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SHEAR BOND STRENGTH OF AN ALKASITE BASED RESTORATIVE MATERIAL TO SDF PRETREATED DENTIN (IN VITRO STUDY)

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ABSTRACT

OBJECTIVES: Evaluate the shear bond strength (SBS) of Alkasite-based restorative material and resin-based composite to primary teeth dentin with or without 38% silver diamine fluoride pretreatment.

MATERIALS AND METHODS: A total of 52 extracted primary molars were ground to obtain flat dentin surface. Teeth were randomly allocated into 2 main groups according to the type of restoration used. Group 1 (n=26): Teeth were restored with Alkasite based restorative material (Cention Forte). Group 2 (n=26): Teeth were restored with composite resin (Tetric N-Ceram Bulk Fill). Each group was subdivided into 2 equal subgroups according to 38% silver diamine fluoride dentin pretreatment.

Subgroup A (n=13): Restoration was placed after 38%SDF dentin pretreatment. Subgroup B (n=13): Restoration was placed without dentin pretreatment. Shear bond strength test was performed using Universal testing machine. Mode of failure was assessed by stereomicroscope. Data were statistically analyzed via Two Way Analysis of Variance (ANOVA) to assess the effect of restorative material and dentin pretreatment on shear bond strength. Pearson chi square test was used to compare mode of failure between subgroups.

RESULTS: Mean shear bond strength of Cention Forte was statistically higher than Tetric N-Ceram Bulk Fill (P=0.006). However, there was no statistical difference between subgroups (P=0.151) (with or without 38% SDF pretreatment).

CONCLUSIONS: Cention Forte performed better than composite resin. However, 38% SDF pretreatment did not influence bond of restorations to primary teeth dentin.

KEYWORDS: Cention Forte, shear bond strength, SDF, Composite resin.

RUNNING TITLE: Shear bond strength of Cention Forte to SDF pretreated primary teeth dentin

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INTRODUCTION

Dental caries is the most common chronic childhood disease. Its prevalence has increased worldwide among children of ages 2 to 5 years, making this population a global priority for action (1, 2). Fluoride-based products, like professionally applied varnishes, can stop and prevent caries. Since the early 1960s,some children all over the world have been treated with silver diamine fluoride (SDF) to arrest dental caries. In the United States, the Food and Drug Administration (FDA) approved it in 2014, and it became accessible in 2015 (3-5).

Silver diamine fluoride prevents the formation of cariogenic biofilm through forming a highly remineralized dentin surface that is filled with phosphate and calcium ions, making it important for both caries prevention and arrest. Moreover, SDF has antimicrobial characteristics.It is also thought to raise the pH of biofilm, prevent dentin demineralization, and protect collagen from deterioration in demineralized dentin (6-8). It has been applied to primary teeth, particularly in cases of early childhood caries, patients with behavioral or medical conditions, and those unable to pay for or receive routine dental care. It has also been used to stop dental caries because it is a safe, viable, efficient method of controlling dentin caries, particularly among preschool-aged children with dentin caries lesions (9, 10).

However, the main disadvantage of SDF is that it darkens the carious lesions, so application of composite or glass-ionomer cement (GIC) restorations on SDF pretreated dentin can cover the black shade of the carious lesion to enhance appearance, enhance chewing efficiency, stop food buildup, and, ultimately, maintain proper oral hygiene. The silver modified atraumatic

restorative technique (SMART) is the name given to this method(11).

Numerous esthetic filling materials are available for modern dental practice. Cention N has been released as a liquid powder, tooth-colored restorative material. It is an "alkasite" restoration which is a new category of filling material, and is considered a subgroup of composite resin (12). According to the manufacturer it is a restorative material made of urethane dimethacrylate alkasite that releases ions that neutralize acids and uses alkaline filler. Because isofiller has a low modulus of elasticity, it is thought to relieve shrinkage stress and decrease microleakage and shrinkage during polymerization. Because it has alkaline glass fillers, it can also release hydroxide, calcium, and fluoride ions, which can be advantageous, especially for pediatric patient. This dual-cured material can be used for bulk placement with or without adhesives. (12, 13). Moreover, Alkasite restorative material is available as auto mixed capsules (Cention Forte). Their composition is the same as Cention N with only exception of the concentration of the initiators, pre-proportioned powder to liquid ratio and primer application (14). A study by Sadeghyar et al. (2022) (15) evaluated shear bond strength of four self-adhesive restorations and four restorations that require dentin pretreatment of bovine incisors, including Cention Forte. Mean shear bond strength of Cention Forte was the highest among restorative materials investigated.
As Alkasite based restorative material is a new class of restorative materials, to our knowledge, there are little studies that evaluate Cention Forte restorative material performance in primary teeth. Therefore, this study aimed to evaluate shear bond strength of the Alkasite-based filling material and resin composite with or without 38% SDF pretreated dentin.

