Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(2), 301-312 | ISSN:2251-6727

“Does the Method of Caries Excavation Affect the Bond Strength of Restoration in Primary Teeth?”

Dr Priyanka Jade, Dr Preetam Shah, Dr Shweta Jajoo, Dr Krishna Patil, Dr Laxmi Lakade, Dr Chetana Jagtap

Dr Priyanka Jade, Postgraduate student, Bharati Vidyapeeth (Deemed to be University) Dental College and Hospital, Pune

Dr Preetam Shah, Professor, Department of Pediatric and Preventive Dentistry, Bharati Vidyapeeth (Deemed to be University) Dental College and Hospital, Pune,

Dr Shweta Jajoo, Assistant Professor, Department of Pediatric and Preventive Dentistry, Bharati Vidyapeeth (Deemed to be University) Dental College and Hospital, Pune,

Dr Krishna Patil, Assistant Professor, Department of Pediatric and Preventive Dentistry, Bharati Vidyapeeth (Deemed to be University) Dental College and Hospital, Pune,

Dr Laxmi Lakade, Associate Professor, Department of Pediatric and Preventive Dentistry, Bharati Vidyapeeth (Deemed to be University) Dental College and Hospital, Pune,

Dr Chetana Jagtap, Assistant Professor, Department of Pediatric and Preventive Dentistry, Bharati Vidyapeeth (Deemed to be University) Dental College and Hospital, Pune,

(Received: 07 January 2024 Revised: 12 February 2024 Accepted: 06 March 2024)

KEYWORDS

Method of Caries, Bond Strength, Primary Teeth

ABSTRACT:

Traditionally caries excavation has been performed according to mechanical principles using rotary and sharp-edged hand instruments. Although these methods are often effective, have some major disadvantages. It is difficult to establish the amount of dentin to be removed due to the apparent lack of objective clinical markers. Secondly, need for local anesthesia to alleviate the pain and discomfort caused by mechanical methods. To circumvent these drawbacks, alternative minimally invasive caries excavation techniques, including laser ablation, air abrasion, sonic abrasion, and chemo-mechanical caries removal were introduced. They are characterized by a common feature of selective removal of caries-infected tissue and leaving the caries-affected tissues intact.

INTRODUCTION

Traditionally caries excavation has been performed according to mechanical principles using rotary and sharp-edged hand instruments. Although these methods are often effective, have some major disadvantages. It is difficult to establish the amount of dentin to be removed due to the apparent lack of objective clinical markers. Secondly, need for local anesthesia to alleviate the pain and discomfort caused by mechanical methods.[1] To circumvent these drawbacks, alternative minimally invasive caries excavation techniques, including laser ablation, air abrasion, sonic abrasion, and chemo-mechanical caries removal were introduced. They are characterized by a common feature of selective removal of caries-infected tissue and leaving the caries-affected tissues intact.[2]

Caries-affected dentin is characterized by a marked reduction in mineral content, loss of crystallinity, and alteration of the organic matrix.[3] There have been two schools of thought, as few studies reported higher bond strengths of etch-and-rinse adhesives than self-etching adhesives to caries-affected dentin.[4,5] On the other hand, few studies have claimed that acid etching might lead to further loss of inorganic content of the caries-affected dentin. [6,7] Omar et al considered self-etching adhesives the “preferred adhesive” for bonding to the wetter, caries-affected dentin, due to its hydrophilic nature. [8] As the selection of an appropriate self-adhesive system compatible with caries-affected dentin makes it difficult

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(2), 301-312 | ISSN:2251-6727

for clinicians, bonding to caries-affected dentin is a controversial topic in adhesive dentistry.

Several studies reported have evaluated the nano leakage patterns and micro tensile bond strengths of self-etching adhesives bonded to residual dentin following chemo-mechanical caries removal. However, very few studies have examined the comparative effect of mechanical and chemo-mechanical caries removal agents on bonding to caries-affected dentin in primary teeth.

Thus, this study aims to compare the effect of mechanical and enzyme-based chemo-mechanical caries removal methods on bonding of self-etch adhesive to caries-affected dentin in primary teeth.

METHODOLOGY

In this study, 20 carious primary molars, extracted due to physiologic mobility and/or orthodontic reasons, caries on occlusal/proximal surfaces extending to dentin were selected. (Fig 2) Grossly carious teeth, teeth affected due to developmental anomalies, and teeth fractured while extraction were excluded. Protocols in cross-infection control as per occupational safety and health administration regulations were observed. These teeth were stored in 2% formalin for 14 days and subsequently in a saline solution. Twenty primary molars were then randomly divided into two experimental study groups.

After obtaining clearance from the Institutional Ethics Committee, the study was carried out in the: Department of Pediatric Dentistry, Bharati Vidyapeeth Deemed University Dental College and Hospital, Pune. In all selected teeth, a caries-detecting dye was used to detect the extent of caries and to define the carious lesion, leaving lightly stained pink "caries-affected" dentin as per the manufacturer's instructions. (Fig 3) **Group A:** BRIX3000 (Brix Srl Argentina) was applied with a blunt spoon excavator allowing it to work for 3 min. Once the applied gel turned turbid, it was removed by using a spoon excavator. This procedure was repeated till the healthy dentin was obtained. When applied for a second or third time, no color change in the gel was observed, which indicated that there was no presence of carious infected tissue. (Fig 4a, 4b, 4c). **Group B:** Caries removal by round diamond bur with a contra-angle high-speed handpiece under a cooling system then the cavity was rinsed with water and wiped with a sterile cotton pellet.

