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RESEARCH ARTICLE

COMPARATIVE EVALUATION OF COMPRESSIVE STRENGTH AND FLEXURE STRENGTH OF ZIRCONIA MODIFIED GLASS IONOMER AS CORE BUILD UP MATERIAL WITH OTHER CONVENTIONAL MATERIALS

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ABSTRACT

Background: A core build-up is a restoration placed in a badly broken down tooth to restore the coronal portion. This facilitates restoration of the broken down tooth by means of extra-coronal restoration. Compressive and flexural strength of core materials is thought to be important because core usually replaces the large bulk of the tooth structure and must resist multidirectional forces. In this study, compressive and flexural strength of a newly introduced core material was determined and compared with conventional core materials. The purpose of the study was to evaluate and compare the compressive and flexural strength of Zirconia modified Glass Ionomer used as a core build-up material with other conventional materials. **Methodology:** Cylindrical specimens measuring 6mm in height and 4mm in diameter were prepared using machined aluminium mold. Ten specimens were prepared in each group. (Amalgam, Resin modified GIC, Light cured composite, Zirconia modified Glass Ionomer). Compressive strength was determined using a universal testing machine. The maximum load applied to fracture the specimen was recorded and compressive strength was calculated in Mega Pascal. **Results:** The mean compressive strength and flexural strength was significantly higher ($p < 0.05$)in Glass reinforced composite group as compared to Zirconia modified Glass Ionomer, DPI alloy and Vitrimer, but no statistically significant difference was observed between Zirconia modified Glass Ionomer vs DPI alloy, Zirconia modified Glass Ionomer vs Vitrimer, DPI alloy vs Vitrimer. **Conclusion:** Within the limitations of this study, Glass reinforced composite had higher strength compared to the other three core build- up materials.

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INTRODUCTION

Post and core is mainly intended to obtain retention and increased resistance of hard dental tissue against occlusal forces, especially on a grossly decayed tooth to facilitate restoration of the by means of subsequent extra-coronal indirect restoration.(1) Recently introduced core materials are a light-activated glass ionomer cement (VariGlass VLC) and a fluoride-release dual cure composite resin (FluoroCore), a conventional silver-reinforced glass-ionomer cement (Miracle Mix). (2)Recently, owing to its convenience and feasibility, there has been an increased demand for the use of prefabricated post systems to restore endodontically treated teeth. There are multiple restorative materials available as core buildup material such as amalgam, composite resin, or glass ionomer which show variable survival rate in post-core-crown restorations (3) The core buildup material becomes an integral part of tooth structure, as it should provide strength to resist both intraoral compressive and tensile forces. Compressive and tensile stresses of core materials are thought to be important because cores usually replace a large bulk of tooth structure and must resist multidirectional masticatory forces for many years. Flexural strength of core materials is vital, as any surface imperfections like cracks or voids can influence the fracture strength. (4) . Various materials like Amalgam, glass ionomer cement and composites have been used for core build up. Amalgam is unaesthetic, requires a prolonged setting time and is difficult to prepare immediately after placement. Composites have adequate strength and low solubility with better aesthetics, the tooth can be prepared immediately after polymerization. It has certain disadvantages like polymerization shrinkage and plastic deformation under constant load. The glass ionomer cements have inferior strength when compared to composite as core build up material. (5) The powder/liquid ratio is reduced to improve flow properties, but this can cause higher solubility, compromising the durability of the fragments.

METHODOLOGY

An in-vitro study was conducted to determine the compressive and flexural strength of Zirconia modified Glass Ionomer core material and compare it with Amalgam, Resin modified GIC, Light cured composite materials.

Preparation of the molds: Two molds were prepared for the purpose of determining compressive strength and flexural strength. The mold was prepared in an Aluminium block measuring 80 mm in length and 20 mm in width, 6mm in height and 4mm in diameter to check for compressive strength. Mold was prepared in a Aluminium block measuring 90mm in length and 25mm in width and 2 mm in thickness, a rectangular mold space measuring 25mm in length and 2mm in width was machined to measure flexural strength.(Fig no 1).

