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EVALUATION OF FRACTURE STRENGTH OF A NEW ALKASITE RESTORATIVE MATERIAL WITH FIBER REINFORCEMENT.

Dentistry

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ABSTRACT

Background: Clinical Toughness of the restorative material is vital for any restorative material clinically and is reliant on the wear resistance and its ability to withstand the occlusal forces depends on the fracture strength. **Aim:** To measure the impact of fiber reinforcement on fracture strength of a new Alkasite restorative material. **Materials And Methods:** Experimental material is prepared by the addition of discontinuous silanized short glass fibers in 5 wt% (0.75 gm) to 15 gm of powder component of Cention N. Standardized class I cavities were prepared on 60 mandibular teeth and are divided into 3 groups each group containing 20 samples. Each group is restored with Tetric N ceram Bulkfill composite, Cention N with fiber and Cention N without fiber. Fracture strength evaluation was done for the samples using Instron testing machine. Statistical analysis was done by using one-way ANOVA and Tukey's multiple post-hoc tests with significance level set at $p \leq 0.05$. **Results:** Cention N with fiber has shown significantly greater fracture strength values when compared to Cention N with out fiber ($p=0.0001$) and resin composite. **Conclusion:** Superior fracture resistance was shown by Cention N with fiber followed by fiber reinforced composite and Cention N with-out fiber.

KEYWORDS

Alkasite, Cention N, Bulk fill composite, Fracture resistance.

INTRODUCTION

Modern dentistry mainly emphases on the conservative preparation of tooth structure and application of adhesive systems which can achieve mineralisation on enamel and dentin. The restorations done via adhesive bonding preserve the anatomically sound tooth substrate and render compatibility with preventive concepts. Preservation and stabilization of hard tissues of tooth by direct restorative techniques are chosen rather than the extensive, macro mechanically considered preparations with various other indirectly used restorative materials or amalgam.[1] Increasing attention towards the aesthetics in the dentistry has led to the widespread and using of composites. Using of composites not only as a direct restorations in the anterior teeth but also as a potential material of choice for substituting unesthetic amalgam restorations in posterior teeth.[2] When coming to the concept of mechanical properties, abrasion resistance, and mainly aesthetics properties of composite resins have improved significantly during the last few years, their polymerization shrinkage still remains a challenge. Marginal discrepancies and microleakage[3], marginal discoloration, postoperative sensitivity, and secondary caries[4] are the consequences of polymerization shrinkage which ultimately limits composite resins application in direct restorations. In the recent times half of the direct restorations done on the posterior teeth were done by using resin based restoratives. The main reason for their popularity was due to their aesthetic nature and minimal tooth preparation and getting better bonding to the tooth structure. The initiation of development of new composite restoratives, with new adhesive systems has carried huge benefits–particularly in terms of esthetics and strides in the direction of minimally invasive dentistry. They may be however little expensive when compared to glass ionomer cements, have several advantages such as fluoride release, adhesion to mineralized dental tissues and a coefficient of thermal expansion similar to that of tooth structure. In spite of so many favourable properties, its poor mechanical properties, limited indication range (unsuitable for stress bearing situations) and low aesthetic value led to the further development of resin-based composites.[5] Due to reasons mentioned above dentists have long sought a real alternative to silver amalgam, glass ionomer cement and composites, a cost-effective, fluoride releasing product that is quick and easy to use without complicated equipment and that offers both strength and good esthetics Ivoclar Vivadent has introduced a tooth coloured filling material, named Cention N, for the bulk application in retentive preparations with or without the application of an adhesive system.[6] Cention N is an “alkasite” restorative material reflecting a new category of filling material as a subgroup of the composite resins.[4] Cention N is a UDMA-based, self-cure material with optional additional light-curing which consists of a powder and a liquid component .[5] The liquid is composed of methacrylate's and initiators and the powder consists of glass fillers, initiators, and pigments. Cention N entails a high-density polymer network and degree of polymerization over the complete depth of the restoration because of its cross-linking methacrylate monomers combined with a stable self-cure initiator.[7]

