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RESEARCH ARTICLE

COMPARATIVE EVALUATION OF MICROLEAKAGE AND DIAMETRAL TENSILE STRENGTH OF VARIOUS RESTORATIVE MATERIALS - *AN IN VITRO STUDY*

Dr. Grace Thanglienzo[1], Dr. Shipra Jaidka[2], Dr. Rani Somani[3], Dr. Deepti Jawa[3], Dr. Muhamed Sabin[4], Dr. Mayanglambam Leleesh[4], Dr. Oinam Renuka[4] and Dr. Sarath Kumar R.[4]

1. Post Graduate Student, Department of Pediatric and Preventive Dentistry, Divya Jyoti College of Dental Sciences and Research.
2. Professor, Department of Pediatric and Preventive Dentistry, Divya Jyoti College of Dental Sciences and Research.
3. Professor and Head, Department of Pediatric and Preventive Dentistry, Divya Jyoti College of Dental Sciences and Research
4. Post Graduate Student, Department of Pediatric and Preventive Dentistry, Divya Jyoti College of Dental Sciences and Research.

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Abstract

Aim: To evaluate and compare microleakage and diametral tensile strength of various restorative materials.

Materials & Method: For the evaluation of microleakage, Class V cavities were prepared on sixty human premolar teeth and restored according to five study groups (n = 15): Group I (Fuji ix), Group II (Zirconomer Improved), Group III (Glasionomer FX Ultra), Group IV (Positive Control) and Group V (Negative Control). The samples were thermocycled and subjected to dye penetration test. The sections were made and evaluated under stereomicroscope at × 40 magnification. For the Diametral Tensile strength evaluation, fourty five cylindrical specimens were fabricated measuring 5 mm × 6 mm and grouped into three study groups (n = 15): Group I (Fuji ix), Group II (Zirconomer Improved) and Group III (Glasionomer FX Ultra). Diametral Tensile Strength was evaluated using Universal Testing Machine.

Statistical analysis used: The data were analyzed using TUKEY'S and ANOVA.

Results: For microleakage, all intergroup comparisions were significant except between Group A (Fuji IX) and Group C (Glasionomer FX Ultra), with Zirconomer Improved showing maximum followed by Fuji IX and Glasionomer FX Ultra. The Diametral Tensile strength was found to be highly significant ($P < 0.01$) except between Group B (Zirconomer Improved) and Group C (Glasionomer FX Ultra) with the maximum score for Zirconomer Improved followed by Glasionomer FX Ultra and Fuji IX.

Conclusion: Glasionomer FX Ultra is recommended as a restorative material because of it's comparable Diametral Tensile Strength to Zirconomer Improved and effective sealing ability.

Corresponding Author:-Dr.Rani Somani
Address:-Professor and Head, Department of Pediatric and Preventive Dentistry, Divya Jyoti College of Dental Sciences and Research, Modinagar, Uttar Pradesh.

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Introduction:-

Dental caries is an infectious microbiologic disease of the teeth that results in localized dissolution and destruction of the calcified tissues. Caries activity, as evidenced by demineralization and loss of tooth structure, varies, and the course of individual lesions is not always predictable. But, once caries occurs it has to be restored as restoration of the tooth structure is essential for the proper functioning of the teeth and prevention of further loss of tooth structure.

Dental amalgam is one of the oldest restorative material used in dentistry, mainly because of it's excellent strength and durability. In spite of many advantages, it has some drawbacks such as unaesthetic appearance, postoperative tooth sensitivity, susceptibility to fracture of the restored teeth, microleakage, hazards of residual mercury and high incidence of development of secondary caries.[1]

Hence, many tooth-colored materials have evolved to replace amalgam in the recent past like GIC, Composite, Amalgomer CR, etc. The Glass Ionomer Cement was introduced by **Wilsonand Kent in 1971** and since then it has been widely used because of its unique properties, such as anti-carcinogenic character, excellent adhesion to dentin, almost same thermal expansion as that of tooth, satisfactory biocompatibility. Despite all these advantages there is still some drawbacks with conventional GIC such as brittleness, low tensile strength, and toughness. To overcome the drawbacks, the conventional GIC has undergone innumerable changes and inclusions in its properties and composition. [2]

A newer material such as Zirconomer improved and Glasionomer FX Ultra has been introduced to overcome the drawbacks.

