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Comparative evaluation of flexural strength, wear resistance and micro-hardness of Zirconia Reinforced Glass Ionomer Cement, Silver Reinforced Glass Ionomer Cement and Conventional Glass Ionomer Cement: An in vitro study.

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Abstract-

Aim-

Glass ionomer cements are one of the most commonly used restorative materials in pediatric dentistry. However, they have a few drawbacks like low wear resistance, low flexural strength and degradation of the surface. To overcome these disadvantages, various materials have been added to these cements. The aim of the current study was to evaluate and compare the flexural strength, microhardness and wear resistance of a zirconia reinforced GIC, Silver Reinforced GIC and a conventional high strength type 9 GIC.

Materials and methods-

The materials to be tested were mixed according to the manufacturer's instructions and placed in customized stainless steel moulds. 5 samples for each test were prepared for each material. Once set, these were removed from the molds and standard machines were used to test the parameters that were to be tested.

Results-

A statistically significant difference was noted in the values for flexural strength and microhardness of the three materials. The highest flexural strength and microhardness was seen in the silver reinforced GIC. The difference in the values of wear resistance between the three groups was not statistically significant.

Conclusion-

Within the limitations of this study, silver reinforced GIc had the better physical properties as compared to zirconomer and Conventional GIC. However, no statistically significant difference was found between zirconomer and Silver reinforced GIC.

Introduction-

Glass Ionomer cements or Glass polyalkenoate cement according to the International Organization for Standardization[1] were introduced in the dental field by Wilson and Kent in 1970 and since then they have been used widely in dentistry in general and pediatric dentistry in particular. [2].These cements set based on an acid based reaction and they are principally composed of polymeric water-soluble acid, basic (ion-leachable) glass, and water.[3] The benefits of glass ionomer cements include their ability to adhere to the tooth structure, fluoride release, remineralization, gingival biocompatibility, aesthetics and contouring. However, along with these advantages they also have certain drawbacks like low wear resistance, low flexural strength and degradation of surface due to buffering oral acids.[4] Over the years different modified materials have been introduced to overcome the disadvantages or drawbacks of the originally introduced cements. Addition of certain materials to the cement has been thought to improve the properties of these materials. One such material is the zirconia reinforced glass ionomer cement which was commercially introduced as Zirconomer by Shofu, Japan. Zirconium oxide is added to the powder component of the GIC. The addition of optimum grain sized zirconia powder results in transformation toughening which gives it better mechanical properties like toughness and high hardness and higher strength along with better corrosion resistance.[5]

Another modification of glass ionomer cements include silver reinforced glass ionomer cement which were introduced in 1977. The addition of silver-amalgam alloy powder results in an increase in the physical strength and also provides radiopacity.[6] most of the modifications in GICs are aimed at improving the mechanical properties of GIC to make it useful for posterior restorations. The decision on which material to use in a particular case is often confusing and difficult which can be aided if there are clear comparisons between the different materials.

Hence this in vitro study was designed to compare and evaluate the flexural strength ,wear resistance and micro-hardness of Zirconia Reinforced GIC, Silver Reinforced GIC and Conventional GIC.

Methodology-

Table1. Materials used

Material	Company
Zirconomer	Shofu Inc.
Hi Dense XP	Shofu Inc.
GC Fuji IX extra	GC

Preparation of specimens-

The specimens of all the three materials were prepared in accordance to the machines to be used for testing the materials. 15 specimens were prepared for each group, 5 each for every test. Customized moulds were used to prepare the specimens according to the required dimensions which were as follows (image 1A and 1B)-

Flexural strength : 25mm x 2mm x 3mm thick block.

Wear resistance : 15mm diameter x 2 mm thick disc.

Micro-hardness: 15mm diameter x 2 mm thick disc.

The materials were mixed according to the manufacturer's instructions. These materials were than gradually expressed in the mould to avoid the formation of voids. Before expressing the material, the moulds were coated with vaseline. The moulds were slightly overfilled and then smoothened using a mylar strip. After the samples were ready, they were subjected to thermocycling (image 2). Thermocycling was done for 500 cycles in water bath between 5°C ± 2°C and 55°C ± 2°C with 30 seconds dwell time in each bath and a 15 second transfer time.

Flexural strength-

The flexural strength was determined by a three point bending test using the universal testing machine. The samples were loaded in a 3 point bending device with 30 mm distance between the support .The crosshead speed used was 3mm per minute. The universal testing machine measures the force during bending as a function of deflection of the beam(image 3A and 3B).

