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The evaluation of microhardness of different restorative glass ionomer cements

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Abstract
The purpose of this study is to compare the microhardness properties of glass ionomer cements in different contents. Method: The study group included five different glass ionomer cements; EQUIA Forte Fil (GC, Tokyo, Japan, EQF), Fuji II LC Light-Cured Glass-Ionomer Cement for Restorative Filling (GC Corp, Tokyo, Japan, F2S), Fuji IX Conventional glass ionomer Cement for Restorative Filling (GC Corp, Tokyo, Japan, F9S),Glass carbomer (Glass Carbomer, GCP), Ionoseal (Glass ionomer cement, VOCO, Cuxhaven, IOS). They were filled in teflon molds (height: 4 mm, width: 6 mm) and irradiated for 20 s chemically or by LED device. The Vickers hardness number was measured on the surface in contact with the stainless steel sheet using a micro-indentation tester (Emco Test Durascan) with a 100N. Statistical analysis was performed on the obtained data (Wilcoxon Signed Ranks Test, ANOVA, Bonferroni). Results: Significant difference was determined between microhardness values, statistically ($p < 0,05$). While microhardness values are highest in F9S, GCP was at least as well. Conclusion: According to microhardness findings, statistically significant hardness differences were observed in glass ionomer cements. However, microhardness values similar to composite materials were obtained in some groups.

Keywords: Microhardness, glass ionomer cement, composite

1. Introduction
In today's modern dental practice, progressive and preventive developments have been achieved with advances in adhesive techniques. The single-session direct restoration techniques applied to provide and protect the integrity of dental hard tissues have become more preferred in this context. As permanent direct restorative materials, amalgam, composite resin and glass ionomer cements are used in routine clinical applications [1].
The physical properties of glass ionomer cements, which have evolved due to changes in their chemical and powder-liquid ratios, have expanded the range of applications in clinical applications [2, 3].
Glass ionomer cements are more aesthetic than amalgam restorations, but this is not as successful as composite resins. However, the availability of antigorogenic potentials due to fluoride release, biocompatibility and chemical adaptations to tooth tissues have made glass ionomer cements a distinctive material group [4].
Due to the ability of glass ionomer cements to cross-link with the subsequent calcium ions and raw metal ions, it now has a wide range of applications in dentistry There are various advantages such as; direct adhesion of glass ionomer cements to dental and raw metals, ant icryogenic properties, thermally compatible tooth enamel and dentin, abstinence of micro-leakage and monomer [5-7]. The purpose of this study is to compare the microhardness properties of four newly produced glass ionomer cements.

2. Materials and methods
Specimens of the five different glass ionomer cements were prepared in re-usable custom-made Teflon molds (split Teflon molds with an inner diameter of 6 mm and a height of 2 mm). Each glass ionomer cement was placed into the standard molds in 1-mm increments by use of prefilled syringes provided by the manufacturers. The glass ionomer cement was covered with a clear polyester matrix strip and a 1-mm-thick glass slide, which was gently pressed under a load of 200 gf during 1 minute.

Each increment was light-polymerized for 20 seconds following manufacturers' specifications with a visible light polymerization unit (Woodpecker; Dental Wireless LED Curing Light Lamp, USA) with an output of 1400 mW/cm2 and a wavelength between 420 and 480 nanometers [8]. The cylindrical blocks were thereafter removed from the teflon molds, thus providing a cylinder with the same dimensions of the bisected cavity (6 mm diameter; 2 mm height). Lots of materials were fabricated and stored in a light proof receptacle with distilled water at 37°C. The experimental part used in the present investigation are presented in Figure 1.

The Vickers hardness number was measured on the surface in contact with the stainless steel sheet using a micro-indentation tester (Emco Test Durascan) with a 100N load applied during 45 sec at two moments: 20 minutes and 24 hours after light curing. The specimens were individually fixed in a holder and positioned in such a way that the test surface was kept perpendicular to the indentation tip. Measurements were made at the top surface of the samples. 3 measurements were taken from the surface of each cylindrical sample to minimize errors in measurements. Averages of 3 measurements were calculated. As a result 5 measurements were taken from each group. For all tested materials, micro hardness means were calculated. Measurements were made at the top surface of the sample and three different measurements were taken from the surface of each cylindrical sample for minimization of the errors in measurements.