After caries removal, in both the experimental groups, Single bond universal (3M ESPE) adhesive was applied following the manufacturer's instructions, followed by light curing of the adhesive for 10 s. [9] (Fig 5a &5b). The cavities were then restored with composite Filtek™ Z250 XT (3M ESPE), as per the manufacturer's instructions. The light-curing unit tip was always held 3 mm from the adhesive or composite resin surface. Resin composite build-ups were constructed incrementally on the polymerized bonding agent in five 1-mm thick layers using a nano-hybrid. The next layer of composite was placed immediately after curing the last one. The hand pressure during the build-up technique was the same for restorations of all teeth. Each layer was light-cured for 40 seconds using the same light-curing unit as before. [10] (Fig 6)

After restorations, both experimental groups were stored in saline at 37^0C for 72 hours separately. Half the specimens of each group were used for micro-tensile bond strength testing using a Universal testing machine, while the remaining specimens were used for nano leakage evaluation under a scanning electron microscope.

Micro tensile bond strength testing

Instruments used: Universal Testing Machine (Computerized, Software-based)

Company: ACME Engineers, India. Model No. UNITEST-10

Accuracy of the Machine: ±1%. Speed: 1mm/min.

For micro tensile bond strength testing, 5 restored teeth from each experimental group were vertically sectioned using a diamond blade in both mesiodistal and buccolingual directions across the bonded interface.[23] (Fig 7). A bonded beam (around 5 mm long) was sectioned from each restored tooth, which consisted of composite, adhesive, and dentin. (Fig 8). Each bonded beam was fixed to the grips of a micro-tensile testing device and tested in tension at 1mm=min until failure in a universal testing machine (ACME Engineers, India. Model No. UNITEST-10) (Fig 9). The bond strength values were converted to MPa and evaluated further.

Journal of Chemical Health Risks
www.jchr.org
JCHR (2024) 14(2), 301-312 | ISSN:2251-6727

Nanoleakage evaluation

Instrument used : FESEM: FEI Nova NanoSEM 450 (Fig 10)

EDS: Bruker XFlash 6I30

Sample preparation and analysis: [22,]Error! Bookmark not defined.

Each bonded tooth was sectioned into halves through the cavity along the mesiodistal plane using a low-speed water-cooled diamond disc. Each bonded tooth was sectioned into halves through the cavity along the mesiodistal plane using a low-speed water-cooled diamond saw. (fig 11). The bonded specimen was coated with two layers of nail varnish within 1 mm of the bonded interface. The specimens were rehydrated in distilled water for 10 min. A modified silver staining technique was used with basic 50 weight% ammoniacal silver nitrate, which was freshly prepared in the Biochemistry Laboratory in Bharati Vidyapeeth Medical College, Pune. The teeth were placed in ammoniacal silver nitrate solution in total darkness for 24 h. This was followed by rinsing under running distilled water for 5 min. Specimens were subsequently exposed to fluorescent light for 8 h in order to reduce the diamine silver ions into metallic silver grains within voids along the bonded interface. Specimens were further rinsed with distilled water for 5 min. They were then ultrasonically cleaned and air-dried. (Fig 12). The samples were mounted on aluminum stubs with an adhesive carbon tape and gold-coated with sputter coater (Fig 13) to analyze the resin-dentin interfaces by Field emission scanning electron microscope (FE SEM; Nova NanoSEM 450) at 20 Kv under backscattered electron mode. Nano leakage pattern was observed under SEM with the technician, Central Instrumentation Facility, Savitribai Phule Pune University, and evaluated qualitatively by the use of scores, following an adaptation of the method suggested by Yuan et al.[11] (Fig 14)

• 0 - No leakage

• 1 - Mild leakage

• 2 - Clear leakage, between 25% and 50% of the evaluated area

• 3 - Large leakage, more than 50% of the evaluated area.[12]

RESULTS

1) Evaluation of tensile and microtensile bond strength of both experimental groups

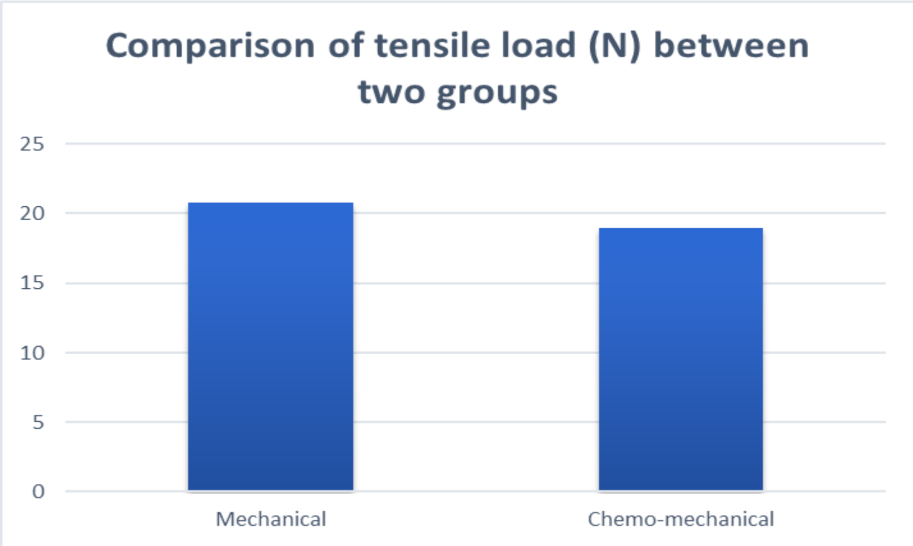
Table 1: Comparison of tensile load (N) between two groups

Group	N	Mean	SD	Difference	p value
Mechanical	5	20.76	4.86	1.78	0.490 (NS)
Chemo-mechanical	5	18.98	2.57		

Independent t test; NS Non-significant difference

This table shows the comparison of tensile load (N) between two groups. Mean tensile load in mechanical caries removal group was 20.76N which was almost similar (p=0.490) to that of tensile load of chemo-mechanical caries removal group (mean=18.98N).

