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IN VITRO COMPARATIVE EVALUATION OF COMPRESSIVE STRENGTH OF THREE MODIFIED GLASS IONOMER CEMENTS IN ARTIFICIAL SALIVA

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***Abstract**: **Introduction:** To evaluate and compare compressive strength of three modified glass ionomer cements – Glass Hybrid Restorative System (Equiaforte), Zirconia reinforced glass ionomer cement (Zirconomer Improved) and resin modified glass ionomer cement (Fuji II LC) in artificial saliva. **Material and Methods**: A total of 45 cylindrical specimens (4 mm diameter and 6 mm height) were prepared for each material following the manufacturer's instructions. After subjecting the specimens to thermocycling of 500 cycles between 50c and 55 0c with the dwell time 15secs, specimens were immersed in artificial saliva for 24 hours for compressive strength testing under a universal testing machine. Data were analyzed using ANOVA. For pairwise evaluation between the groups post hoc dunnet t3 test was used (P< 0.005). **Results**: The result exhibited that the compressive strength of Zirconia reinforced glass ionomer cement was maximum with the mean value of 153.777 ± 1.55 MPa when compared with other groups. The difference between groups was found to be statistically significant (p<0.05). **Conclusion**: Zirconia reinforced glass ionomer cement shows highest compressive strength preceded by glass hybrid restorative system and then the resin modified glass ionomer cement.*

KEY WORDS

Compressive strength, glass hybrid restorative system, resin modified glass ionomer cement, zirconomer improved

INTRODUCTION

Dental caries has been affecting mankind from time immemorial. Since ancient times to 18th century, dental caries have been replaced or restored with wide variety of materials. Dental professionals continue their voyage in pursuit of a 'biomimetic' ideal restorative dental material that may synergistically match enamel and dentin. It is of paramount importance by the dental professionals to preserve and conserve what nature has given. The restorative material that is serving this dual purpose of 'restoring function' and 'maintaining aesthetics' altogether in contemporary dentistry is GLASS IONOMER CEMENT. With the decline in popularity of amalgam in recent years, there is a need for improved strength Glass ionomer (GI) cements. Since then, several modifications have been introduced with the purpose of enhancing their mechanical properties. One of the most commonly employed methods to better understand the mechanical properties of GICs is compressive strength testing because core build-ups usually replace a large amount of tooth structure and it must resist multidirectional masticatory forces.[1] Resin- modified glass-ionomer cement were introduced to the dental profession in 1991. They contain the same essential components as conventional glass-ionomers (basic glass powder, water, polyacid), but also include a monomer component and associated initiator system.[2] A yet new material- zirconia reinforced glass ionomer cement (Zirconomer improved) reinforces structural integrity of restoration and imparts higher mechanical properties befitted for utilization in posterior teeth. This is a high strength restorative material, reinforced with zirconia nano fillers known as zirconomer improved and has been a

Table 1: Individual mean values of compressive strength with standard deviation of all the three groups using one way ANOVA

				95% confidence interval of mean	

Table 2: Intergroup comparison of compressive strength values after application of post hoc dunnet t3 test

(I) Material	**(J) Material**	**Mean difference I - J**	**sig**
Group A (Equiaforte)	Zirconomer improved	-19.02140*	.000
	RMGIC	22.86380*	.000
Group B (Zirconomer improved)	Equiaforte	19.02140*	.000
	RMGIC	41.88520*	.000
Group C (RMGIC)	Equiaforte	-22.86380*	.000
	Zirconomer improved	-41.88520*	.000

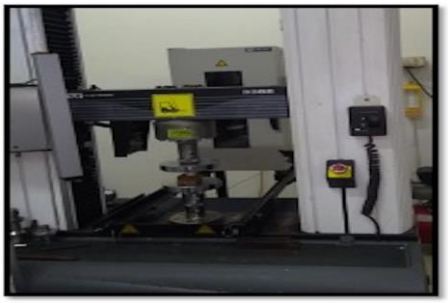
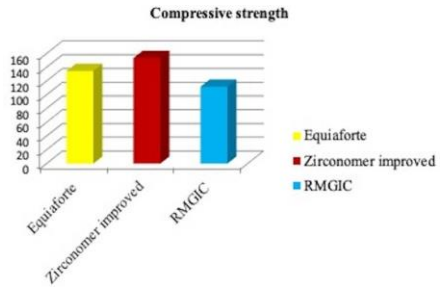