Specimen preparation for compressive strength: The mold space was coated with thin layer of petroleum jelly before packing it with the material being studied for easy separation of the specimens. The screws were tightened completely to hold the two parts of the block together. A glass slab was placed below the under surface of the mold to create a uniform smooth surface of the specimens. Powder and liquid for all the cements were dispensed and mixed according to the manufacturer's instructions. The material was packed into the mold spaces and allowed to set and the two halves of the block were separated gently. Ten specimens of Resin modified GIC were retrieved carefully and stored till testing procedures. For Light cure composite resin, the mold space was coated with a thin layer petroleum jelly. The material was injected into the mold space and cured using visible spectrum of wavelength 450 nm for 40 seconds as per manufacturer's instructions. Ten specimens of Light cured composite resin were retrieved carefully and stored till testing procedures. The samples were left to set in the molds at room temperature for 10 minutes before being stored in a humid environmentat 370C. All the specimens were mounted vertically between disk plates of the universal testing machine, maximum loads were applied to fracture the specimens and the compressive strength (MPa) was calculated. Another rectangular mold was fabricated for measuring the flexural strength. A three point bending test was carried out using a universal testing machine. A total of 80 specimens were divided into four groups; each group consisted of 10 specimens (n=10) to check the compressive strength and flexural strength. To determine the compressive and flexural strength of specimens a Universal testing machine was used. (Praj Metallurgical Laboratory, Pune ACME Engineers, India. Model No. UNITEST-10, India). (fig no-2,3). The accuracy of the machine was+/- 1%. Cross head speed was set at 0.5mm/minute. The values obtained were tabulated and subjected to statistical analysis. The mean compressive strength and flexural strength values with its standard deviation were calculated for each core material. One way ANOVA and Kolmogorov Smirnov tests were used to compare the values for statistical analysis.

RESULTS

In this study, four core build up materials used were Zirconia modified Glass Ionomer, Glass reinforced composite, DPI Alloy and Vitrimer (Table1).

Values of Compressive strength and flexural strength of all four core build-up materials were measured. The results demonstrated that the mean compressive strength and flexural strength were significantly higher ($p<0.05$) in Glass reinforced composite group when compared to Zirconia modified Glass Ionomer, DPI alloy and Vitrimer. But there was no statistically significant difference ($p>0.05$) between Zirconia modified Glass Ionomer vs DPI alloy, Zirconia modified Glass Ionomer vs Vitrimer, DPI alloy vs Vitrimer. The mean compressive strength was significantly higher in Glass reinforced composite group as compared to Zirconia modified Glass Ionomer, DPI alloy and Vitrimer. But no difference was observed between Zirconia modified Glass Ionomer vs DPI alloy, Zirconia modified Glass Ionomer vs Vitrimer, DPI alloy vs Vitrimer. The mean scores are also presented in the following figure (table 2,graph 1)

The mean flexural strength was significantly higher in Glass reinforced composite group as compared to Zirconia modified Glass Ionomer, DPI alloy and Vitrimer. But no difference was observed between Zirconia modified Glass Ionomer vs DPI alloy, Zirconia modified Glass Ionomer vs Vitrimer, DPI alloy vs Vitrimer. The mean scores are also presented in the following figure.(table3,graph 2). The statistical analysis was done using One-way ANOVA test and Tukey's multiple testto compare the change between the groups. There was a statistically significant difference observed between four study groups (Zirconia modified Glass Ionomer, Glass reinforced composite, DPI alloy and Vitrimer) with compressive strength scores ($F=9.1206$, $p<0.05$) and flexural strength scores($F=16.4586$, $p<0.05$).The mean compressive strength was different in different four groups (Zirconia modified Glass Ionomer, Glass reinforced composite, DPI alloy and Vitrimer). The mean compressive strength of Zirconia modified Glass Ionomer group was 31.81MPa, Glass reinforced composite group was 110.46 MPa, DPI alloy was 44.467 MPa and Vitrimer was 39.77 MPa; followed by mean flexural strength of Zirconia modified Glass Ionomer group was 24.98 MPa , Glass reinforced composite group was 65.45 MPa, DPI alloy was 33.12 MPa, and that of Vitrimer group was 60.15 MPa. The data obtained was validated using Kolmogorov Smirnov test. It was found that the values followed a normal distribution and were further analyzed using parametric test which indicated statistically significant difference among core materials.