Journal of Chemical Health Risks
www.jchr.org
JCHR (2024) 14(2), 301-312 | ISSN:2251-6727



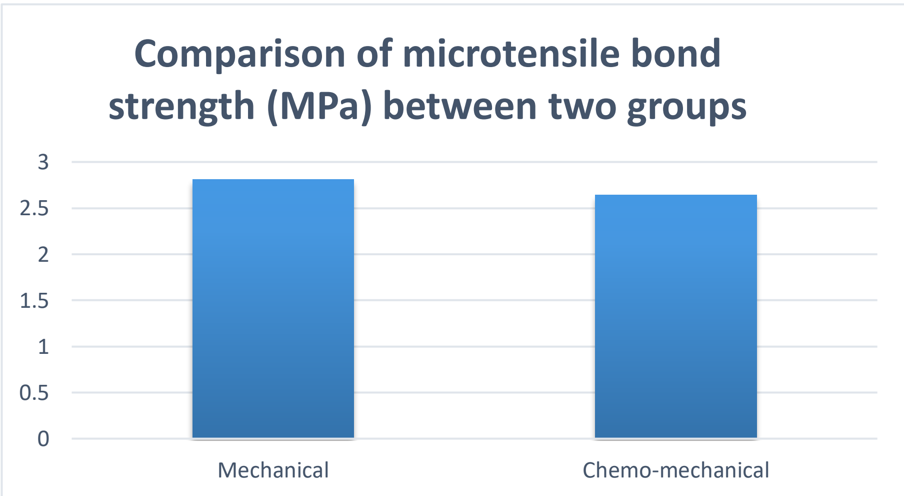
Graph 1 Showing comparison of tensile load between two groups

Table 2: Comparison of microtensile bond strength (MPa) between two groups

Group	N	Mean	SD	Difference	p value
Mechanical	5	2.81	0.14	0.17	0.153
Chemo-mechanical	5	2.64	0.21		

Independent t test

This table shows the comparison of micro tensile bond strength (MPa) between the two groups. Mean micro tensile bond strength (MPa) in the mechanical caries removal group was 2.81MPa which is almost similar to that of the micro tensile bond strength (MPa) of the chemo-mechanical caries removal group (mean=2.64MPa).



Graph 2 showing Comparison of microtensile bond strength between two groups

Journal of Chemical Health Risks
www.jchr.org
JCHR (2024) 14(2), 301-312 | ISSN:2251-6727

2) Evaluation of nanoleakage of both experimental groups

Representative FE-SEM micrographs showing nanoleakage patterns of the bonded interfaces from the mechanical and chemomechanical caries removal are shown in Figure15 and 16 .

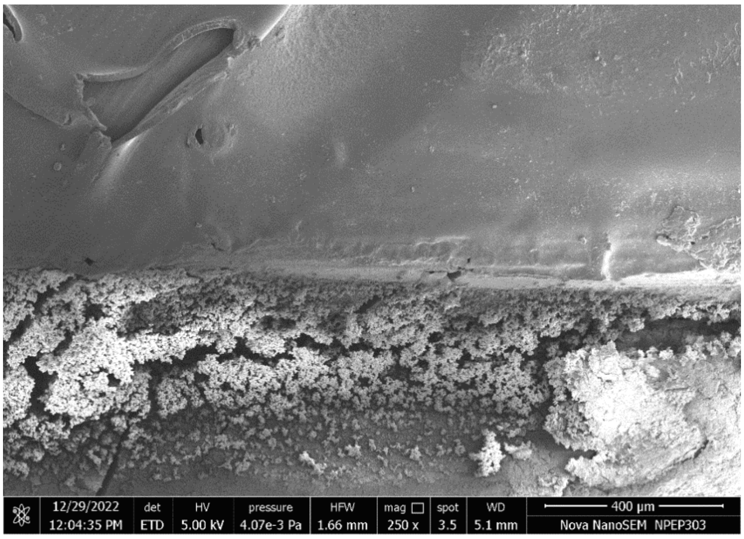


Figure 1 Mechanical Caries removal showing higher silver ion uptake due to presence of smear layer