Wear Resistance-

Initial weight of the sample was measured after which the sample was fixed on the jig of the tester. The jig was attached to a motor and a tooth which was mounted was fixed to the upper jig to carry out the testing.

The tooth and the sample were then touched to each other and a load of 1.0kg was applied on the sample. The machine was then started at a speed of 350 rpm for 5000 cycles. The sample was then removed from the jig and weighed on a precision balance with an accuracy of 0.0001g. Percent wear was calculated by the formula - %wear = initial weight –weight after abrasion/initial weight x 100 (image 4A and 4B)

Micro hardness:

The sample was polished at one end and kept on a hardness tester table. A load of 50 or 100 grams was applied and held continuously for 20 seconds after which the indentation created by the load was measured. The vicker's hardness was then calculated from a standard table (image 5A and 5B).

Statistical Analysis-

Statistical analysis was performed using Statistical Product and Service Solution (SPSS)

version 16 for Windows (SPSSInc, Chicago, IL).

Data normality was checked by using Shapiro – Wilk test.

Confidence interval was set at 95% and probability of alpha error (level of significance) set at

5%.Power of the study set at 80%.

Comparisons among three groups in relation to different physical properties measured on

continuous quantitative scale was performed by Analysis of variance (ANOVA) test.

Multiple pair wise intergroup comparison between means of three groups was done with

help of Tukey's post hoc test.

Results-

Flexural strength-

Highest flexural strength was found in Silver Reinforced Glass Ionomer Cement (Group II)

followed by Zirconia Reinforced Glass Ionomer Cement (Group I) and least in Conventional

Glass Ionomer Cement (Group III).

On overall comparative evaluation of Flexural strength of Zirconia Reinforced Glass Ionomer

Cement (Group I), Silver Reinforced Glass Ionomer Cement (Group II) and Conventional

Glass Ionomer Cement (Group III) respectively using ANOVA F test, there was found to be

statistical significant difference (p<0.05) among three groups.

On individual pair wise comparison between groups using Tukey's post hoc test, there

was found no statistical significant difference between Group I and Group II, Group I and Group III ($p > 0.05$). But, Group II was found to have statistical significant higher flexural strength ($p < 0.05$) as compared to Group III

Wear Resistance-

No significant difference in wear resistance was noted between the three materials. However, among the groups the conventional glass ionomer cement showed the highest mean wear resistance.

Micro- Hardness

The microhardness was highest for the silver reinforced GIC (Group II) followed by the conventional GIC(Group III). It was the lowest for Zirconomer(Group I). The difference between the three was statistically significant.

On individual pair wise comparison between groups using Tukey's post hoc test, a statistically significant difference in the microhardness was noted between group I and group II.

Discussion-

Glass Ionomer cements are one of the most widely used materials in dentistry. Their advantages like biocompatibility, aesthetics, adhering to the tooth structure make them one of the most sought after materials in dentistry. However , a major drawback of these materials is their limited wear resistance and reduced flexural strength. To overcome these disadvantages various modified GICs have been introduced.

In the current study, the silver reinforced GIC showed the highest values for both flexural strength and microhardness which was followed by zirconomer. Wear resistance was higher in the conventional GIC as compared to the other two groups.

Flexural strength is the amount of force required to break a test sample of a defined diameter. The higher the flexural strength, the better the material will be as a posterior restorative material or in a high load bearing area. In the current study the highest flexural strength was seen in silver reinforced GIC followed by zirconomer. Zirconia (zirconium dioxide, ZrO_2), or "ceramic steel", is known to have superior toughness, strength, and fatigue resistance, in addition to excellent wear properties and biocompatibility.[7] Shofu HiDense is a silver reinforced glass ionomer cement. The addition of silver to dental materials is thought to be beneficial for multiple reasons.

Bonaficio et al reported similar findings with Hi Dense showing a high flexural strength. The flexural strength in this study is higher than that reported by Bonaficio et al [8]

In the study by Bonifacio et al, hi dense was seen to have high wear test results initially but they were comparable to the other GICs in the long term.[8] This is in accordance with the results obtained in the current study as well where no statistically significant difference was observed among the three test groups.