Thus, the proposed null hypothesis of this study assumed that there is no significant difference in shear bond strength between Cention Forte and resin based composite with and without 38% SDF pretreated dentin.

MATERIALS AND METHODS

This study was performed after approval of the research ethic committee (IRB: 00010556–IORG 0008839). in Faculty of Dentistry, Alexandria University, Egypt.

Sample size estimation: Sample size was based on 95% confidence level to detect differences in shear bond strength between Cention N and Tetric N-Ceram Bulk Fill composite resin. Kumari and Singh 2022 (16) reported mean ± SD shear bond strength of Cention N= 9.89 ± 1.23, while Bas and Uslu-Cender 2021 (17) reported mean ± SD shear bond strength of Tetric N-Ceram Bulk Fill composite= 6.19 ± 0.92. The calculated mean ± SD difference= 3.70 ± 1.08, 95% confidence interval= 2.71, 4.69. Soliman et al. (2020) (18) found that silver diamine fluoride pre-treatment raised shear bond strength of primary dentin. The minimum required sample size was calculated to be 12 dentin samples, increased to 13 to make up for laboratory processing errors. The total required sample size= number of subgroups × number per subgroup= 4 × 13= 52 (19).

This sample size was calculated using MedCalc Statistical Software version 19.0.5 (MedCalc Software bvba, Ostend, Belgium; https://www.medcalc.org; 2019).

Study sample: fifty-two sound primary molars. The teeth were collected from the out-patient clinics of the Pediatric Dentistry Department, Faculty of Dentistry, Alexandria University, Egypt.

Inclusion and exclusion criteria: Sound primary molars extracted for orthodontic reasons (serial extraction) without any fillings, cracks, enamel defects or developmental anomalies were included in the present study. After being cleaned, teeth were kept in distilled water.

Shear bond strength test: Each specimen root was cut 2mm below the cemento- enamel junction (CEJ) using diamond disc in low-speed handpiece, the coronal part was embedded in 14x20 mm acrylic blocks with their buccal surface displayed and perpendicular to the long axis of the mold. Buccal surface was ground using silicon carbide 0.1 grit abrasive in order to obtain flat dentin bonding surface, for creating a standardized bonding area, a plastic cylindrical shaped mold (3x3) was placed on surface of the flat dentin of teeth. Teeth complying with the inclusion criteria will be randomly assigned using a computer-generated list of random numbers to two main groups(n=26). Teeth will be randomly and equally allocated to two main groups depending on the type of restorative material used
Group 1: Cention Forte (n=26)
Subgroup 1A (n=13) 38% SDF solution was applied to the dentin surface (Advantage arrest Elevate oral care, USA) for 3 minutes with a microbrush, then rinsed with water for 30 seconds (20).
Subgroup 1B (n=13) Distilled water was applied to dentin surface for 3 minutes then rinsed with water for 30 seconds.

For both subgroups Cention primer (Ivoclar Vivadent, Schaan, Liechtenstein) was applied to flat dentin surface for 10 seconds then air dried. After that the Cention Forte capsule (Ivoclar Vivadent, Schaan, Liechtenstein) was activated, mixed for 15 seconds (according to the

manufacturer's directions)) using Rock-Mix amalgamtor, placed in bulk using the plastic cylindrical molds and light cured (Elipar S10; 3M ESPE, St. Paul, MN, USA) for 20 seconds.
Group 2: Tetric N-Ceram Bulk Fill (n=26)
Subgroup 2A: 38% SDF solution was applied to the dentin surface for 3 minutes with a microbrush, then rinsed with water for 30 seconds (20).
Subgroup 2B: Distilled water was applied to dentin surface for 3 minutes then rinsed for 30 seconds.

For both subgroups dentin surface was etched with 37% phosphoric acid etching gel (N-etch gel, Ivoclar Vivadent, Schaan, Liechtenstein). for 20 seconds, then washed with distilled water for 30 seconds and dried. Bonding agent (Tetric N bond universal, Ivoclar Vivadent, Schaan, Liechtenstein). was applied and cured for 10 seconds. After bonding Tetric N-Ceram Bulk Fill (Ivoclar Vivadent, Schaan, Liechtenstein) was placed in bulk using the plastic cylindrical molds and light cured for 20 seconds. Specimens of all groups were stored in distilled water for 48 hours at 37˚C until subjected to Shear bond strength test.