The ideal restorative material should also have good compressive strength, shear strength, tensile strength and should be biocompatible, esthetically sound and should have low microleakage, low solubility.

Another important characteristic of the restoration is its Diametral Tensile Strength (DTS), which is a maximum load that a material can support without fracture when being stretched. A restorative material needs to have a good diametral tensile strength to resists masticatory forces effectively.

Hence in light of the above knowledge, the present in vitro study is planned to compare the sealing ability and diametral tensile strength of newer restorative materials.

Methodology:-

The present in vitro study was carried out in the Department of Pediatric and Preventive Dentistry, D.J. College of Dental Sciences & Research, Modinagar in collaboration with Subharti Dental College, Meerut and Apex Assessment Laboratory, Mohan Nagar, Ghaziabad, Uttar Pradesh

Preparation of samples for microleakage study:

Fifty human premolar teeth extracted for orthodontic or periodontal reasons fulfilling the inclusion criteria were taken as a sample for the study. The following inclusion criteria was used - teeth free from restoration and fluorosis, teeth without any caries, teeth with intact buccal/lingual surface and teeth without any developmental anamoly.Standardised class V (3mmwide x 2mm high x 1.5 mm) deep cavities were prepared on the buccal/lingual surfaces of all the teeth in the selected sample using a round bur in a high speed airotor. Fifty teeth were divided into five equal groups and were restored with Fuji IX, Zirconomer Improved and Glasionomer FX Ultra respectively according to manufacturer's instruction except for positive and negative groups.

All the samples were then thermocycled having a temperature differential of 5-55^{O} c for 500 cycles with a time of 30 seconds to stimulate oral conditions, after which they were incubated at 37^{0}C for 48 hours and immersed in a 2% Methylene Blue for 48 hours. A diamond disc at slow speed in a micromotor straight hand piece was used to section the teeth longitudinally in a bucco-lingual direction (Figure 1). The samples were then evaluated for microleakage using stereomicroscope.

Microleakage Evaluation (Stereomicroscopic)
The microleakage was assessed by viewing all the treatment groups under stereomicroscope at a magnification of 40X.

The scoring criteria for the microleakage assessment were followed according to Vinay S and Shivanna V (2010).

0 = No dye penetration.
1 = Dye penetration up to 1/3rd cavity depth
2 = Dye penetration up to 2/3rd cavity depth
3 = Dye penetration to full depth of cavity
4= Dye penetration onto axial wall of cavity.

The same procedure was followed for all the remaining samples. Data was collected, tabulated and sent for statistical analysis.