Fig. 1: Universal Testing Machine



Graph 1: Mean values compressive strength of all the three groups in artificial saliva

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".[3] The recent development in the glass ionomer cement restoration is the introduction of bulk fill glass hybrid restorative system (Equiaforte) which represents the latest innovation in glass ionomer and resin technologies working in synergy. It is a combination of a self-adhesive, chemically cured, highly filled GIC and a self-adhesive, filled resin surface sealant. Since the comparison of the mechanical properties of glass ionomer cement would help the clinician to choose the appropriate and best material available for the restoration of weakened tooth structure, the present study has been conducted to comparatively evaluate the compressive strength of three different types of glass ionomer cement namely resin modified glass ionomer cement(Fuji II LC), zirconia reinforced glass ionomer cement (Zirconomer improved) and glass hybrid restorative system (Equiaforte) in artificial saliva.

MATERIALS & METHODS

Following materials were selected for this study:

Group A: Glass Hybrid restorative system - Equiaforte (GC Corporation, Tokyo, Japan).

Group B: Zirconia reinforced glass ionomer cement - Zirconomer improved (Shofu Inc., Japan).

Group C: Resin modified glass ionomer cement - Fuji II Lc Improved (GC Corporation, Tokyo, Japan).

Total of 45 cylindrical samples measuring 4mm diameter and 6mm height were fabricated in metallic split mold. Prior to the placement of any material in the metallic mold, petroleum jelly was applied on the inner side of the mold. Then for group A (equiaforte), one end of the capsule which is to be placed on the applicator was pressed against the firm surface to loosen the powder, following this the capsule was positioned in the amalgamator for mixing with dwell time of 10sec. Immediately capsule was placed into a

capsule applier and the lever was clicked until the mold was completely filled by the material. For group B (Zirconomer Improved), for easy retrieval of material from the mold petroleum jelly was applied on the inner surface. Powder and liquid ratio for each sample in this group was 3.6 / 1.0 (2 Scoops: 1 Drop), dispensed on the mixing pad with working time: 1min 30 sec (from start of mixing) and then it was placed on the mold by means of plastic instrument incrementally and condensed. For group c (Fuji II LC) also petroleum jelly was applied on the inner surface of mold. Then powder and liquid was dispensed on the mixing pad with the ratio of 3.2g: 1.0 with working time of 3min and 45 sec, and then by means of plastic instrument it was placed on the mold and light cured. Following the placement material in the mold for each group, back and forth of the mold was covered with mylar strip and pressed against glass slab to remove the excess the material. Finally each cylindrical specimen was smoothed by carbide paper and then it was left undisturbed. After this all the 45 samples were subjected to thermo cycling test comprising 500 cycles between 5°C and 55°C with the dwell time 15 secs.

Determination Of Compressive Strength

After subjecting the specimen to thermocyclying, 45 samples were selected for compressive strength determination with 15 of each material. Following this, all samples were soaked in artificial saliva at 37°C at pH 7 for 23 ± 0.5 hours. Artificial saliva used in this study was according to Gupta et al (2011) criteria(4).

Then each specimen was placed with the flat ends between the plates of the universal testing machine and a compressive load was applied along the long axis at a crosshead speed of 1mm/minute. The compressive strength was calculated, in MPa, using the following formula:$C = (4p)/(\pi d2)$.Where p was the maximum force applied, in Newton; d is the average measured diameter of specimen, in mm and π which has a numerical constant of 3.14.

STATISTICAL ANALYSIS

The data obtained in this study were calculated using the SPSS version 22 with P value < 0.05 was considered statistically significant. The statistical normal distribution suitability of sorption, solubility and compressive strength values was tested using the Kolmogorov-Smirnov method. Since the obtained values show normal distribution differences between the groups data were analyzed using the one way analysis of variance (ANOVA). Descriptive statistics were used to determine mean, standard deviation, minimum and maximum values between groups. The difference between groups was found to be significant ($p<0.05$). For pairwise evaluation between the groups post hoc dunnet t3 test was used

RESULTS

The mean compressive strength values and standard deviation of group A, B and C were 134.756 ± 2.85, 153.777 ± 1.55 and 133.475 ± 3.24 MPa respectively for all the three groups using one way ANOVA (table no:1), with highest mean compressive strength values for group B followed by group A and then group C. Statistically difference between the groups was shown in table no:2. These results are represented graphically (graph no:1) showing mean compressive strength values of all the three groups.