3. Results & Discussion

The mean values and standard deviations of microhardness of five restorative materials are presented in Table 1. Because our data was 50 denier, our data were observed to be normal distribution according to Shapiro-Wilk test results (p> 0.05) (Table 2). When we look at the homogeneity test, the result is 0,64, which is 0,05 den. In other words, it shows the difference between variances (Table 3). The results of the Vicker's microhardness value for each material with 95% confidence limits are listed in Table 4. The results indicated statistically significant differences (p<0, 05) among the tested materials. It was observed that GCP showed significantly lower hardness (32, 17 HV-02) compared with all other tested materials. Microhardness of F9S exhibited a significantly higher value (70, 28 HV-02) than all the other materials tested (Figure 2).

In the conventional method of opening the cavity, the removal of affected tooth tissues from cavities and cavities is essential; a minimally invasive approach based on the principle of removing only the soft and diseased caries layer without lifting the affected tooth tissues, which are now healthy and potentially remineralizable, is emerging. Restorative materials with remineralization potency have become important with the acceptance of the minimally invasive approach. What is important today is not just tooth restoration, but the long-term preservation of the existing tissue after restoration, without the necessity of an invasive procedure. In addition to the aesthetic features of the restoration, physical and mechanical properties are also of great importance for this reason.

Glass ionomer cements have been used for different clinical applications since their introduction. Recently, the idea of using glass ionomer cements instead of amalgam and composite resins as permanent restoration material has come to the forefront.

Glass ionomer cements (CIS) are materials that can be used as an alternative to composites in the conservative restoration of lesions in the posterior region. CISs have advantages such as having a thermal expansion coefficient similar to that of natural tooth tissue, physicochemical adhesion to tooth tissues, fluoride release, biocompatibility, low shrinkage, low edge leakage, anti-caries properties on restoration edges, and increased remineralization in adjacent proximal caries [9].

3.1 Tables and Figures

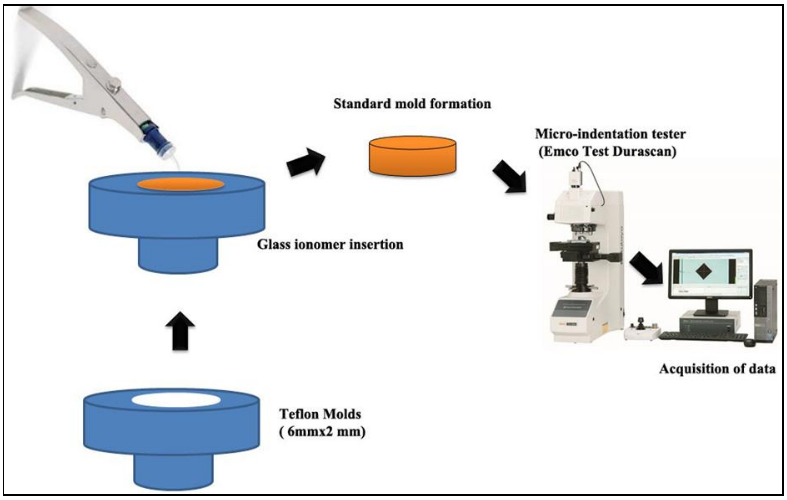

Fig 1: Experimental setup of this study

Table 1: Descriptives of microhardness results

Microhardness								
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
F2S	10	59,812	14,0757	4,4511	49,743	69,881	31,6	79,7
IOS	10	32,920	5,3277	1,6848	29,109	36,731	27,2	46,2
F9S	10	70,280	14,4207	4,5602	59,964	80,596	53,5	97,8
GCP	10	31,170	9,8379	3,1110	24,132	38,208	14,7	44,6
EQF	10	52,000	11,7022	3,7006	43,629	60,371	36,2	71,7
Total	50	49,236	18,9323	2,6774	43,856	54,617	14,7	97,8

Table 2: Shapiro-Wilk test results p> 0.05

Groups		Shapiro-Wilk		
		Statistic	df	Sig.
Microhardness	EQF	,925	10	,398
	F2S	,961	10	,797
	F9S	,927	10	,424
	GCP	,949	10	,657
	IOS	,814	10	,021