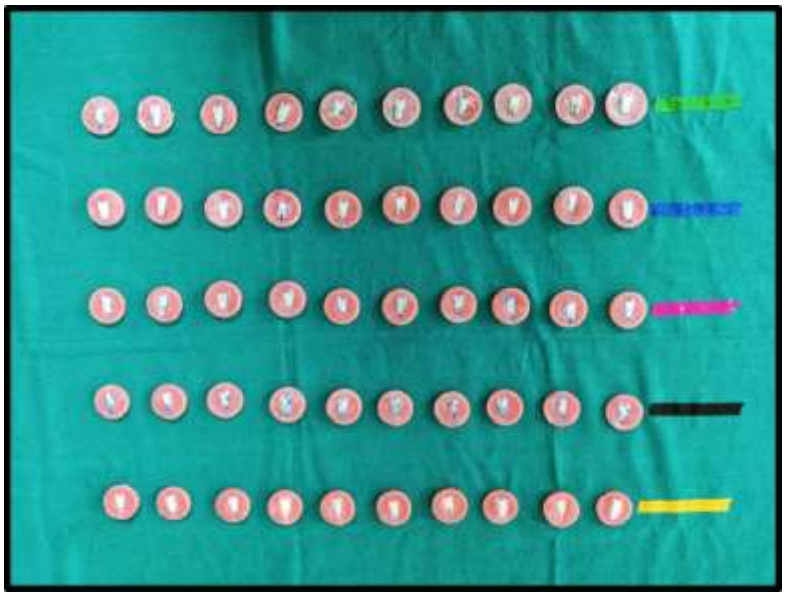


Figure 1:- Sectioned samples.

Diametral Tensile Strength Evaluation:
Forty five pellets were used for the study and the restorative material pellets were prepared using a cylindrical mold of 6cm x 7mm dimension. Measurements were made by vernier caliper and marker pen. The pipe were then cut by using BP blade and mylar strips were placed on the top of the glass slab and mould were kept on it. After which, mixing of materials was done according to manufacturer's instructions using autoclaved sterile instruments and the mixed restorative cement were carried with plastic filling instrument and were placed into the mould. The moulds were then covered with mylar strip and compressed with a glass slab to extrude the excess material and to get a polished surface (Figure 2). After the materials were set, the pellets were removed from the themoulds by cutting them with a BP blade and were subjected to thermocycling to simulate oral conditions (Figure3). Thermocycling was done in the same manner as was done for microleakage evaluation. Then, the restorative pellets from all the groups were subjected for Diametral Tesile Strength determination using Instron Universal Testing Machine in collaboration with Apex Laboratories, Mohan Nagar .

This collected data of all the specimens were evaluated and subjected to statistical analysis.

Division Of Samples :
The prepared 45 samples were randomly divided into the following three groups and color coded accordingly.
Group I - samples to be restored with GIC Type IX. (n=15)(Green colour)
Group II - samples to be restored with Zirconomer. (n=15)(Purple colour)
Group III - samples to be restored with Glasionomer FX Ultra. (n=15)(Red colour)

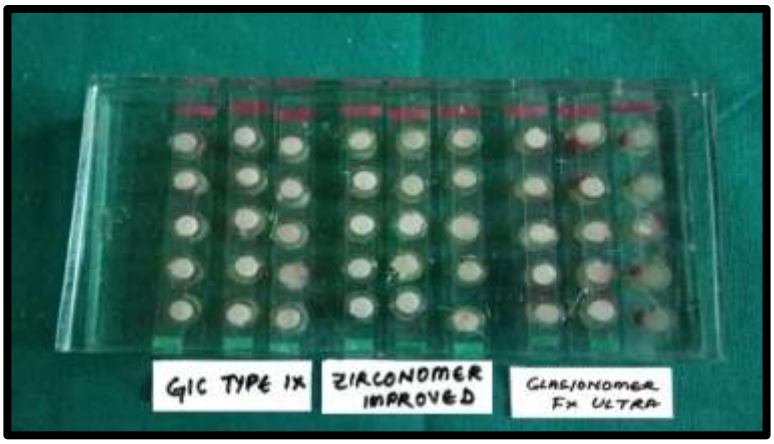


Figure 2:- Restored pellets in plastic molds covered on both sides by acetate strips.

Figure 3:- Pellets.

Results:-

The data was statistically analysed using TUKEY'S and ONE WAY-ANOVA and the following results were obtained.

In case of microleakage, it was noted that Group D (Zirconomer Improved) has the highest mean value (3.60) while group C (Glasionmer FX Ultra) showed lowest mean value (2.10) of microleakage. While in case of Diametral Tensile Strength, it was noted that Group B (Zirconomer Improved) had the highest mean value (7.03) whereas Group A (Fuji IX) had the lowest mean value (6.03) of Diametral Tensile Strength.

