN), it become blunt when it comes in contact with it and removes only demineralization infected dentin (0-30KHN). A study done by ShakyaVK ,Chandra A, Tikku AP (2012) on comparative evaluation of dentin caries removal with polymer bur and

conventional burs it was concluded that the smart prep bur is more conservative in caries removal and showed decreased microhardness than conventional burs.[14]

The carious lesions removed by ART(Group B)showed the least increase in microhardness after caries removal. The most important reason for the same is due to the inefficient removal of carious dentine because of the use of hand instruments only which results in reduced microhardness of remaining dentin even after caries removal. Press finger technique which is unique to clinical ART protocol especially using spoon excavators to remove carious dentin, causes a rough restoration surface with irregular margins, supporting potential plaque and soft caries lesion retention.[15] Moreover Molina GF (2009) reported that, the size of the opening of the cavity appears to have an effect on the level of cleanliness of the cavity in occlusal surfaces.[16] If it is a non cavitated or cavitated lesion with narrow opening it becomes difficult to clean the cavity or remove the infected dentin appropriately.

Thus, according to the study and results, SDF can be suggested as an alternative for caries removal in rampant caries in young population especially in mass population treatment camps and in rural areas. We recommend further studies to authenticate the results of this hassel free alternative method for caries removal.

Conclusion

The percentage increase in microhardness of the residual dentin after use of SDF was found comparable with Diamond Burs. Thus it is recommended that SDF can be used as an efficient and atraumatic adjunct in caries removal especially in paediatric patients.

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Legend Figure and Tables

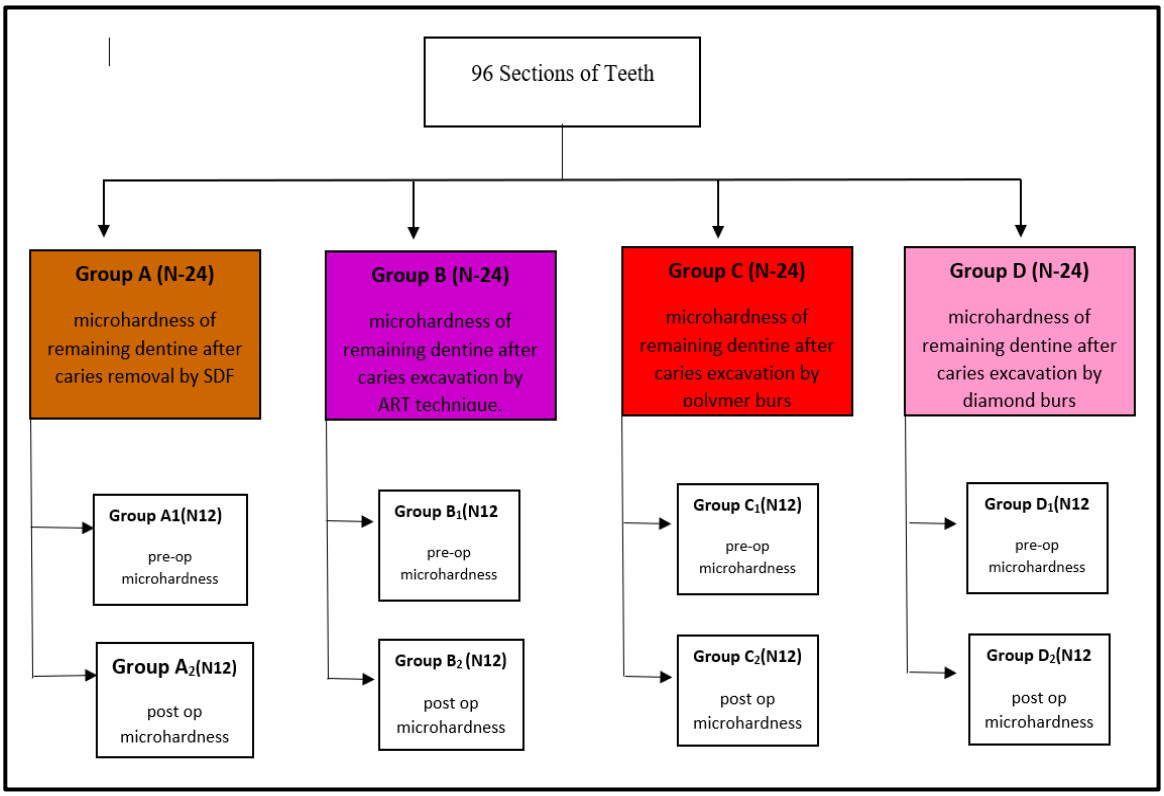

Figure 2: Samples ued in the study

Figure 3: vickers microhardness evaluation.