Generally, polyethylene fibers (woven or braided), glass fibers (discontinuous, pre-impregnated silanized E-glass, hollow) have been used to reinforce glass ionomer cement. Discontinuous glass microfiber reinforcement, i.e. the fibers with cross-sectional diameter ranging from few microns to twenty microns with higher amount of aspect ratio are used in medicine and dentistry fields.[8] The incorporation of discontinuous fibers like glass, polyethylene, carbon to GICs can improve its mechanical properties. Many studies have shown an appreciable rise in flexural capacity and fracture toughness, on discontinuous glass fibers incorporation to GICs. It was also mentioned that there is certain decrease in brittleness of GIC by the incorporation of discontinuous fibers, thereby reducing the incidence of catastrophic failures. Hence, the aim of the current study is to analyse the influence of discontinuous e-glass fiber reinforcement on fracture strength of Cention N.

MATERIALS AND METHODS

60 extracted mandibular human molar teeth devoid of hypoplastic lesions, cracks or caries were collected after the informed consent obtained from the patients. Teeth were disinfected with 0.5% Chloramine-T (Viachem, Texas, USA) solution and stored in 0.1% thymol solution until the start of the study. Considering the previous data published, sample size estimation was done using G* power software 20.0 version. A power analysis set at the level of 80% calculated the minimal sample size of 20 to test the variables and thus a total of 20 samples per group were taken. Standardized class I cavities were prepared in all the 60 teeth samples using diamond bur and #245 carbide bur (SS White, NJ, USA) with high-speed handpiece and the preparation was extended up to proximal pits present both mesially and distally while maintaining the pulpal floor flat and keeping the buccolingual width of 3 mm and pulpal floor depth of 3.5 mm.

Restorative procedure: Restorative procedure for bulk fill composite (Tetric N Ceram) (control) restorations (n=20): Twenty of the prepared class I cavities were rinsed with water and air dried to acquire a clean and dry operating area. Application of etching gel - 37% phosphoric acid (Ivoclar Vivadent AG, Schaan, Liechtenstein, Europe) to all the prepared cavity surfaces was performed with an applicator tip. In the class I (n=20) cavities, bonding agent was employed on all the etched surfaces. The adhesive was cured with LED Bluephase light-curing unit (Ivoclar, Schaan, Austria) for 10 seconds. Tetric N ceram Bulk fill composite was condensed into the adhesive coated class I cavity and condensed with Teflon coated plastic filling instruments. The occlusal cavities were filled, contoured and light-cured for a period of 20 seconds.

Discontinuous salinized short glass fibers (E- glass® fibers, EFT, USA) with a diameter of 6 µm were cut by the manufacturer into a uniform length of 0.5 mm to create fibers with an aspect ratio of ~100. The cut fibers were added in 5 wt% (0.75 gm) to 15 gm of powder before mixing with the liquid.[3] Hand mixing is done by using mortar and pestle where 0.75 gm of fiber was combined with 15 gm of Cention N powder. The manipulation of Cention N without addition of fiber was done according to the manufacturer's recommendations.

Cention N Posterior Restoration With And Without Fiber :
In Cention N restoration without fiber (n=20) and with fiber (n=20), surface conditioning of samples was done before the placement of the restoration. Manipulation of the cement was done after dispensing using a plastic spatula, The application of this mixture was done on treated dentinal surface using a cement carrier and allowed to chemical cure for 3 to 6 minutes. Finishing of the restorations was done after 6 minutes from the start of cement mixing.

The fracture strength evaluation was done using Universal testing machine, (Instron Electropuls E3000, Massachusetts, USA). A cylindrical ball indenter having 2.2 mm diameter conical tip was fixed to the upper arm of Instron machine to exert load on the tooth to fracture. The tooth was centred below the plunger placed on lower platen, and the plunger was downwardly driven with a crosshead velocity of about 0.5 mm/ minute along the tooth long axis until the occurrence of tooth fracture. An audible crack sound was also observed for most of the specimens. Throughout the testing procedure, the control system and its associated software recorded the load of compression used on the specimen. The values were recorded for maximum load in newtons required to fracture each specimen.

Statistical Analysis:
All the statistical evaluations were performed using the SPSS for windows version 22.0 software (IBM, Armonk, NY). One - way ANOVA test was used to compare the mean values of fracture strength between the groups and among the groups. For pair-wise comparisons between the groups, Tukey's multiple post-hoc test was employed. The confidence and significance levels were established at 95% and α = 0.05, respectively.