Table 1:-Mean values of Microleakage of all the various groups.

Sl. No.	Various Groups	Mean	Std. Deviation	Std. Error	Minimum	Maximum
1.	Group A (Fuji IX)	2.3000	1.05935	.33500	.00	4.00
2.	Group B (Zirconomer Improved)	3.6000	.69921	.22111	2.00	4.00
3.	Group C (Glasionomer FX ultra)	2.1000	1.52388	.48189	.00	4.00
4.	Group D (Positive Control)	4.0000	.00000	.00000	4.00	4.00
5.	Group E (Negative Control)	0.0000	.00000	.00000	.00	.00

Distribution of variance between and within the groups using ANOVA test

The intercomparison of various groups was done using ANOVA test. The mean variation of microleakage of various restorative material was compared between different groups and within the groups and it was found that mean value of microleakage in all the groups have a significant difference at p value 0.001.

Table 2:- Comparison of Means of Microleakage among the various groups.

ANOVA						
Sl. No.	Various Groups	Sum of Squares	df	Mean Square	F	Sig.
1.	Between Groups	98.600	4	24.650	31.335	0.001 (Sig)
2.	Within Groups	35.400	45	.787		
3.	Total	134.000	49			

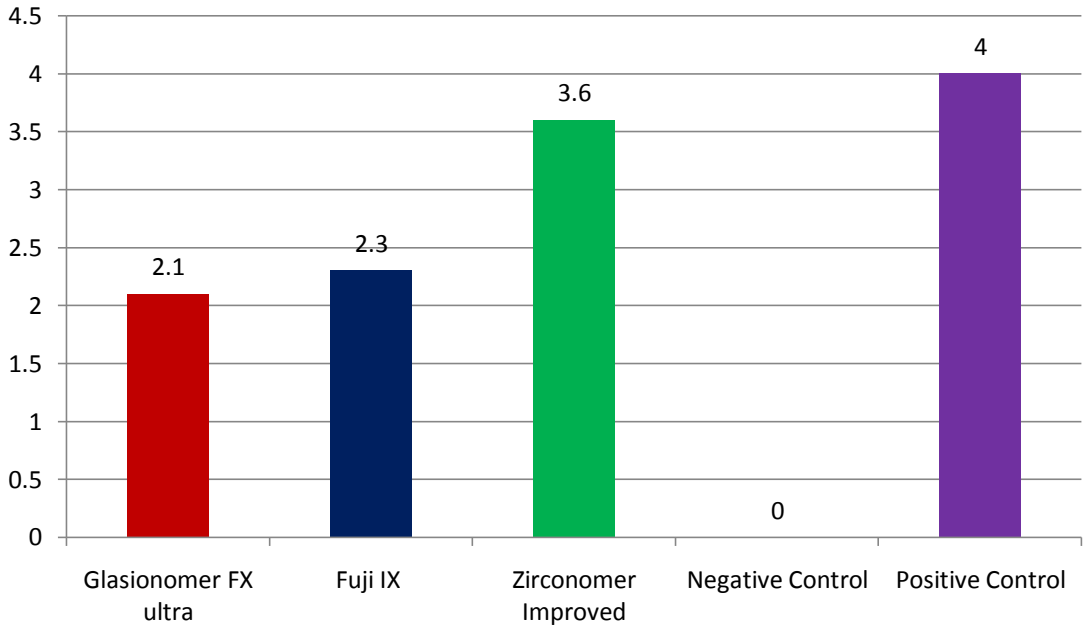
Inter comparison of Microleakage of various groups:

Inter comparison of microleakage of various groups was done using Tukey's (2-sided Post Hoc tests). All intercomparisions between the mean microleakage values of various groups was found to be highly significant except, between Glasionomer FX Ultra and Fuji IX.

Table 3:- Inter comparison of Microleakage of various groups by Tukey Post Hoc Test.

