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Research Article

Fracture resistance of three posterior restorative materials: A preliminary *in vitro* study

Swati Mohanty, Sindhu Ramesh

Department of Conservative Dentistry and Endodontics, Saveetha Dental College, Saveetha University, Chennai, Tamil Nadu, India

Correspondence: Sindhu Ramesh, Department of Conservative Dentistry and Endodontics, Saveetha Dental College, Saveetha University, 162, Poonamallee High Road, Chennai – 600077, Tamil Nadu, India. Phone: +91-9840136543. E-mail: drsinramesh@gmail.com

ABSTRACT

Numerous restorative materials have been used in dentistry to achieve adequate strength as well as esthetics. Dental amalgam has been used for decades now, owing to its superior mechanical properties, but it is unesthetic. Composites, on the other hand, are esthetic but exhibit polymerization shrinkage and microleakage. To overcome all these drawbacks, a new restorative material, Zirconomer has been introduced. The aim is to evaluate and compare the fracture resistance of conventional posterior restorative materials, dental amalgam, and bulk-fill composite with a novel posterior restorative material Zirconomer. A total of 15 pellets, 5 pellets of each of the 3 groups, were fabricated using a stainless-steel die with the required specifications. Group 1 - dental amalgam, Group 2 - Zirconomer, and Group 3 - bulk fill composite. All the samples were subjected to compression testing using a universal testing machine, and the values were obtained. Statistical analysis with one-way ANOVA was done. Composite resin (bulk fill) can withstand higher compressive stress (statistically significant) when compared to dental amalgam and Zirconomer. The difference in compressive stress that Zirconomer can withstand when compared to dental amalgam is statistically insignificant. Zirconomer can be used as a potential posterior restorative material of choice.

Keywords: Composite resin, compressive strength, dental amalgam, universal testing machine, Zirconomer

Introduction

Through decades now, amalgam has been used as a posterior restorative material. However, when patients became more esthetic conscious, silicates and dimethacrylate materials were put to use. Silicate cement, owing to their poor mechanical properties, were used only in anterior teeth and overall also had a high failure rate. Composite resins were then introduced to over the disadvantages of the other cement.[1] On the other hand, glass ionomer cement (GICs) have been used in dentistry for over the past 3 decades. The material has a diverse group of applications including luting, restorative, and sealants. However, owing to its poor tensile and compressive strength, GIC is not advised to be used as a posterior restorative material.[2,3]

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Compressive strength testing is carried out to compare materials which are brittle and generally weak in tension such as amalgam, cement, or composite resins. Composite resins are improving every day because of their chemical ingredients, bonding ability, conservative preparation, preservation of tooth structure, and esthetics. In anterior teeth, composite resins are the materials of choice due to their superior esthetics, but in the posterior region, composite resins should have good mechanical properties including having a compressive strength equal to or more than tooth to resist the masticatory forces.[1,2,4] Many researchers have been undertaken to evaluate the compressive strength of the different restorative materials. A restorative material with lower compressive strength than tooth tends to fail, fracture and it ends with periodontal problems or extraction of the broken tooth.[5,6] The studies in this area showed different results. In some studies, amalgam showed the highest compressive strength,[4] but in some of the composite resins had the higher strength;[2] however, some have shown no significant difference between amalgam and composite resin. Furthermore, the compressive strength has changed with time of evaluation.[6-13]

Numerous restorative materials have been used in dentistry to achieve adequate strength as well as esthetics. Dental amalgam has been used for decades now, owing to its superior mechanical properties, but it is unesthetic. Composites, on the other hand, are esthetic

but exhibit polymerization shrinkage and microleakage. GIC is not recommended as a posterior restorative material owing to its poor mechanical properties. To overcome all these drawbacks, a new restorative material, Zirconomer has been introduced. Zirconomer is a new class of restorative GIC that claims to have the strength and durability of amalgam and the protective benefits if glass ionomer and thus completely eliminating mercury hazards as well issues related to polymerization shrinkage.[14] The aim of this study is to evaluate and compare the fracture resistance of conventional posterior restorative materials, dental amalgam, and bulk fill composite with a novel posterior restorative material Zirconomer.

Materials and Methods

A total of 15 pellets, 5 pellets of each of the 3 groups, were fabricated using a stainless-steel die and Teflon die with the required specifications