The mean fracture strength and standard deviation of test and control groups are described in

Table 1. A Significant Difference Was Observed Between The Groups With Fracture Strength (N).

Groups	Mean	SD	SE	95% CI for mean	
				Lower	Upper
Tetric N Ceram Bulkfill	921.00	10.26	2.96	898.48	921
Cention N	812.33	10.16	2.93	798.88	812.33
Cention N with fiber	998.58	15.80	4.56	934.55	998.58

DISCUSSION
There have been several attempts to increase the strength of GIC while preserving biological characteristics of the material. The range of applications for glass ionomer cements has expanded because to improvements in handling characteristics, a reduction in setting time, and greater wear resistance and strength. [9]

Recently the newer material which was quoted as an alternative to the amalgam for using in the posterior teeth was marketed widely by the Ivoclar Vivadent for the bulk applications in the posterior teeth.[10,11]

The integration of glass fiber is a desirable way to improve mechanical performance. The matrix- fiber interface connection is strengthened as a result of pull-out of fiber or crack bridges formed during fracture. By adding reinforcement in the form of fibres, glass ionomers can change from being brittle to being more ductile. This results in more resistance to microcrack formation and crack propagation than brittle materials do owing to stress relaxation and inhabiting catastrophic fracture. The durability of repair is significantly influenced by the GICs' fracture resistance.[9,10,11]

An effective bulk fill restorative material that was introduced into restorative dentistry is Tetric N ceram Bulk fill (Ivoclar Vivadent Dental Products Zurich, Switzerland). It was intended for use in high stress bearing areas. It is comprised of randomly oriented E glass fibers integrated within resin matrix and particulate fillers. It has 65-85% of filler content, out of which the short fibers content is about 5-15%. Fibers in the material are 17µ in diameter and 800 µ in length giving a higher aspect ratio. These fibers also intertwine with each other. [12]

Random fibre orientation together with semiIPN upgraded the mechanical properties. In-vitro studies on the everX Posterior small fiber resin composite showed significantly superior physical properties in terms of fracture toughness, flexural strength and modulus compared to particulate filler resins. Relatively deeper depth of cure has been exhibited. The short E-glass fibres present in this composite improves modulus by transforming the stresses from the resin matrix to the fibers acting as stress absorber and stops the cracks propagation in the restoration.[13]

The posterior teeth are subjected to masticatory forces ranging from 8 to 880 newtons. Higher masticatory loads have been recorded in those with parafunctional behaviours like bruxism. Molars are subjected to significantly higher chewing forces, which can result in cracking or fracture of the tooth when eccentric stresses are applied during trauma or biting. Masticatory loads are greatest on the posterior teeth, with a 4:2:1 ratio for molars, premolars, and incisors.[14] Apart from the physical features of the restorative materials, the increased masticatory stresses on these teeth makes restoration survival difficult. Based on the studies published, fiber reinforced GICs have better flexural strength, fracture strength, elastic modulus, and other mechanical parameters. [15]However, there was relatively limited publications regarding the impact of using discontinuous glass fibers in regularly used GICs that are already available on the market. Hence, this study was planned to investigate the influence of fiber incorporation on the wear resistance and fracture strength of two different high viscous GIC's in comparison with fiber reinforced composite as a control.

The null hypothesis is rejected based on the findings of the present study, it was proved that with fiber incorporation, have shown significantly greater fracture strength when compared with out incorporation of fibers. The above results are supported by the studies included below, Kobayashi M et al. have investigated on fracture strength effect upon 40%–60% volume of fiber loading.[16] It was proven that adding reactive glass fibers with the same formulation as that of GICs increased the materials' toughness and fracture strength. This may be explained by the morphology of short fibers and the reactivity of the short fibers to the mixing liquid. The probable reason for the increase of fracture resistance of the Cention N is as a effect of the definite fiber pull-out mechanism which is supposed to be under control of the weak reactive matrix - fiber interface. Also, when fibres are incorporated into the matrix of the material, bridging forces emerge, resulting in crack stability and an improvement in the energy of fracture.[16,17]

CONCLUSION
With in the limitations of the present study, it was concluded that the Cention N with fiber has showed better fracture resistance and is similar to resin composite when compared to Cention N with out fiber.

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