Shear bond strength test :Universal Testing machine (AUTOGRAPH, AG5KNIS MS, SHIMADZU Co. Kyoto, Japan) was used to assess the shear bond strength. Using a sharp blade and a cross head speed of 1 mm per minute, shear load was applied parallel to the bonded interface until failure took place. The following equation was used to calculate the shear bond strength: Shear bond strength in Megapascals (MPa) = the maximum failure load in Newtons (N) / surface area of the bonded interface (mm2) (21).

Failure mode assessment: A single examiner assessed the failure modes. (demonstrator at Dental Biomaterial Department, Alexandria University) using stereomicroscope at x20 magnification, and classified as: Adhesive (failure at the interface between restoration and dentin), Cohesive (failure within the restorative material) and Mixed (partly adhesive and partly cohesive) (22).

Statistical analysis: Normality of shear bond strength was assessed using Shapiro wilk test and Q-Q plots, Normal distribution was confirmed for the shear bond strength thus it was presented using mean, standard deviation (SD), 95% confidence interval (CI). Two Way Analysis of Variance (ANOVA) was employed to assess the effect of restorative material and dentin pretreatment on shear bond strength and the interaction between both. Mode of failure was presented using frequency and percentage and it was compared between subgroups using Pearson chi square test. All tests were two tailed and the significance level was set at p value ≤0.05. Data were analyzed using IBM SPSS, version 23 for windows, Armonk, NY, USA.

RESULTS

The SBS of the two materials was tested with and without 38% SDF pretreatment, and the mean and standard deviation were calculated for every group. Cention forte with SDF pretreatment showed the highest mean ±SD 7.94 ±3.02 followed by Cention forte without SDF pretreatment 7.64 ±2.62 then Tetric N-Ceram bulk fill without SDF pretreatment 5.94± 2.49 and the least Mean ±SD was Tetric N-Ceram bulk fill with SDF pretreatment 5.63 ±1.83 (Table 1)

The two-way ANOVA test was carried out and showed that a statistically significant difference was present in SBS among the two main groups (P=0.006). (Table 2)
No statistically significant difference was detected between subgroup A and subgroup B (P=0.994). (Figure 1)

Failure mode assessment results: Chi square test was done to compare different failure modes between subgroups (Table 3)
According to P_{MC} > 0.05, the difference between the studied subgroups was not significant in terms of the type of failure mode.

Tetric N ceram bulk fill groups showed only mixed type (100%) in both subgroups Cention forte showed mixed type (84.6%) and cohesive type (15.4%) in subgroup A with SDF pretreatment while in subgroup B without SDF pretreatment it showed mixed type failure (100%). (Figure 2)

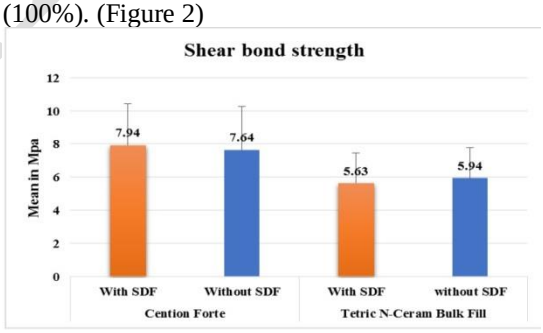

Figure1: Mean shear bond strength among subgroups.

Figure 2: Mode of failure between the subgroups.

Table 1: Comparison of shear bond strength (SBS) between the Tetric N-Ceram Bulk Fill and Cention Forte with and without Silver diamine fluoride(SDF).

	Group 1 (Cention Forte)		**Group 2 (Tetric N-Ceram Bulk Fill)**	
	Subgroup 1A (with 38%SDF) (n=13)	**Subgroup 1B (without SDF) (n=13)**	**Subgroup 2A (with 38%SDF) (n=13)**	**Subgroup 2B (without SDF) (n=13)**
Mean ±SD	7.94 ±3.02	7.64 ±2.62	5.63 ±1.83	5.94 ±2.49
95% CI	6.53, 9.35	6.23, 9.05	4.22, 7.04	4.53, 7.35

Table 2: Two Way Analysis of variance(ANOVA) assessing the effect of restorative material and dentine pretreatment on shear bond strength.

Variables	Mean square	F test	*p* value	Partial Eta Squared
Restorative material	52.53	8.22	0.006*	0.146
Dentine pretreatment	0.00	0.00	0.994	0.00
Interaction	1.211	0.189	0.665	0.004
Corrected model	17.91	2.80	0.050*	0.149

*Statistically significant difference at *p* value≤0.05, Adjusted R Squared= 0.096

Table 3: Comparison of failure type between Cention Forte and Tetric N-Ceram Bulk Fill with and without Silver diamine fluoride(SDF).

