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Research Article

COMPARATIVE EVALUATION OF COMPRESSIVE STRENGTHS OF ZIRCONOMER, AMALGAM AND COMPOSITE – AN INVITRO STUDY

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A B S T R A C T

The purpose of this research is to evaluate the Zirconomer's compressive strength and hardness as currently there is little research on it.15 specimens were fabricated for each group, in a total of 45 specimens. The materials were manipulated according to the powder/liquid ratio recommended by the manufacturer for the Zirconomer, and appropriate light-curing time recommended by the manufacturer for composite and recommended trituration time for amalgam. The materials were slowly inserted through metallic moulds openings and another mylar strip was placed on the upper surface followed by a 2-mm-thick glass slab manually pressured to obtain a regular material surface and then they are subjected to universal testing machine. According to the results obtained in the study, amalgam has the highest and composite has a higher compressive strength compared to Zirconomer. However, all the materials achieving mean compressive strength of more than 300MPa, hence all these materials are suitable in stress-bearing regions for posterior tooth restorations.

INTRODUCTION

Dental caries has been considered as a historically important component of the global oral disease burden. Dental professionals must choose the appropriate material according to the restorative situation. This decision should be based on a number of factors, such as knowledge of the materials' physical properties, bio- compatibility, esthetics, and application.

The human tooth structure mainly destroyed by trauma and caries is always replaced with suitable core materials to bring the success and longevity of the subsequent cast restoration. Large varieties of dental materials such as silver, amalgam, composite resin glass ionomer cement, resin modified glass ionomer cement and compomers have been used for core build-up procedures. Compressive Strength of core materials is thought to be important because core build-ups usually replace a large amount of tooth structure and it must resist multidirectional masticatory forces. Compressive strength may be considered to be a critical indicator of success because higher the compressive strength, maximum resistance to resist masticatory and parafunctional forces.

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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)

Dental amalgam, in widespread use for over 150 years, is one of the oldest materials used in oral health care .(2) Amalgam has traditionally been used as the best build-up material (3) due to its superior mechanical properties such as good compressive strength and addition of copper content to dental amalgam alloy causes an increase in compressive strength and hardness (4). However, mercury content and unpleasant color, were the reasons why alternative core build-up materials have been developed. (5)

Composite resins are used because of their appearance, convenience of a single visit core placement and preparation avoiding mercury controversy and reliable, strong bond strengths (11−28 MPa). Comparing to glass ionomers,

composites proved superior in respect to their mechanical properties. The compressive strength of composite resins (250−350 MPa) is close to enamel and dentin, but the tensile strength of composite resins is much lower (50−90 MPa). (6)
Glass ionomer cements emerged as a restorative material in the early 1970s by Wilson and Kent *et al*. They are esthetically more pleasing than metallic restorations. On the contrary, their use in dentistry as a restorative material in stress-bearing areas is limited due to poor mechanical properties, such as low fracture strength, toughness, and wear resistance.
A high-strength restorative material, which has been reinforced with zirconia fillers known as zirconomer (white amalgam), has been a recent substitute to glass ionomer cement in dentistry. Zirconia (ZrO2) is a white crystalline oxide of zirconium. It is a polycrystalline ceramic without a glassy phase and exists in several forms. The name "zirconium" comes from the Arabic word "Zargon" which means "golden in color." (7)

GIC also known for its fluoride releasing property, Fluoride release from GICs restorations following a continuous uptake process increases the fluoride concentration in saliva and in adjacent hard dental tissues. Thus, continuous small amounts of fluoride surrounding the teeth decreases demineralization of the tooth tissues. (8)

The purpose of this research is to evaluate the Zirconomer's compressive strength and hardness as currently there is little research on it. Therefore, our aim is to evaluate and compare the compressive strength of newer material zirconomer with amalgam and composite restorative material

MATERIALS AND METHODS

A Zirconia reinforced GIC (Zirconomer Improved – Shofu Dental Asia-Pacific Pte Ltd.), a A3.5 composite (Southern Dental Industries (SDI) ICE Composite)and amalgam (Southern Dental Industries (SDI) GS 80) were employed in this study, using specimen dimension of 6mmx 4mm according to ISO 7489:1986 specifications for water based dental cements. Metallic cylindrical moulds were made (6mm in height and 4mm in diameter).

15 specimens were fabricated for each group, in a total of 45 specimens. The materials were manipulated according to the powder/liquid ratio recommended by the manufacturer for the Zirconomer, and appropriate light-curing time recommended by the manufacturer for composite and recommended trituration time for amalgam. In order to obtain a smooth and shiny GIC, powder and liquid were dropped and manipulated over mixing pad and mixed with plastic spatula according to manufacturer's instruction.

The metallic moulds were previously isolated with Vaseline and protected at the bottom surface using a mylar strip. (Figure 1) The materials were slowly inserted through moulds openings and another mylar strip was placed on the upper surface followed by a 2-mm- thick glass slab manually pressured to obtain a regular material surface.

Composite A3.5 (Southern Dental Industries (SDI) ICE Composite) was inserted in 2mm layers, and each one was light-cured for minimum 20s using a light cure unit (SDI Radii Plus High-power Cordless LED Curing Light). For composite, specimens were fabricated one at a time and were visually analyzed and, when voids or irregularities were detected, they were discarded.