In the present study, the microhardness of Zirconomer was higher in comparison with conventional glass-ionomer however silver reinforced GIC had the highest microhardness. In a study by Gu et al, the microhardness of zirconia-reinforced glass-ionomer was higher than miracle mix by 20%.[9] another study carried out by Sharafeddin F et al, concluded that Zirconomer had lower microhardness than was lower than silver-reinforced glass-ionomer which is in accordance with the current study. [10] In a study by Challiserry et al, Zirconomers were also found to have a higher compressive strength and diametral tensile strength. [11]

GICs reinforced with Zirconia showed higher compressive strength and microhardness compared to normal GIC in an in vitro study. [12] In a study to compare the compressive strength of zirconomer and amalgam, it was noted that addition of zirconia increased the strength of GIC significantly as compared to conventional glass ionomer cement. It was equivalent to amalgam at 1 hour but after 24 hours, it was weaker than amalgam.[13] Bala O et al compared the surface roughness and microhardness of GICs reinforced with different materials and the silver reinforced GIC showed the highest value for microhardness and the surface roughness was lower than the conventional GIC both before and after polishing.[14]

Both these materials have shown significant advantages over the conventional GICs. However the highly viscous conventional GIC is still very useful when it comes to their use in atraumatic restorative treatment. Zirconomers have an advantage over silver reinforced GIC due to better aesthetics. Both Zirconomers and silver reinforced GIC are known to have antimicrobial properties. [15]

The use of reinforced cements has been subject to multiple controversies. While a few authors reported significantly improved physical properties[16], others did not find any difference[17].

The physical properties also depend on the particle size of the added materials and these might result in a variation in the results of different studies.

Other factors like aesthetics and patient acceptance also play an important role in deciding the material of choice in each case and hence the results of all such studies should be evaluated and decisions made on a case to case basis.

Conclusion

Within the limitations of this study it can be concluded that, the silver reinforced GIC seems to have the highest flexural strength and microhardness followed by zirconomer. The conventional GIC had the least FS and microhardness. The difference in the wear resistance was not statistically significant among the three groups. The decision to use the materials would depend on the individual cases however when the physical properties are considered, the reinforced GICs have an advantage over the conventional GIC.

However this study was an in vitro study and a more accurate understanding and comparison would require an in vivo study. Another limitation is that all the values were tested at only one time interval and these might change over a period of time and on exposure to the oral factors.

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Table 2 : Comparative evaluation of Flexural strength of Zirconia Reinforced Glass Ionomer Cement (Group I), Silver Reinforced Glass Ionomer Cement (Group II) And Conventional Glass Ionomer Cement (Group III) respectively

Flexural strength	Mean	S.D	ANOVA F TEST	p value, Significance
Group I (Zirconomer)	22.84	7.89	F= 8.743	p = 0.005*
Group II (HI Dense XP)	30.46	5.37		
Group III (GIC Extra)	15.50	2.27		
Tukey's post hoc test to find multiple individual pair wise comparisons				
Group	Comparison group		Mean Difference	p value, Significance
Group I (Zirconomer)	Group II (HI Dense XP)		7.64	p = 0.125
	Group III (GIC Extra)		7.34	p = 0.143
Group II (HI Dense XP)	Group III (GIC Extra)		14.99	p = 0.003*

Table 3: Comparative evaluation of Wear Resistance of Zirconia Reinforced Glass Ionomer Cement (Group I), Silver Reinforced Glass Ionomer Cement (Group II) And Conventional Glass Ionomer Cement (Group III) respectively

Wear Resistance	Mean	S.D	ANOVA F TEST	p value, Significance
Group I (Zirconomer)	0.38	0.046	F = 1.168	p = 0.347
Group II (HI Dense XP)	0.36	0.041		

Group III (GIC Extra)	0.40	0.046		
Tukey's post hoc test to find multiple individual pair wise comparisons				
Group	**Comparison group**		**Mean Difference**	**p value, Significance**
Group I (Zirconomer)	**Group II (HI Dense XP)**		**0.024**	**p = 0.681**
	Group III (GIC Extra)		**0.021**	**p = 0.758**
Group II (HI Dense XP)	**Group III (GIC Extra)**		**0.045**	**p = 0.319**

Table 4: Comparative evaluation of Microhardness of Zirconia Reinforced Glass Ionomer Cement (Group I), Silver Reinforced Glass Ionomer Cement (Group II) And Conventional Glass Ionomer Cement(Group III) respectively