Tukey's (POST HOC)					
Sl. No.	Various Groups	Mean Difference (I-J)	Std. Error	P value	Significance
1.	Goup A vs Group B	-1.30000*	.39665	.002	Significant
2.	Group A vs Group C	-.20000	.39665	.617	Non-Sig
3.	Group B vs Group C	-1.50000*	.39665	.000	Significant
*** p value < 0.05 Significant**					

Group A – GIC type IX
Group B – Zirconomer improved
Group C – Glsionomer FX Ultra



Graph 1:- Graphical representation of mean of Microleakage among the various groups.

Mean values of Diametral Tensile strength in various groups

The mean value of Diametral Tensile strength was 6.03 for Group I (GIC Type IX), 7.03 for Group II (Zirconomer Improved), 6.91 for Group III (Glasionomer FX Ultra).

It was noted that Group II (Zirconomer Improved) has highest mean value of 7.03, while Group I (GIC Type IX) has lowest mean value of diametral tensile strength, i.e, 6.03

Table 4:- Mean values of Diametral Tensile strength of the various groups.

Sl. No.	Various Groups	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
1.	Fuji IX (Group A)	15	6.0327	.78824	.20352	4.32	7.40
2.	ZirconomerImproved(Group B)	15	7.0320	1.25942	.32518	5.19	8.98
3.	Glasionomer FX ultra(Group C)	15	6.9133	1.72480	.44534	5.22	11.69

Distribution of variance between and within the groups using ANOVA test

The inter-comparison of various groups was done using ANOVA test. The mean variation of Dimetral Tensile strength of various restorative material was compared between different groups and within the groups and it was found that mean value of compressive strength in all the groups have a significant difference at p value 0.001

Table 5:- Comparison of Means of Diametral Tensile strength among the various groups.

ANOVA						
Sl. No.		Sum of Squares	df	Mean Square	F	Sig.
1.	Between Groups	8.942	2	4.471	2.588	0.087 (Non-Sig)
2.	Within Groups	72.553	42	1.727		
3.	Total	81.495	44			

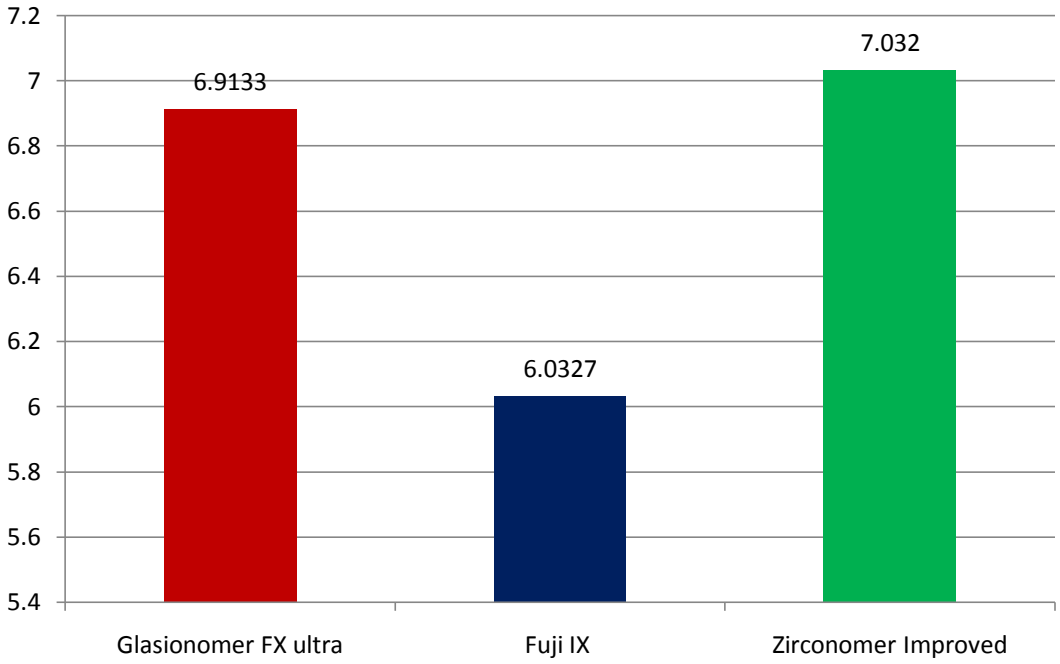
Inter comparison of Diametral Tensile Strength of various groups