DISCUSSION

All of the direct placement core materials require bulk of material for strength. The strength values of glass ionomer cements shown in the literature are difficult to be compared due to the great variability in test conditions results and available material. These differences can be determined by composition, manufacturing process, size of the powder particles, type, concentration and molecular weight of liquid, and powder/liquid ratio. The ratio of Resin in glass ionomer plays an important role in determining physical and mechanical properties and their degradation (6). Glass-ionomer cement was considered as material of choice due to reduced manipulation time when compared to the Silver Amalgam, the physical properties of conventional glass ionomer cement are not suitable for use as a core build up material due to moisture contamination and low strength. Studies have suggested the use of miracle mix, which is modified form of GIC with Amalgam alloy powder, which showed higher strength when

Table 1.

Material	Composition		Manufacturer
DPI alloy	Fine Grain - high silver content (68.7 %) alloy.		Dental product of India ltd
Vitremer	**POWDER:** Fluoroaluminosilicate glass; Redox system.	**LIQUID:** Aqueous solution of a modified polyalkenoic acid, hydroxyl ethyl methacrylate.(HEMA)	3 MESPE AG dental products Seefeld-many USA.
Paracore (Glass reinforced Composite)	Resin matrix:bisphenol a and glycidyl methacrylate (BisGMA,) triethylene glycol dimethacrylate (TEGDMA), Urethane dimethacrylate (UDMA) Filler: fluoride, barium glass, amorphous silica (68 wt%, 0.1-5 mm)		Coltene (Whaledent)
Zirconomer (Zirconia reinforced Glass Ionomer)	**POWDER:** Alumino-fluoro-silicate glass, Zirconiumoxide, tartaric acid	**LIQUID:** Polyacrylic acid, Deionized water	Shofu, Japan

Table 2. Pair wise comparison of four study groups (Zirconomer, Paracore, DPI alloy and Vitrimer) with compressive strength scores by Tukeys multiple posthoc procedures'

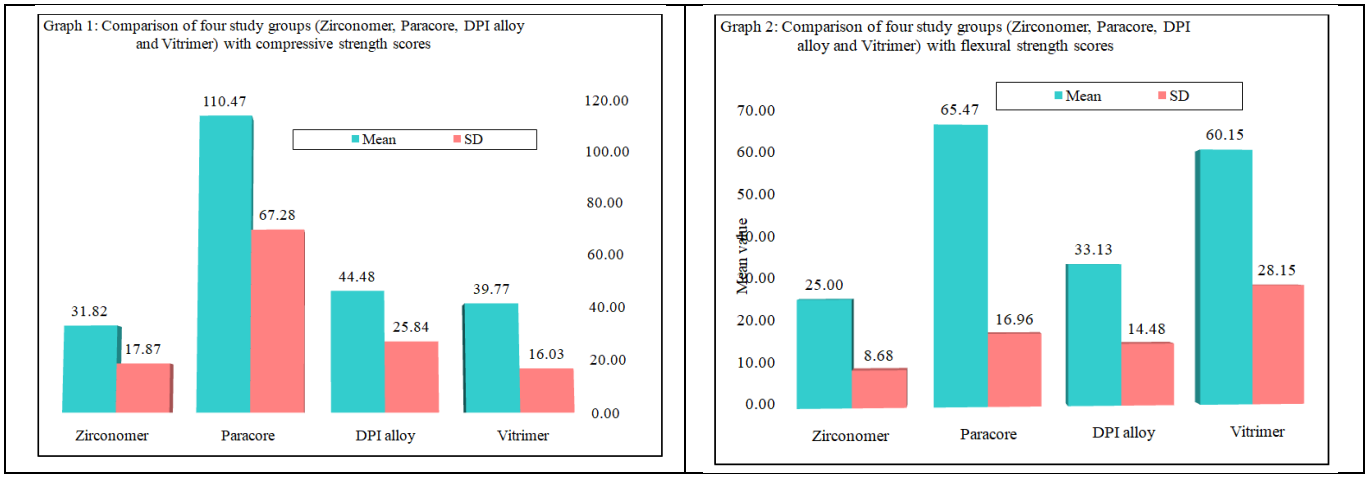
Groups	Zirconomer	Paracore	DPI alloy	Vitrimer
Mean	31.82	110.47	44.48	39.77
SD	17.87	67.28	25.84	16.03
Zirconomer	-			
Paracore	p=0.0004*	-		
DPI alloy	p=0.8783	p=0.0024*	-	
Vitrimer	p=0.9655	p=0.0012*	p=0.9926	-