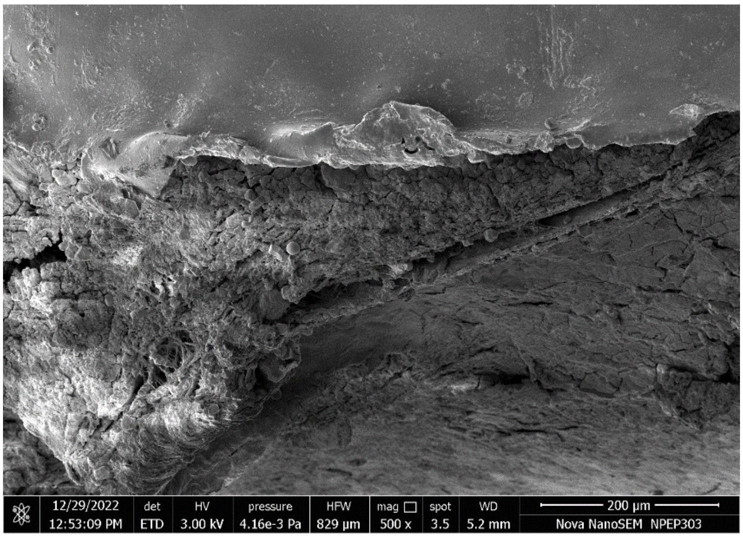


Figure 2: Chemomechanical caries removal showing non uniform hybrid layer

DISCUSSION

In ancient times, caries removal was done with the use of a hand drill, which was later surpassed in 1871 by James Morrison's instrument developed from Issac Singer's sewing machine. This led to the evolution of rotary instruments - from low speed to ultrahigh speed. However, the removal of dental caries using rotary instruments is frequently associated with thermal and pressure effects on the pulp producing pain. Moreover, drilling may also involve the removal of sound tooth tissue adjacent to the caries-affected area. Due to the shortcoming of the drill, alternative techniques such as air abrasion, sonoabrasion, ultrasonic instrumentation, laser, and chemomechanical approach to caries removal were developed. Out of these, air abrasion, sonoabrasion, ultrasonic instrumentation and laser are costly and tooth - sensitive methods and therefore, less frequently used.[27]

Treatment with rotary instruments has progressively amended in accuracy and efficiency for enamel and dentin excavation (Chaussain et al., 2003), however, it is unpleasant to many patients. Moreover, drilling can cause over heating on the pulp, vibration, noise and pain stimulation (require local anesthesia to be reduced) (Mhatre et al., 2011), in addition it may involve the removal of excessive sound tissues that lowering the degree of regenerative potential of the pulp-dentin complex (Heyeraas et al., 2001).

The goal of modern approaches in operative dentistry revolves around the concept of sound tissue preservation. Minimally invasive techniques gained popularity with the advancements in adhesive dentistry, which turns to be a farewell for the traditional perceptions of "extension for prevention." Therefore, operative treatment for caries removal is currently conceptualized as arresting the progression of the lesion and providing a sound restorative foundation by removing only infected soft tissue.[13]

Chemomechanical methods for elimination of carious dentin have so far proved to be promising methods, particularly in pediatric dentistry, medically compromised or anxious patients. They have the ability to identify the superficial and highly infected tissue (infected dentin) from the internal carious tissue (affected dentin), by which they provide pulp protection, which can give a chance for the remineralization of the affected dentin (Banerjee et al., 2000; Lima et al., 2005). Their action take place by the chemical softening of the carious dentinal tissue, which will be removed by a gentle excavation; mean that there is a selective removal of the degraded soft collagen fibrils in the carious infected dentin lesion while preserving the affected demineralized dentin layer.[9]

The idea of chemomechanical caries removal has been developed in 1970s by an endodontist M. Goldman, while using five percent sodium hypochlorite (5% NaOCl) in removing organic materials in the root canals. This chemical got the ability to dissolve carious dentin and since that time, the idea of removing caries by chemical means was borne. The chemomechanical method of caries removal was first introduced in 1975 by Habib et al. by using 5% sodium hypochlorite (NaOCl), followed by introduction of GK-101 in 1976 by Goldman et al. However, NaOCl itself was too corrosive to be used on healthy tissues because of its high reactivity and its ability to decompose non-necrotic tissue. Subsequently NaOCl was diluted and buffered with sodium hydroxide, sodium chloride, and glycine producing a solution of 0.05% N-monochloroglycine (NMG) having a pH of 11.4, commercially known as GK 101. It was followed by introduction of N-Monochloro-D-2-Aminobutyrate (NMAB), that is, GK101E (CARIDEX) in 1984. CAREIDEX proved to be useful in chemical caries removal however it had unpleasant taste, lengthy procedure time (10-15 min), use of large volumes of solution (200-500 mL), complicated delivery system and high cost limits, which led to the introduction of CARISOLV system developed by the Swedish Medi Team in 1997. [3,28] In 2003, a research project in Brazil procure to the evolution of Papacarie which was intrinsically created from papain gel, toludine blue ,chloramines, thickening agent and salts, which all together idiosyncrasies to its act as anti-inflammatory and antibacterial features(Kholi and Surbhi ,2015). In India, Carie-care was used as a chemomechanical agent for caries removal, which was a gel-based comprise a purified enzyme, which was derived from Carica papaya (papaya) with the benefits of Clove oil that had antiseptic and analgesic effects (Hegde et al., 2014). Recently, a new material had been found in Argentina in 2016. It was named as Brix 3000 (Brix SRL Argentina), which was a dental product for non-traumatic caries treatment involving an enzymatic activity 3000 U/mg (U/mg: can be defined as the International units to measure a specific enzymatic activity or the concentration of enzymatic activity) in which papain was a bio-encapsulated using EBE Technology (Encapsulating Buffer Emulsion). It is an exclusive technology, immobilizes and confers stability that increases the enzymatic activity of the final product exponentially with respect to current technology. Thus, the followings are achieved: higher proteolysis effectiveness to remove the collagen fibrils in its decayed tissue, less dissolution of active principle by the oral fluids, greater resistance to storage even in unfavorable conditions, does not requiring cold-chain preservation, greater antibacterial and antifungal potency with an increase in its antiseptic effect on the tissue. Brix 3000 holds a dermatological certificates attesting to the non-

Journal of Chemical Health Risks
www.jchr.org
JCHR (2024) 14(2), 301-312 | ISSN:2251-6727

toxicity of the product to mouth, skin or eyes demonstrating that it does not provoke any type of reactions when it comes into contact with the healthy tissue (Torresi and Besereni ,2017; Romero et al., 2018).