Inter comparison of compressive strength of various groups was done using Tukey's (2-sided Post Hoc tests). All intercomparisions between the mean compressive strength values of various groups was found to be highly non-significant except, between Fuji IX and Zirconomer Improved.

Table 6:- Inter comparison of Diametral Tensile Strength of various groups.

Sl No.	Groups	Mean Difference (I-J)	Std. Error	P value	Significance
1	Group A vs Group B	-0.999	0.479	0.074	Significant
2	Group A vs Group C	-0.880	0.479	0.806	Significant
3	Group B vs Group C	0.118	0.479	0.043	Non-Sig

Group A Fuji IX
Group B Zirconomer Improved
Group C Glasionomer FX Ultra



Graph 2:-Graphical representation of mean of Diametral Tensile Strength of the various groups.

Discussion:

The ancient art of dentistry and the need for dental materials arose from man's attempt to combat and repair the effect of dental diseases, which are largely associated with the development of civi1ization. The subject of dental materials forms an essential part of restorative dentistry. It is not merely a specialized branch of materials science, itself a complex amalgam of the chemical and physical sciences and technologies, but combines also the elements of cosmetic art, biological science, and clinical practice. It remains an art as well as a science and the requirements of one may impinge on those of the other. Thus basic chemistry cannot always be dissociated from biological and aesthetic requirements and this adds to the complexities of research. The development of restorative dentistry has been related to the availability of suitable materials.[3] The search for these has continued throughout the history of dentistry and has been largely dependent on general advances in science and technology. As there are morphological and histological difference between deciduous and primary teeth, so, the ideal requirements of restorative material differs. The foundation for aesthetics is based on their position, contour, texture and color. Glass ionomer cement (GIC) is one of the first aesthetic restorative materials introduced in the dental arena by Wilson and Kent way back in 1972.[2]

However, conventional GIC were susceptible to fracture and exhibited low wear resistance. To overcome the disadvantages of low compressive strength and brittleness of glass ionomer, metal reinforced materials like Miracle Mix and Ketac Silver were introduced. Though it increased the strength but they became unacceptable because of unaesthetic appearance.

Thus, this current study was designed in vitro, with the aim to evaluate and compare the marginal sealing ability and diametral tensile strength of GIC type IX, Zirconomer Improved and Glasionomer FX ULTRA.

The results of the present study showed that Zirconomer Improved had the highest microleakage among the various groups. While Glasionomer FX Ultra showed least microleakage. The microleakage value of Fuji IX and Glasionomer FX Ultra were comparable.

Glasionomer FX Ultra had least microleakage among all experimental group as it contains polyacrylic acid in addition to fluoroalumino silicate glass in powder form. The use of Polyacrylic acid also significantly reduced dye penetration, this is in accordance to the study done by **PRATI et al (1989)**[4]on theEffects of acid and cleansing agents on shear bond strength and marginal microleakage of glass-ionomer cements**.** This study is a pioneer study

evaluating the microleakage of Glasionomer FX Ultra. As Glasionomer FX Ultra is a new material and not much of studies have been done on it, more research work is needed to be done to have a better vision about this new material.