*p<0.05

Table 3. Pair wise comparison of four study groups (Zirconomer, Paracore, DPI alloy and Vitrimer) with flexural strength scores by Tukeys multiple posthoc procedures

Groups	Zirconomer	Paracore	DPI alloy	Vitrimer
Mean	25.00	65.47	33.13	33.13
SD	8.68	16.96	14.48	14.48
Zirconomer	-			
Paracore	p=0.0002*	-		
DPI alloy	p=0.5680	p=0.0002*	-	
Vitrimer	p=0.5680	p=0.0002*	p=0.9999	-

*p<0.05



compared to conventional GIC but lacked in aesthetics. (7) To overcome the drawbacks of conventional GIC, Resin modified GIC was introduced, which consisted of HEMA, having the capability of dual curing. Zirconia modified Glass Ionomer is developed as a reliable and durable tooth coloured Zirconia Reinforced Posterior restorative material. Novel nano sized zirconia fillers enhance material translucency for a closer shade match to natural tooth with superior handling characteristics for a simple, easy and fast bulk placement. According to manufacturer, it exhibits the strength and durability of Amalgam and protective benefits of glass ionomer, while eliminating the hazards of mercury.

Zirconia modified Glass Ionomer is considered to be a structural core for a large bulk of restoration. In recent years, composites due to their rapid rate of polymerization and better strength have become the popular choice for core build-up of teeth. These materials are esthetically pleasant and the tooth can be prepared immediately after polymerization. It has certain disadvantages like polymerization shrinkage, plastic deformation under constant load.(8) There are many composite build-up materials available; most of them are either self cured or light cured or dual-cured. A study done by Anche S concluded that dual cure composite with fibre reinforced had higher strength compared to the other core build-up materials

Figure 1. Metal Molds

Figure 2. Universal Testing machine

(9) Studies conducted on Packable composite resin (Filtek P60), visible light cured nanohybrid resin composite (Grandio), and organically-modified ceramic (Admira) to check the compressive strength and flexural strength concluded that composite materials had higher compressive than the other materials.(10) In our study we compared the compressive strength and flexural strength of newly introduced Zirconia modified Glass Ionomer which is used as a core build up material with most commonly used materials which are silver Amalgam, Glass reinforced composite and Vitrimer. Despite the successful use of dental amalgam for coronal–radicular dowel and core build up in endodontically treated posterior teeth, newer materials offer many potential advantages over amalgam and have better patient acceptance (11). Strength is one of the most important criteria for selection of a core material. Stronger materials better resist deformation and fracture provide more equitable stress distribution, greater stability, and greater probability of clinical success. (12) The present study influences only mechanical properties of the core build up materials. According to Kerby RE et al, composite resin and Vitremer tricure visible-light-cured glass-ionomer cement are significantly greater in both compressive and diametral tensile strength than any other materials tested after 7 days. (13) In our study the newer materials used (Zirconia modified Glass Ionomer vs Vitrimer) to check the compressive and flexural strength which have shown good results in terms of strength. While choosing the core material; the mode of stress and amount of stress distribution affects the stress transmission to the post. Usually as the firmness increases the stress goes directly to the root and less to the post. Limitation of the study: Since the mechanical properties were tested in an in-vitro environment, the exact simulation of forces acting on core-buildup materials cannot be achieved leading to deviation in results when compared to patient's oral environment, hence an in-vivo study for long term fracture resistance in oral environment would provide clarity over the prognosis of such materials.

CONCLUSION

The mean compressive strength and flexural strength of Glass reinforced composite was statistically significant ($p<0.05$) when compared to other group level and there was no significant difference ($p>0.05$) between the groups Zirconia modified Glass Ionomer, DPI Alloy and Vitrimer. Within the limitation of this study, Glass reinforced composite was considered to be better core build-up material as compared to the Zirconia modified Glass Ionomer, DPI alloy and Vitrimer.

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