Thus, Brix 3000, a recently introduced CMCR agent, was preferred in this study as it provides maximum preservation of the healthy tooth structure aiding in the removal of the infected dentin only while the removal of the sound dentine, which is painful, will be avoided. Hence, the use of local anesthesia would be minimized especially for pediatric patients and this was in accordance with the findings of Beeley et al. in 2000.[9]

Due to continuous advancement in mechanical and adhesive properties of restorative materials, the excessive tooth cutting required to obtain resistance and retention form in conventional cavity preparation is minimized. Traditional means of cavity preparation are based on a philosophy of extension for prevention and includes high-speed handpieces and slow-rotating instruments. However, this modality of cavity preparation usually induces pain, sounds and vibrations. Drilling often removes parts of tooth, which are healthy, in addition to the decayed areas. This weakens the tooth and makes it less durable in the long run. Therefore, chemo-mechanical removal of caries has been developed as an alternative to the conventional methods of removing caries.[14]

Usually, dentinal caries could be recognized as two distinct successive layers, which are different in their clinical features, as well as in their microscopic and chemical structures. The outer layer (infected dentin) is highly decalcified and infected with bacteria. Despite the possible discoloration, the inner layer (affected dentin) is less decalcified with intact collagen fibers and no bacterial invasion. Moreover, it is more resistant to the proteolytic attack and the progression of carious lesions. In this instance, there is no necessity to continue preparing the tooth until the dentin is stain-free. However, the ability to discriminate and remove only the diseased tissue remains essential.[15]

Histological studies have shown that dentine caries consist of five zones: normal, subtransparent, transparent, turbid, and infected. The deepest zone is the 'normal' sound dentine. The deeper two zones are the 'subtransparent' and 'transparent' zones, where demineralization has occurred; however, the collagen framework remains intact without bacterial penetration. The 'subtransparent' and 'transparent' zones, where the integrity of the collagen is maintained, are referred to as 'caries-affected dentine' and the current clinical evidence supports the retention of infected dentine in certain specific circumstances. The more superficial two surface zones are the 'turbid' and 'infected' zones, which are characterized by marked destruction of the tubular structure, decomposition of the collagen framework and bacterial infiltration. Conversely, the decomposed infected dentine from the 'turbid' and 'infected' zones is called 'caries-infected' dentine and should ideally be removed.[16,17]

However, it is well known that there are many differences in histomorphological structure, hardness, and mineral content between sound and caries-affected dentine. Furthermore, several studies have shown that there were distinct differences in surface morphology of the remaining dentine after CMCR and conventional rotary excavation, which may affect dentine bonding. The residual dentine following CMCR exhibited lower hardness values compared to the remaining dentine following conventional rotary excavation methods.

Analysis of tensile and micro tensile bond strength of both experimental groups

Previous studies that evaluated the micro tensile bond strength of residual caries-affected dentin following enzyme-based chemo-mechanical caries removal used demineralized dentin to avoid the effect of caries lesion size, shape, depth, and surface irregularities on the results of the bond strength test.[18,19] However, results obtained from demineralized dentin should be interpreted with caution, because natural carious dentin contains a wide variety of pathogenic materials, organic acids, hydrolytic enzymes, and whitlockite occluding the dentinal tubules. Kinney et al reported that artificial loss of mineral content led to the collapse of the collagen fibers, which might affect resin hybridization into the dentin and bond strength results.[22,28]

Micro-tensile bond strength testing permits measurements of small areas, so it is possible to assess the adhesion strength of resin composite to caries-affected dentine in specimens of limited size and shape. The universal testing machine is popularly used for measuring microtensile bond strength. In vitro, shear bond strength tests are valuable and fundamental for analyzing the potential of adhesive systems and their association with clinical scenarios. Using this method, several studies have indicated that resin bond strengths to caries-affected dentine and normal dentine depend both upon the type of dentine and adhesive systems used.

Bonding to normal dentine with self-etching primer systems and with total-etch and self-etch adhesives show tensile bond strengths significantly higher than those to caries-affected dentine. These bonding tests, however, have been conducted using flat, polished caries-affected dentine surfaces. It may be more clinically relevant to carry out the bond strength measurements made to excavated caries-affected dentine surfaces after they have been created under clinically relevant conditions.[22] Alternative caries excavation techniques may lead to differences in the quality and quantity of dentine remaining after cavity preparation. These differences might be clinically significant when considering the surface bonding ability with many adhesive restorative materials.[20]

Self-etch adhesive system does not completely resolve or remove the smear layer, but rather partly integrates into the hybrid layer and it has relatively high bond strength to enamel and dentin and has been designed to simplify clinical procedures and hence used in this study. The self-etching system lacks the rinsing step and thus the smear layer is not removed due to which a high amount of marginal leakage was reported in the group subjected to the conventional method of caries removal.[21]

To investigate the conditions of daily clinical practice, the completeness of caries removal was judged by standard clinical criteria. It has been suggested that conventional visual and tactile criteria are sufficient to ensure the removal of most infected dentin.[22] At the same time, the extracted teeth may respond to caries excavation differently than the teeth in function, since an outward flow of fluid has been reported in in-vivo dentin, which is partly ameliorated by using freshly extracted teeth.[23]