Figure 1: Group 1: Amalgam

Figure 2: Group 2: Composite

Figure 3: Group 3: Zirconomer

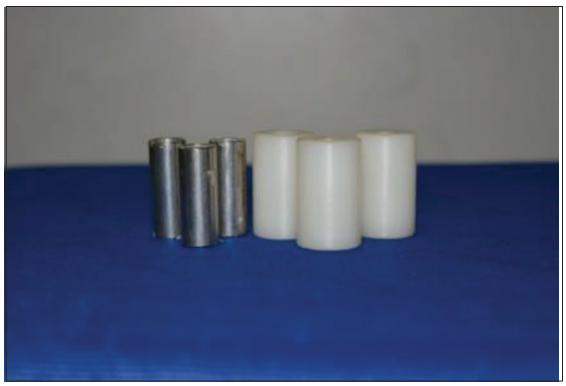


Figure 4: Stainless steel and Teflon Dies

Figure 5: Placement of test material in universal testing machine

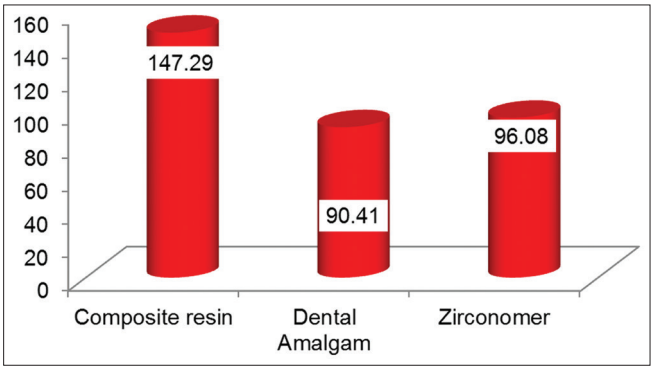
Figure 6: Fracture of material after compression testing

Figure 7: Fractured particles of amalgam

Figure 8: Fractured particles of composite

Figure 9: Fractured particles of Zirconomer

according to American standard for testing and materials [Figure 1]; Group 1 - dental amalgam, Group 2 – bulk-fill composite, and Group 3 - Zirconomer. All the samples were subjected to compression testing [Figures 2-4 & Graph 1] using a universal testing machine, and the values were obtained [Figures 5-6]. Statistical analysis with one-way ANOVA was done.



Graph 1: Depicting difference in compressive strength between the groups

Table 1: Average load and displacement of each group

Composite	Average load (kN)	Average displacement (mm)
Dental Amalgam	6.680	1.4
Composite	3.655	0.3
Zirconomer	5.450	0.6

Table 2: Mean compressive strength ($P<0.05$ statistically significant)

Material	Mean compressive stress (MPa)	*P*
Composite	147.29±21.11	0.03*
Dental amalgam	90.4±11.45	0.75
Zirconomer	96.08±13.24	0.66

SD: Standard deviation

Results

Group 1 - Composite resin showed the highest average compressive strength values (147.29 MP). It is a more ductile material, hence fractures in a more longitudinal direction exhibiting a polished and laminated surface as depicted in Figure 7. Group 2 - dental amalgam showed the least compressive strength of the three materials (90.41 MPa). It is a brittle material but fractured in a longitudinal section exhibiting a fine-grained surface as depicted in Figure 8. Group 3 - Zirconomer showed a higher compressive strength than amalgam (96.08 MPa), but the values were not statistically significant. It fractured into grainy power exhibiting its brittle nature depicted in Figure 9.

Statistics

One-way Anova test was carried to find statistical difference between the 3 groups. Table 1 depicts the average load and displacement of each group. The mean and p values are given in Table 2.

Discussion

With the evolutionary development of filling materials, there is an ever-increasing need for better tooth-colored restorative materials to replace missing tooth structure and to modify tooth color and contour, thus enhancing facial esthetics.[14] During the past few decades, the increasing demand for esthetic dentistry has led to the

development of resin composite materials for direct restorations with improved physical and mechanical properties, esthetics and durability. Dental amalgam has been used as a posterior restorative material for decades. But owing to its color and extensive tooth preparation, its popularity has come down. Many hybrids of materials such as composite, GIC, and amalgam alloy (miracle mix) have also been used in clinical practice.[15-18] But none have shown good mechanical properties so as to be used as a posterior restorative material successfully. Zirconomer is a novel zirconia reinforced restorative material that claims to have properties of amalgam and is esthetically more acceptable. The zirconia particles that have been included in the glass component of Zirconomer reinforces the structural integrity of the restoration and imparts superior mechanical properties for the restoration of posterior load-bearing areas where the conventional restorative of choice is amalgam.[19] According to the manufacturer, Zirconomer is developed to exhibit strength that is consistent with amalgam, through a rigorous manufacturing technique. The glass component of this high-strength glass ionomer undergoes finely controlled micronization to achieve optimum particle size and characteristics.[20] The homogeneous incorporation of zirconia particles in the glass component further reinforces the material for lasting durability and high tolerance to occlusal load. The polyalkenoic acid and the glass components have been specially processed to impart superior mechanical and handling qualities to this high-strength glass ionomer.[20-25]

In the present study, composite resin (bulk fill) can withstand higher compressive stress (statistically significant) when compared to dental amalgam and Zirconomer. The difference in compressive stress that Zirconomer can withstand when compared to dental amalgam is statistically insignificant.

More studies need to be conducted with more number of samples and on tooth models to achieve a more accurate result.

Conclusion

Under the limitations of our study, the compressive strength of Zirconomer was significantly lesser than bulk-fill composite resin and similar to that of dental amalgam. Thus, Zirconomer can be used as a potential posterior restorative material of choice.

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