DISCUSSION

To evaluate the mechanical properties of GICs, the most commonly employed method to better understand the properties is by means of compressive strength test. To carry out these studies, some researchers have adopted standards and specifications for dental materials, instruments and dental equipment. Mallmann *et al*., suggested the use of smaller specimen dimensions (6 mm x 4 mm) to analyze mechanical properties of glass ionomer cements, according to ISO 7489:1986 specifications. The goal is to reduce the variability that may result when large amounts of material are manipulated. Hence, he emphasized when small specimens have been used, during manipulation process several increments of material is reduced, which may, in turn, result in a lower number of voids and internal failures and, consequently, in better standardization of the results. In this study specimens are used in accordance with dimensions of ISO specification (7489: 1986) measuring 6mm in height and 4mm in diameter for dental materials.[5] In the present study, the specimens for the compressive strength were stored in artificial saliva and thermocycled for 500 cycles at 5 degree celsius and 55 degree celsius to stimulate a one year aging period. There is wide variation in temperature and amplitude as well as in the number and duration of the elected cycles of 10,000 cycles at 50c and 550c cycles.[6] There are conflicting opinions reported in the literature degradation of glass ionomer after aging, while others show no degradation effects using stimulation aging method.[7,8] In the current study compressive strength was recorded by positioning the specimen vertically on the universal testing machine base and then subjected to axial compressive loading until fracture. The

average value of the compressive strength of the Zirconia reinforced glass ionomer cement shows a value of 153.777 MPa, Equiaforte of 134.756 MPa and RMGIC of 111.892 MPa which ranked first, second and third respectively. The reason for this should be observed for in the manner of preparation of samples, composition, methodology, as well as in the placement of the mix into the molds. Though the specimens were prepared under the same condition and by the same researcher, the residual error cannot be completely avoided due to human factor. The better compressive strength in our study for zirconia reinforced glass ionomer cement is probably due to incorporation of nano zirconia filler which is responsible for enhanced structural durability especially making it suitable for posterior stress bearing areas. In addition to this, it has the property of transformation toughening, lead to increase in the volume of the particle during tetragonal monoclinic phase which prevent the propagation growth of cracks and enhance the zirconia its unique mechanical properties.[3] Chitharanjan Shetty *et al*., determined the compressive strength of specimen measuring 3 mm in diameter and 6 mm in height using three materials namely ketac molar, zirconomer and Zirconomer Improved. The result exhibited compressive strength higher for zirconomer compared to ketac molar and zirconomer improved. But the compressive strength values obtained in their study for zirconomer improved was higher than our study.[9] It might be due to larger size specimen dimension. Mashaverinia *et al*., reported in their study compressive strength of Equiaforte with other materials such as Fuji IX GP and ChemFil Rock were not statistically significant but the compressive strength value obtained in their study higher than current study.[10] This was contrary to our study it might be due to aging stimulation method which contributes to variation in values. This study finding was in accordance with the study conducted by Sallinovic *et al*., where the compressive strength of Equiaforte Fil values obtained was similar to our study. But the values obtained were lower compared to manufacturer claims. This may be due to the specimen were stored in deionized water and that ions were leached out into the fluid contribute to lower values for all the tested materials.[11] We might try to draw a parallel with the results of Poornima *et al*., who evaluated the compressive strength of Equiaforte, RMGIC with conventional GIC where they obtained values higher for Equiaforte when compared with RMGIC which was similar to our study. This could be of different in mixing behavior affects the structure of the material. Hand mixing may be results in uneven distribution of force and it manifest themselves as crack propagation sites when the material was stress under load.[12] However this could be avoided if RMGIC capsule was used, mixing done with amalgamoter results in uniform mass with less incorporation of voids and it may yield better compressive strength value.

CONCLUSION

With the results, examined from this study Zirconia reinforced glass ionomer cement has increased values in terms of compressive strength followed by this glass hybrid restorative system and resin modified glass ionomer cement. Further studies should be done as this is an in vitro study where the ecosystem of oral environment cannot be mimicked and also for better results.

CONFLICT OF INTEREST & SOURCE OF FUNDING

The author declares that there is no source of funding and there is no conflict of interest among all authors.

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