The shear bond strength of composite bonded to primary teeth dentin is less than that of permanent teeth. Minimum bond strength of 17–20 Mpa is needed to resist contraction forces of resin composite materials for enamel and dentin as confirmed by clinical data.[24] A comparatively low bond strength of primary teeth as compared to permanent teeth may be attributed to the differences in the chemical and morphological features between them. Calcium level and total available area of solid dentin are the two major criteria that affect the shear bond strength of adhesives as suggested by Bordin-Aykroyd et al. Primary teeth have relatively larger pulp chambers. A lower level of calcium is seen in dentin which lies closer to a pulp. This may lower the bond strength in primary teeth as the effective dentin that remains after cavity preparation is the dentin which lies near the pulp. Intertubular dentin is the most important site for bonding. However, primary teeth have relatively less intertubular dentin and a comparatively thicker peritubular dentin. The reduced adhesive strength in primary teeth may be due to the thicker interface and the bonding system being incompletely impregnated in the collagen network. [24,24,25]

The literature demonstrates that the adhesion force between composite resin systems and primary dentin ranges from 5.53 to 70.1 MPa. This wide variation could be attributed to the differences in methods employed, as well as the innate factors related to the tooth and material.[26] Results from studies with permanent teeth were taken as reference due to the lack of studies conducted on primary teeth.

The present results showed that there was no significant difference in tensile load and micro tensile bond strength between the two caries excavation methods. The null hypothesis that chemo-mechanical caries removal does not affect the bonding of self-etching adhesives to caries-affected dentin could not be rejected. Hamama et al reported that papain-based chemomechanical caries removal agents remove the smear layer because of the proteolytic property thus patent dentinal tubules are left behind. This enhances bonding by infiltration of adhesive resin into intertubular dentine and patent dentinal tubules. [22] Pravin et al concluded that rough dentine surface having micro-irregularities is generated with the chemo-mechanical method which improves the adhesion of restorative materials.[13] Banerjee et al found that conventional caries removal using burs resulted in a smooth and regular dentine surface with a smear layer which is expected to form weaker bonding with adhesive systems.[31] Following the present study, Kavaya K et al

Journal of Chemical Health Risks
www.jchr.org
JCHR (2024) 14(2), 301-312 | ISSN:2251-6727

and Zawaideh et al in their study observed that the chemomechanical method did not influence the bond strength of the material. Similarly, Cehreli et al and Chittum et al[43] concluded that the mode of caries removal doesn't affect the bond strength of restoration. In controversial to this study Pravin et al[13] reported that the Shear bond strength of papacarie-treated teeth was higher than that of conventionally treated teeth on bonded restoration. NM Khattab et al[27] reported that Papain-based gel enhanced the shear bond strength of composite resin restoration. The strength values of the links depend on the laboratory equipment, sample geometry, sample preparation, surface area, storage protocols, and operator variability. There are only a few studies conducted using Brix 3000. The use of natural lesions in the present study did not allow standardization of all the variables of the sample like the shape of lesions, activity status of the lesions, type of lesions, consistency, and depth. Hence, more long-term clinical studies are required to evaluate the relevance of these in vitro results.[28]

Analysis of nano leakage of both experimental groups

Microleakage has been used to express the longevity of bonded restorations for many years. Microleakage may lead to marginal discoloration, postoperative sensitivity, secondary caries, pulpal inflammation, and eventually partial or complete loss of that restoration leading to a decrease in longevity.[29] "Nanoleakage" is a type of leakage that occurs within the hybrid layer in nanometer-scaled spaces.[30] It causes seepage of oral fluids and bacterial products through the interface which may in turn compromise the stability of the bond between tooth dentin and composite resin. Nanoleakage evaluation is considered a useful determinant of hybrid layer quality and sealability of restorative material.[24.31]

In 1993, Garcia-Godoy & Finger showed that with the restoration in place, the traditional microleakage microscopic analysis did not detect the exact location of leakages in 75% of the cases. In 1994, Sano et al and Pashley et al demonstrated the penetration of specific substances into the area of the hybrid layer even in the absence of a marginal gap. This type of leakage is due to penetration paths through porosities in the range of a few nanometers only. Sano et al introduced the term "nanoleakage" to describe the mechanism of dye penetration within the hybrid layer or at the dentin margin of the hybrid layer, in contrast to marginal effects caused by gap formations which is known as microleakage. The term nano leakage was first quoted as being the impregnation of silver grains within the porosities of the hybrid layer that were not properly filled with adhesive resin. The second mode of nano leakage, termed "reticular mode," has also been described. These delicate, branching channels of nanovoids are thought to be morphological manifestations of the water treeing phenomenon, which is probably a result of aging. Aging is thought to cause polymer deterioration which is water-induced.[24,32]

Mechanisms of nano leakage formation –

Demineralization of dentin during conditioning with acids should be considered as a complex process restricted to the outermost dentin surface layer. Acid etching of this area not only removes the smear layer but in addition demineralizes the top few micrometers, thus exposing the collagen fibers. Underneath this layer, a partially demineralized zone follows, characterized by increased mineralization and finally into dentin not affected by conditioning. Studies using high-resolution techniques showed that the bonding agent of current adhesives failed to completely seal the dentin from the acid-induced porosities. The size of the porosities in dentin was estimated to be about 10-50 nm. Neither low-viscosity water-compatible monomer mixtures nor microscopic restoration particles (in a dentin adhesive as small as 7 nm), can close the pores. Therefore, dentin affected in its cohesive stability by acid etching will not be reinforced. This zone of partially demineralized dentin with microcavities may be considered as a weak point in the attachment. Similar studies in enamel showed no evidence for the formation of respective porosities or penetration paths. [52]