	Group 1 (Cention Forte)		**Group 2 (Tetric N-Ceram Bulk Fill)**	
	Subgroup 1A (with 38%SDF) (n=13)	**Subgroup 1B (without SDF) (n=13)**	**Subgroup 2A (with 38% SDF) (n=13)**	**Subgroup 2B (without SDF) (n=13)**
	n (%)	n (%)	n (%)	n (%)
Adhesive	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Cohesive	2 (15.4)	0 (0%)	0 (0%)	0 (0%)
Mixed	11 (84.6%)	13 (100%)	13 (100%)	13 (100%)
Test (*p* value)	5.308 (0.151)			

DISCUSSION

The clinical success of filling material relies on a good bond with dentinal surface to withstand different dislodging forces acting inside the oral cavity. Shear bond strength is critical to the restorative material clinically due to the shearing effect of the main dislodging forces at the tooth restoration interface (23). Thus, a stronger shear bond implies a better bond between the material and the tooth. The results of this study showed that the shear bond strength (SBS) of Cention forte was significantly higher than composite resin (*p* value=0.006) this agrees with Sadeghyar et al. (2022) (15) who compared the SBS of eight different materials to bovine dentin. It was found that Cention forte had the highest mean shear strength of the investigated materials. Also Mazumdar et al.(2018) (24) showed that Cention-N had a greater bonding strength than Tetric N Ceram. Another study by Naz et al.(2021) (25) compared Cention N with glass ionomer cement and nanohybrid composite. It was determined that Cention N had the highest shear bond strength value. Moreover, Dhull et al. (2022) (26) compared the adhesive bond strength of conventional glass ionomer cement (GIC) and Cention N to the primary teeth enamel and dentin using an accelerated fatigue test. It was concluded that Cention N resisted significantly more number of endured cycles before separation from the cavity as compared to GIC.

The strong mechanical properties of Cention Forte could be due to its chemical composition as its monomer matrix consists of a mixture of urethane dimethacrylates (UDMA), tricyclodecan-dimethanol dimethacrylate (DCP), tetramethyl-xylylendiurethane dimethacrylate (aromatic aliphatic-UDMA) and polyethylene glycol 400 dimethacrylate (PEG-400 DMA), which interconnects (cross-links) during the process of polymerization leading to stronger mechanical properties. The material gains strength from the inorganic filler, barium-aluminum-silicate glass (14).

However, in contrast to these results, Pai et al. (2024) (27), found that resin modified glass

ionomer cement(RMGIC) had a stronger shear bond than Cention N in sound primary teeth. This controversy could be due to the methodology used in that study as Cention N was directly bonded to primary tooth surface, whereas RMGIC was bonded after dentin preconditioning.

Furthermore, the present study showed that there was no statistically significant difference between subgroups. In this study primary dentin was treated with 38% SDF, This percentage was chosen according to a systematic review by Contreras et al. (2017) (28) that recommended 38% usage for caries prevention in primary teeth or first permanent molar. The 38% SDF protocol did not influence dentin bond strength. This is attributed to methodology used in this study as 38% SDF was applied for 3 minutes followed by rinsing for 30 seconds by water. According to Lutgen et al. (2018) (20) rinsing can eliminate the excess of silver precipitate from peritubular and intertubular dentin, favoring adhesion.

A systematic review and meta-analysis by Frohlich et al. (2022) (29), found that the SDF pretreatment does not jeopardize the bonding of glass ionomer cement to dentin. The same is valid for adhesives only if a rinsing step after SDF application is done.

On the other hand, Abdullah et al. (2022) (30), tested Shear Bond Strength of different restorative materials to primary carious dentin treated with SDF. It was concluded that the SDF group had significantly lower SBS. This could be due to the nature of the affected carious dentin which has lower bond strength than sound dentin (31). Another study conducted by Soliman et al. (2020) (18), found that pretreatment of sound primary teeth dentin with SDF raised significantly SBS of RMGIC to dentin. This may be explained as there is a difference in the type of restoration used. The present study showed some limitations. Being in-vitro, it does not totally represent the intra-oral environment and also that it was performed using intact dentin. Meanwhile, in carious dentin the SBS is anticipated to be lower. According to these results, the null hypothesis was partially rejected. However, further clinical studies are recommended to confirm the obtained findings.

CONCLUSION

According to the results of this study, it was concluded that Cention Forte has higher shear bond strength than Tertic N Ceram bulk fill resin composite and 38% SDF dentin pretreatment has no effect its shear bond strength.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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