After the specimens were left undisturbed for 30 min, they were stored in distilled water for 24 hours, after which they were subjected to compressive strength testing in a universal testing machine (INSTRON 5582) using a claw with 2 cm in diameter, under a crosshead speed of 0.5 mm/min until specimen fracture. The specimens were measured using a Vernier caliper before being loaded.

RESULTS

The data obtained subsequent to compressive strength testing were analyzed using Mann-Whitney U Test Calculator (9) to establish the statistical significance between the groups.(Table 1) The *U*-value is 0. The critical value of U at $p<0.05$ is 23. Therefore, the result is significant at $p<0.05$.The *Z*-Score is -3. 74185. The p-value is 0.00018, which is statistically significant at $p<0.05$. The results of the study shown that there is statistically significant difference between the three groups (Table 2), Amalgam has the highest compressive strength mean value of 406.2 ±5.49, whileComposite has higher compressive strength mean value of 373.04 ± 8.78 compare to Zirconomer with compressive strength mean value of 301.02 ± 7.68. A p-value of 0.00018 was obtaind which is <0.05 and indicating there is statistically significant difference between the sample groups, Zirconomer and Composite and with mean difference of 76.09MPa. With the higher mean compressive strength, amalgam and composite have a greater compressive strength when compared to Zirconomer.

Table 1 Mann-Whitney U Test ranking of compressive strength (MPa) between zirconomer compositeand amalgam.

Sample No.	Compressive Strength (MPa)		
	Zirconomer	Composite	Amalgam
1	315.74	357.59	403.72
2	302.77	373.55	411.43
3	287.42	378.42	408.71
4	293.6	377.91	409.22
5	306.52	368.84	398.08
6	308.35	382.27	402.37
7	297.88	377.36	396.47
8	290.14	385.9	415.19
9	300.37	379.26	409.82
10	301.73	366.29	405.2
11	296.44	359.66	412.39
12	306.39	377.94	403.51
13	308.31	362.93	409.36
14	294.95	366.48	399.26
15	304.76	381.3	405.63
Mean	301.02	373.04	406.02

Table 2 Mean and Standard deviation of the three samples

Materials	N	Mean	Standard Deviation	Minimum	Maximum
Zirconomer	15	301.02	7.68	287.42	315.74
Composite	15	373.04	8.78	357.59	385.9
Amalgam	15	406.02	5.49	386.47	415.19

Figure 1 Metallic moulds with the samples.

DISCUSSION

The availability of variety of restorative materials in the field of dentistry results in continual scrutiny of the properties of the material. This is to ensure the right choice of the material for clinical purposes which would adhere optimally to the tooth structure and which can withstand the masticatory forces. Compressive strength testing is commonly used as a measure by which clinicians and researchers predict the performance of a restorative material in oral environment. (8)

Among mechanical properties compressive strength of restorative materials is important to resist intraoral compressive and tensile forces that are produced in function and parafunction. Material should have the same mechanical properties as tooth structure. A material with the higher or lower amount of a property will adversely effect on longevity of the tooth structure, and the restoration and premature failure of each will happen. Compressive strength is the ability of a material to resist compression in the dental field; this method is often applied to test the strength of cement which set through an acid-base reaction.

Amalgam fillings are usually indicated for Class I and Class II restorations and tend to be preferred large posterior load-bearing fillings in permanent posterior dentition where esthetic appearance is less important. The clinical success of an amalgam restoration depends on various factors including: Appropriate cavity preparation involving undercuts due to the non-retentive nature of amalgam, condensation technique, anatomical characteristics, and final finish. Amalgam can also expand or contract, depending on how it has been manipulated; severe contraction can lead to microleakage, plaque accumulation, and secondary caries; and excessive expansion can cause protrusion, put pressure on the pulp, and cause postoperative sensitivity.(9,10,11) Amalgams offer unparalleled longevity and strength but are coupled with poor esthetics and controversial ingredients. Dentists have long sought after a real alternative to amalgam a cost-effective, fluoride releasing product that is quick and easy to use without complicated equipment and that offers both strength and good esthetics. The search for a new material that has the fluoride-releasing capability of GIC and durability of composites led to the introduction of Zirconomer. (12)

The increase in compressive strength in Zirconomer has been attributed to the introduction of nano-zirconia fillers making it suitable for posterior load bearing areas as per various studies.

For the composite, with its content of nanomers using nanotechnology as well as hybrid technology enables a high filler loading for increased strength hence enhances longevity of a composite.(13) In this study, Amalgam, Zirconomer and composites exhibited compressive strength values of over 300Mpa after 24 hours as per the limit set by ISO for materials to be used as posterior restoratives although Composite exhibits a greater compressive strength with the mean value of 373.04± 8.78MPa while Zirconomer with the mean value of 301.02±7.68 MPa. This result is coinciding with the study done by Mohanty S and Ramesh S.(2017), in which Composite showed higher compressive strength when compared to Zirconomer.(10)

CONCLUSION

According to the results obtained in the study, amalgam has the highest compressive strength and composite has a higher compressive strength compared to Zirconomer. However, all the materials achieving mean compressive strength of more than 300MPa, hence all these materials are suitable in stress-bearing regions for posterior tooth restorations; however long-term clinical studies need to be carried out to substantiate the results of this study.

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