Scanning electron microscopic studies allowed Tay et al to differentiate between five individual zones that allowed dye penetration located in the resin-dentin interface. Considering the chosen methods and possible corresponding artifacts, the interpretation of these experiments seems difficult. In particular, the question of whether penetrations in these zones are due to marginal gaps or occur in a functioning adhesive, may not be answered.[52]

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(2), 301-312 | ISSN:2251-6727

Use of Scanning electron microscopy (SEM) –

SEM is a well-established technique to examine the interface between dentin and restorative materials. Adequate use of the technique of penetration tests is subjected to the selection of a suited dye, a so-called "tracer substance". The dyes for SEM, similar to those used in light microscopy, should easily migrate within the interface zone to induce an electron microscopic measurable contrast. Furthermore, the substance must have the potential to be immobilized during the necessary drying of the dentin samples, to exclude a subsequent penetration. For this purpose silver nitrate (AgNO,), as used in photography, proved to be suitable.

The qualitative nanoleakage observations in this study showed that there was not much variation in the amount of silver precipitation among the caries-affected dentin, following the two caries excavation methods. Silver penetration was observed within the intertubular dentin of the caries-affected dentin, following chemo-mechanical caries removal, which was in accordance with a study conducted by Hamama et al. (Fig 13 and 14)

The caries-affected dentin following rotary caries excavation showed high silver penetration on the top of the excavated dentinal surface, which may be attributed to the presence of the smear layer (Figs 13). The high silver uptake of the smear layer is most likely due to the internal porosities within the smear layer, which allow silver ions to diffuse through it. The increased silver uptake by the bonded interface of the residual dentin, compared to sound dentin, may be due to the porous nature of the caries-affected dentin, which entrapped water along the bonded interface, allowing silver ions to diffuse along the interface. Furthermore, this type of dentin also contains microcracks, which can act as pathways for the silver ions.[22] In contrast, the caries-affected dentin following Brix 300 chemo-mechanical caries excavation exhibited silver penetration on the top of the excavated dentinal surface with an irregular hybrid layer, which may be due to its high water content, partial coverage with smear layer. (Fig 14)

Salient Features of this Study**:**

- Use of chemomechanical caries excavation methods in primary teeth was studied
- A newer chemomechanical caries removal method, Brix 300 was used
- A newer generation single-step bonding agent was used
- First study to evaluate micro tensile bond strength and nano leakage in primary teeth

Limitations of this study:

- The sample size to analyze micro tensile bond strength was relativelyless.
- The samples used in this study were unable to completely simulate the complex intraoral conditions leading to caries development. It cannot mimic solid surface area/solution ratios or the saliva/plaque fluid composition encountered in vivo, since different oral surfaces are bathed in different volumes and source combinations of saliva.

CONCLUSION

Within the limitations of the present study, it may be appropriate to conclude that:

- Chemo-mechanical caries excavation methods did not affect the bonding of self-etching adhesives to caries-affected dentin, in comparison to the rotary caries excavation method
- Thus, Brix 300 can be considered a minimally invasive method for the removal of caries, having almost the same efficacy and effectiveness as the commonly used caries removal methods with the advantage of being gentler on dentinal tissue without aerosol generations
- Therefore, pedodontists can choose between the two depending on the cooperativeness of the child, to create a friendly environment without local anesthesia.

Further directions

There is enough literature to prove clinical efficacy of chemo-mechanical caries removal methods. The findings of the present study project a comparable effect on bond strength of adhesive to primary dentin after mechanical and chemo-mechanical caries removal. Thus newer chemo-mechanical caries removal methods should be developed and researched to incorporate them as integral

Journal of Chemical Health Risks
www.jchr.org
JCHR (2024) 14(2), 301-312 | ISSN:2251-6727

part of minimal invasive dentistry in pediatric population.

---

[1] A. Cederlund, S. Lindskog, and J. Blomlof, “Efficacy of carisolv- ¨ assisted caries excavation,” International Journal of Periodontics and Restorative Dentistry, vol. 19, no. 5, pp. 465–469, 1999.

[2] C. S. de Magalhaes, A. N. Moreira, W. R. D. C. Campos, F. M. ˜ Rossi, G. A. A. Castilho, and R. C. Ferreira, “Effectiveness and efficiency of chemomechanical carious dentin removal,” Brazilian Dental Journal, vol. 17, no. 1, pp. 63–67, 2006

[3] Zanchi CH, Lund RG, Perrone LR, Ribeiro GA, del Pino FA, Pinto MB, Demarco FF. Microtensile bond strength of two-step etch-and-rinse adhesive systems on sound and artificial caries-affected dentin. Am J Dent 2010;23:152-156.

[4] Ceballos L, Camejo DG, Fuentes VM, Osorio R, Toledano M, Carvalho RM, Pashley DH. Microtensile bond strength of total-etch and self-etching adhesives to caries-affected dentine. J Dent 2003;31: 469-477

[5] . Scholtanus JD, Purwanta K, Dogan N, Kleverlaan CJ, Feilzer AJ. Microtensile bond strength of three simplified adhesive systems to cariesaffected dentin. J Adhes Dent 2010;12:273-278.

[6] Nakajima M, Sano H, Burrow MF, Tagami J, Yoshiyama M, Ebisu S, Ciucchi B, Russell CM, Pashley DH. Tensile bond strength and SEM evaluation of caries-affected dentin using dentin adhesives. J Dent Res 1995;74:1679-1688.