Table 3: Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
2,397	4	45	,064

Table 4: Multiple Comparisons of Dependent Variable

Tukey HSD						
Groups		Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
F2S	IOS	26,8920*	5,1699	,000	12,202	41,582
	F9S	-10,4680	5,1699	,271	-25,158	4,222
	GCP	28,6420*	5,1699	,000	13,952	43,332
	EQF	7,8120	5,1699	,561	-6,878	22,502
IOS	F2S	-26,8920*	5,1699	,000	-41,582	-12,202
	F9S	-37,3600*	5,1699	,000	-52,050	-22,670
	GCP	1,7500	5,1699	,997	-12,940	16,440
	EQF	-19,0800*	5,1699	,005	-33,770	-4,390
F9S	F2S	10,4680	5,1699	,271	-4,222	25,158
	IOS	37,3600*	5,1699	,000	22,670	52,050
	GCP	39,1100*	5,1699	,000	24,420	53,800
	EQF	18,2800*	5,1699	,008	3,590	32,970
GCP	F2S	-28,6420*	5,1699	,000	-43,332	-13,952
	IOS	-1,7500	5,1699	,997	-16,440	12,940
	F9S	-39,1100*	5,1699	,000	-53,800	-24,420
	EQF	-20,8300*	5,1699	,002	-35,520	-6,140
EQF	F2S	-7,8120	5,1699	,561	-22,502	6,878
	IOS	19,0800*	5,1699	,005	4,390	33,770
	F9S	-18,2800*	5,1699	,008	-32,970	-3,590
	GCP	20,8300*	5,1699	,002	6,140	35,520
*. The mean difference is significant at the 0.05 level.						

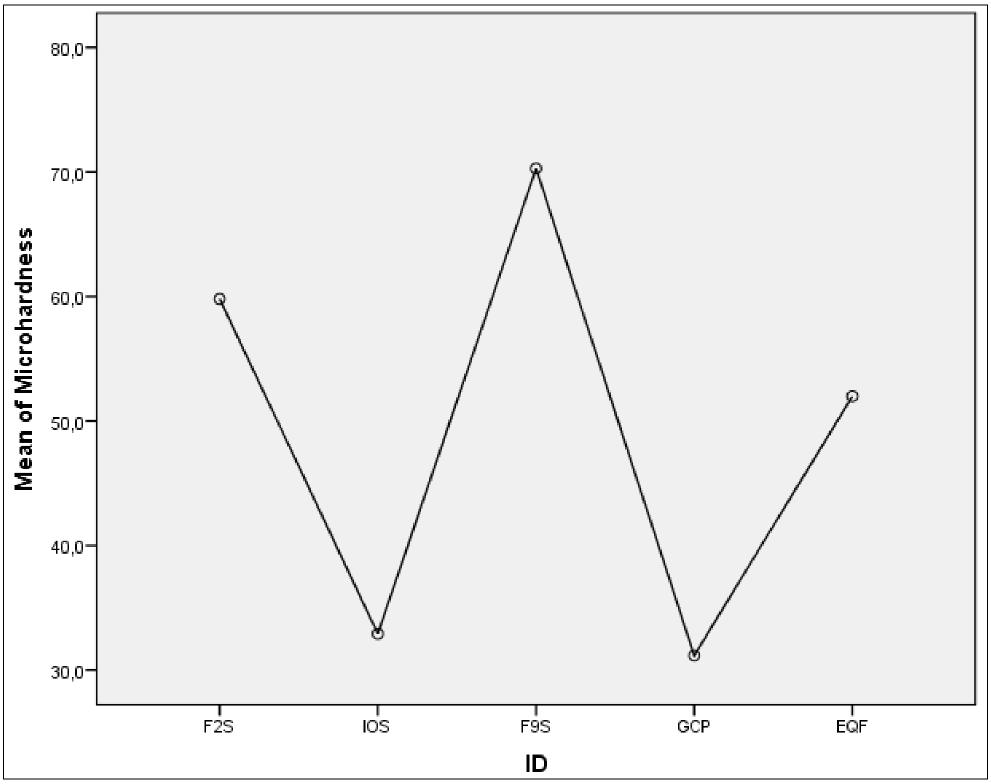

Fig 2: Mean of microhardness (ID: Groups/ results in HV-02)

4. Conclusions

The results of this study suggest that clinicians may prefer F9S, F2S, EQF, IOS and GCP respectively.

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