Microleakage of Glasionomer FX Ultra was comparable to Fuji IX and statistically lesser than Zirconomer Improved. Powder of Fuji IX contains only fluoroaluminosilicate glass and it is recommended to use a conditioning agent to decrease microleakage. The usage of two materials might be the reason that Fuji IX had more microleakage than Glasionomer FX Ultra but as both had same basic composition that might be the reason for comparable results. **Pontes DG (2014)**[5]ComparedandEvaluated Microleakage of Class V Restorations with Conventional and Resin-modified Glass Ionomer Cements, where conventional GIC materials presented more microleakage than RMGIC.

Microleakage of Zirconomer Improved was the highest among all experimental group. One explanation to this is that large size of the filler particle in Zirconomer prevents proper adaptation of this material to the tooth surface and also due to it's poor working consistency, longer setting time, and rough surface texture. **Asafarla S (2017)**[6] Compared & Evaluated the Microleakage of – Zirconomer, Fujii IX Extra GC and Ketac Molar, in which the result shows that the highest microleakage was found in Zirconomer.

When mean diametral tensile strength was evaluated, it was found that Zirconomer Improved had the highest Diametral Tensile Strength among the experimental group. One of the reason could be that Zirconia is unstable in nature which even after addition of Yttrium remains metastable so to further stabilize it aluminium is added as an impurity in the Zirconomer powder. These impurities of alumina occupy the edges of zirconia and provides an increase in transgranular fracture mode which means in case a crack has been created either because of internal stress or external masticatory load, it will appear only at the border of the transgranular structure of aluminium stabilized Zirconia filler. In response to stress, Zirconia changes its shape to monoclinic and thus expands slightly and closes this propagation of cracks thus making it a stiffer structure having good diametral strength. **Chalissery VP et al (2016)**[7] Study the Mechanical Properties of the Novel Zirconia-reinforced Glass Ionomer Cement, silver amalgam and reinforced glass ionomer cement, in which, Diametral Tensile Strength was found to be significantly higher for the zirconia-reinforced GIC and silver amalgam compared with Fuji IX (GIC).

The mean Diametral Tensile strength of Glasonomer FX Ultra was found to be comparable to that of Zirconomer Improved. The high diametral tensile strength can might be because of the faster setting reaction of the high viscosity GICs (Glasionomer FX Ultra). **Dheeraj M et al (2019)**[8] Compared & Evaluated Diametral Tensile Strength of Zirconomer with GIC and Amalgam, in which GIC had the least value of diametral tensile strength when compared to amalgam and Zirconomer.

The mean Diametral Tensile Strength of Glasionomer FX Ultra was found to be more than GIC Type IX. The possible explanation is that, in the liquid composition of Glasionomer FX Ultra tartaric acid is absent which was present in Fuji IX. **D. Xie et al (2000)**[4] studied the Mechanical properties and microstructures of glass-ionomer cements**.** The studies showed that resin-modified GICs (RM GICs) exhibited much higher Diametral Tensile Strength when compared to the conventional GICs.

The mean Diametral Tensile strength of Fuji IX was found to be lowest when compared to other experimental groups. The reason could be because when powder reacts with liquid in GIC, the matrix formed is of polyacrylic hydrogel which has less viscosity and thus are not so stiff to counteract enough stresses or occlusal load which might lead to fracture of the restoration because of lesserdiametral tensile strength. **Iftikhar N et al (2019)**[10] Compare & Evaluate Diametral Tensile Strengrh of Four Different Restorative Materials namely Fuji IX, ClearFil AP-X, Filtex Z350-XT, and Cention N. The result shows that ClearFil AP-X exhibits the highest Diametral Tensile Strength and least values were obtained by the Fuji IX.

Conclusion:-

Hence, it can be concluded that Glasionomer FX Ultra is recommended as a restorative material as it has the best sealing property as microleakage is found to be least when compared to other groups, followed by Fuji IX and the highest in Zirconomer Improved. Whereas, the study shows that ZirconomerImproved has the highest durability as it has the highest Diametral Tensile Strength when compared to other groups, followed by Glasionomer FX Ultra and the least is Fuji IX.

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