[7] Yoshiyama M, Tay FR, Doi J, Nishitani Y, Yamada T, Itou K, Carvalho RM, Nakajima M, Pashley DH. Bonding of self-etch and total-etch adhesives to carious dentin. J Dent Res 2002;81:556-560.

[8] Omar H, El-Badrawy W, El-Mowafy O, Atta O, Saleem B. Microtensile bond strength of resin composite bonded to caries-affected dentin with three adhesives. Oper Dent 2007;32:24-30.

[9] H.Hamama,Y.Cynthia,B.Michael. Effect of Chemicomechanical Caries Removal on Bonding of Self-etching adhesives to Caries-affected Dentin. J Adhes Dent 2014;16:507-516.

[10] Marcelo Tavares de Oliveira , Marina Di Francescantonio , Simonides Consani , Marcelo Giannini & Gláucia Maria Bovi Ambrosano (2007) Influence of Dentin Smear Layer Created by Chemo-Mechanical or Bur Excavation Methods on Adhesion of SelfEtching Primers and a Conventional Adhesive, The Journal of Adhesion, 83:9, 821-83

[11] Yuan Y, Shimada Y, Ichinose S, Tagami J. Qualitative analysis of adhesive interface nanoleakage using FE-SEM/EDS. Dent Mater 2007;23:561-9

[13] Allen KL, Salgado TL, Janal MN, et al. Removing carious dentin using a polymer instrument without anesthesia versus a carbide bur with anesthesia. J Am Dent Assoc 2005;136(5):643–650. DOI: 10.14219/jada. archive.2005.0237

[14] Jawa D, Singh S, Somani R, Jaidka S, Sirkar K, Jaidka R. Comparative evaluation of the efficacy of chemomechanical caries removal agent (papacarie) and conventional method of caries removal: An in vitro study. J Indian Soc Pedod Prev Dent 2010;28:73-7.

[15] Elkholany NR, Abdelaziz KM, Zaghloul NM, Aboulenine N. Chemomechanical method: A valuable alternative for caries removal. J Minim Interv Dent 2002;9:16-22.

[16] Fusayama T, Terachima S. Differentiation of two layers of carious dentin by staining. J Dent Res 1972;51:866.

[17]Roberson TM, Heymann H, Swift EJ, Sturdevant CM. Sturdevant’s art and science of operative dentistry. In: Roberson M, Cariology. The lesion, etiology, prevention and control. 5th edn. St. Louis: Mosby Elsevier, 2006:97–102.

[18] Botelho Amaral FL, Martao Florio F, Bovi Ambrosano GM, Basting RT. Morphology and microtensile bond strength of adhesive systems to in situ-formed caries-affected dentin after the use of a papain-based chemomechanical gel method. Am J Dent 2011;24:13-19.

[19] Gianini RJ, do Amaral FL, Florio FM, Basting RT. Microtensile bond strength of etch-and-rinse and self-etch adhesive systems to demineralized dentin after the use of a papain-based chemomechanical method. Am J Dent 2010;23:23-28.

[21] H. Li, W. Wang, S. Yu, and Q. Wen, “Morphological

and microtensile bond strength evaluation of three adhesive systems to caries-affected human dentine with chemomechanical caries removal,” Journal of Dentistry, vol. 39, no. 4, pp. 332–339, 2011.

[22] E. A. Kidd, S. Joyston-Bechal, and D. Beighton, “The use of a caries detector dye during cavity preparation: a microbiological assessment,” British Dental Journal, vol. 174, no. 7, pp. 245–248, 1993.

[23] N. Vongsavan and B. Matthews, “Fluid flow through cat dentine in vivo,” Archives of Oral Biology, vol. 37, no. 3, pp. 175–185, 1992.

[24] Bordin-Aykroyd S, Sefton J, Davies EH. In vitro bond strengths of three current dentin adhesives to primary and permanent teeth. Dent Mater 1992;8:74-8.

[25] Hirayama A. Experimental analytical electron microscopic studies on the quantitative analysis of elemental concentrations in biological thin specimens and its application to dental science. Shikwa Gakuho 1990;90:1019-36

[26] Bengtson CR, Bengtson AL, Bengtson NG, Turbino ML. Do the origins of primary teeth affect the bond strength of a self-etching adhesive system to dentin? Braz Oral Res 2010;24:355-60.

[27] Khattab NM, Omar OM. Papain-based gel for chemo-mechanical caries removal: influence on microleakage and micro shear bond strength of esthetic restorative material. Journal of American Science,2012:8(3):391- 9.

[28] Kavya Krishna K, K Korath Abraham, Ektah Khosla, Arun Roy James, Elza Thenumkal. Comparative evaluation of shear bond strength of composite restoration following conventional and chemo mechanical caries removal techniques. International Journal of Dental Sciences, Volume 4, Issue 1, 2022, Pages 50-55

[29] Eick JD, Welch FH. Polymerization shrinkage of posterior composite resins and its possible influence on postoperative sensitivity. Quintessence Int 1986;17:103-11.

[30] Andia-Merlin RY, Garone-Netto N, Arana-Chavez VE. SEM evaluation of the interaction between a three-step adhesive and dentin. Oper Dent 2001;26:440-4

[31] Naga AA, Yousef M, Ramadan R, Fayez Bahgat S, Alshawwa L. Does the use of a novel self-adhesive flowable composite reduce nanoleakage? Clin Cosmet Investig Dent 2015;7:55-64.

[32] Pioch T, Staehle HJ, Duschner H, García-Godoy F. Nanoleakage at the composite-dentin interface: A review. Am J Dent 2001;14:252-8