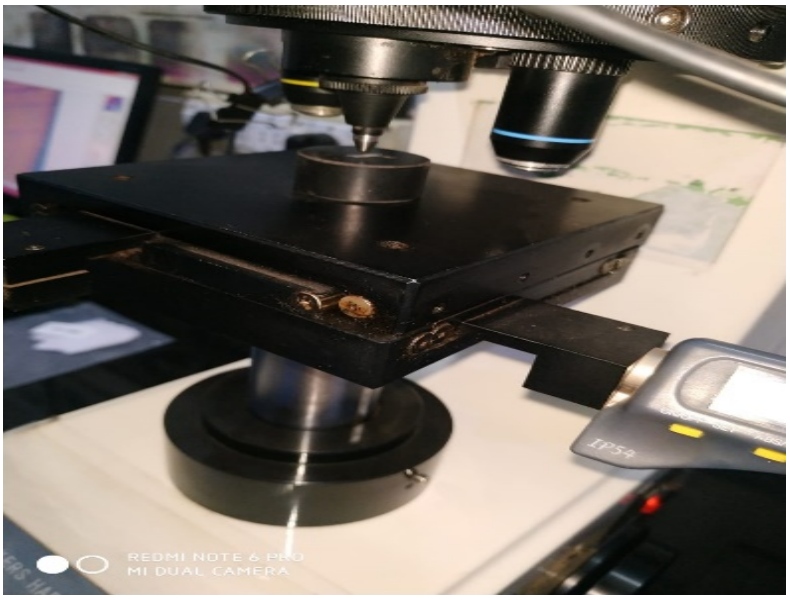

Figure 4: Blacklite powder mould for microhardness eveluation.

Figure 5: Light microscope images of well shaped indentations on dentin. a) pre-op sample b) post-op sample

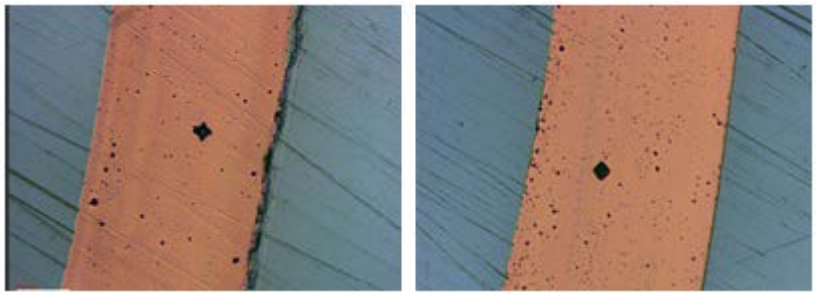

Table 1: Comparison of microhardness before caries removal in various groups by one way ANOVA.

Groups	N	Mean	Std. Deviation	Std. Error	95% confidence interval for mean		F-value	p-value
					Lower bound	Upper bound		
Group A	12	20.23	0.6773	0.2042	19.847	20.613	2.120	0.123
Group B	12	20.67	1.3136	0.3960	19.927	21.413		
Group C	12	20.6	1.0887	0.3282	19.984	21.216		
Group D	12	21.68	1.1487	0.3463	21.030	22.330		
Post-hoc analysis								
(I) GROUP		(J) GROUP	Mean Difference (I-J)	Sig.	95% Confidence Interval			
					Lower bound	Upper bound		
Group A		Group B	-.44167	0.751	-1.6219	.7386		
		Group C	-.36667	0.840	-1.5469	.8136		
		Group D	-1.45000*	0.011	-2.6303	-.2697		
Group B		Group C	.07500	0.998	-1.1053	1.2553		
		Group D	-1.00833	0.118	-2.1886	.1719		
Group C		Group D	-1.08333	0.082	-2.2636	.0969		

*p value <0.05 Significant

Table 2: Comparison of microhardness after caries removal in various groups by one way ANOVA.

Groups	N	Mean	Std. Deviation	Std. Error	95% confidence interval for mean		F-value	p-value
					Lower bound	Upper bound		
Group A	12	54.38	1.6775	0.5058	53.431	55.329	678.377	>0.001*
Group B	12	30.24	1.6675	0.5027	29.297	31.183		
Group C	12	35.64	1.1681	0.3521	34.979	36.301		

Group D	12	60.35	2.1823	0.6580	59.115	61.585		
Post-hoc analysis								
(I) GROUP			(J) GROUP	Mean Difference (I-J)	Sig.		95% Confidence Interval	
							Lower bound	Upper bound
Group A			Group B	24.14167*	<0.001*		22.2757	26.0077
			Group C	18.74167*	<0.001*		16.8757	20.6077
			Group D	-5.96667*	<0.001*		-7.8327	-4.1007
Group B			Group C	-5.40000*	<0.001*		-7.2660	-3.5340
			Group D	-30.10833*	<0.001*		-31.9743	-28.2423
Group C			Group D	-24.70833*	<0.001*		-26.5743	-22.8423

*p value <0.05 Significant

Tables 3: Comparison of mean percentage increase in microhardness after caries removal in various groups by one way ANOVA.

Groups	N	Mean	Std. Deviation	F-value	p-value
Group A	12	168.9	9.7168	77.471	0.001*
Group B	12	46.38	5.4129		
Group C	12	73.2	6.7992		
Group D	12	178.6	12.0863		
Post-hoc analysis					
(I) GROUP	(J) GROUP	Mean Difference (I-J)	Sig.	95% Confidence Interval	
				Lower bound	Upper bound
Group A	Group B	122.52500*	<0.001*	112.8363	132.2137
	Group C	95.68333*	<0.001*	85.9946	105.3721
	Group D	-9.75000*	0.051	-19.4387	-.0613
Group B	Group C	-26.84167	<0.001*	-36.5304	-17.1529
	Group D	-132.27500*	<0.001*	-141.9637	-122.5863
Group C	Group D	-105.43333*	<0.001*	-115.1221	-95.7446

*p value <0.05 Significant