Micro Hardness	**Mean**	**S.D**	**ANOVA F TEST**	**p value, Significance**
Group I (Zirconomer)	**91.20**	**6.53**	**F = 7.758**	**p = 0.007***
Group II (HI Dense XP)	**105.80**	**5.89**		
Group III (GIC Extra)	**98.20**	**5.06**		
Tukey's post hoc test to find multiple individual pair wise comparisons				
Group	**Comparison group**		**Mean Difference**	**p value, Significance**
Group I (Zirconomer)	**Group II (HI Dense XP)**		**14.60**	**p = 0.005***
	Group III (GIC Extra)		**7.00**	**p = 0.184**
Group II (HI Dense XP)	**Group III (GIC Extra)**		**7.60**	**p = 0.143**

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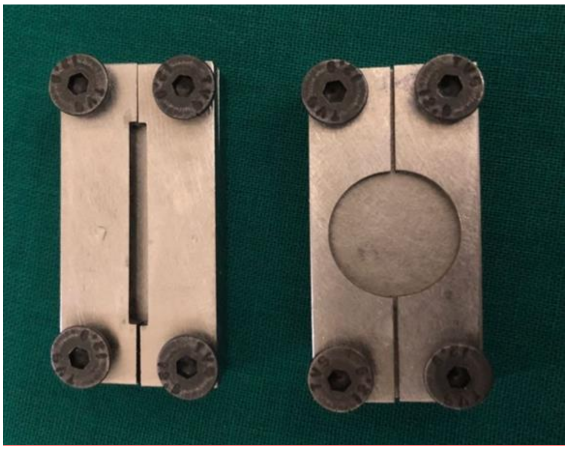


Image 1A: Prepartion Of Samples : Moulds

Image 1B: ALL SAMPLES TOGETHER

IMAGE 2:THERMOCYCLING

IMAGE 3A :UNIVERSAL TESTING MACHINE FOR FLEXURAL STRENGTH

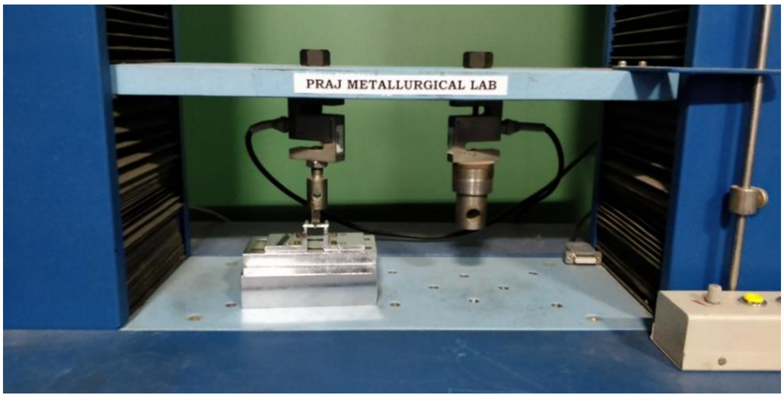


IMAGE 3B :UNIVERSAL TESTING MACHINE FOR FLEXURAL STRENGTH

IMAGE 4A: WEAR RESISTANCE

IMAGE 4B: WEAR RESISTANCE

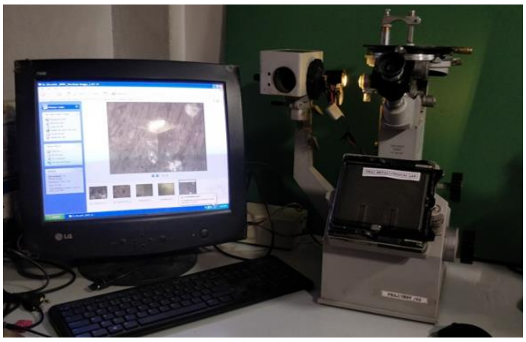
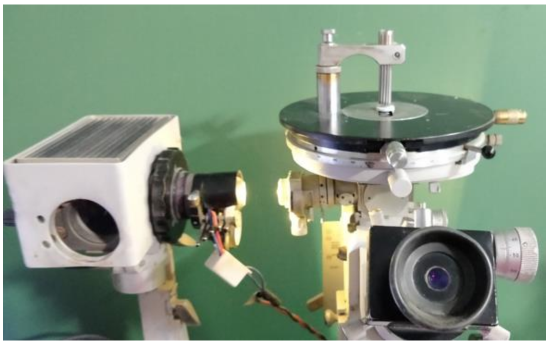


IMAGE 5A: MICRO-HARDNESS



MAGE 5B: MICRO-HARDNESS