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Comparative Evaluation of the Mechanical Properties and Fluoride Release of Conventional Glass Ionomer Cement and Bulk-Fill Resin Composites in Permanent Posterior Restorations in a Pakistani Population.

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ABSTRACT

Background: Dental caries is still a significant oral health issue that requires long-lasting restorative materials with good clinical outcomes and preventive advantages. For posterior restorations, bulk-fill resin composites and glass ionomer cement (GIC) are frequently utilized, each with unique benefits.

Objective: Over the course of a 24-month follow-up period, assess the clinical performance, fluoride release characteristics, and survival outcomes of GIC and bulk-fill composite restorations in posterior teeth.

Materials and Methods: A comparative clinical trial was conducted in two groups (n=66) on 66 posterior restorations that were allocated equally to the GIC and bulk-fill composite group (n=33 each). Restorations were also evaluated in terms of marginal integrity, surface wear, fracture resistance and secondary caries at baseline, 6, 12, 18 and 24 months using modified USPHS criteria. The fluoride release at different intervals was dialogued with the help of an ion-selective electrode. In order to determine group differences, Kaplan-Meier survival analysis and appropriate statistical tests were used.

Results: Bulk-fill restorations were better than GIC in the area of marginal integrity, surface wear, color stability and survival rates ($p < 0.05$) at 24 months. However, the release and recharge capacity of fluoride was significantly greater at GIC during the trial period ($p < 0.001$). There was no significant difference in secondary caries and postoperative sensitivity between the groups.

Conclusion: GIC demonstrated higher fluoride-mediated preventative effects, while bulk-fill composites offered better clinical durability. Caries-preventive potential and mechanical performance should be taken into account while choosing a material..

Keywords: *Bulk-fill composite, glass ionomer cement, fluoride release, dental restorations, USPHS criteria, survival analysis.*

INTRODUCTION

Bulk-fill composite, glass ionomer cement, fluoride release, dental restorations, USPHS criteria, survival analysis By contrast, bulk-fill resin composites are a more recent type of composite restorative material which aims to ease the process of restorative treatment and enhance the mechanical properties. These materials can be placed with a higher increment of thickness (to 4 5 mm) with sufficient polymerization thus shortening the operative time and sensitivity to technique [8,9]. Bulk-fill composites also have better mechanical properties, marginal adaptation, fracture resistance and aesthetic outcomes

than the traditional glass ionomer materials. A number of randomized clinical trials and systematic reviews have found that bulk-fill restorations used in the posterior teeth demonstrated good clinical results and high survival rate of the treatment over medium- to long-term follow-up period [10,11].

Regardless of these developments, the long term clinical performance of such materials is an active research area. Past researches have contrasted GIC and composite restorations based on clinical standards like the United States Public Health Service (USPHS) evaluation system, which evaluates such parameters as the marginal integrity, surface wear, color stability, fracture resistance and secondary caries. Although composite restorations tend to show improved mechanical performance and esthetics, the GIC materials remain appreciated due to their release of fluoride and ability to prevent caries, which might prove especially useful when working with high caries diseases population.

Dental caries in Pakistan is still very high as there is a lack of knowledge on oral health, excessive consumption of sugar and lack of access to dental preventive services. The type of restorative material used in the field of dentistry especially in the state-run dental facilities is usually determined by the clinical performance and also cost, convenience and preventability. The most popular types of cement are glass ionomer cement due to its cost-effectiveness and fluoride-release features and bulk-fill composites that are becoming more popular in the practice because of high mechanical strength and appearance. But there is a dearth of long term clinical data on the comparison of these materials in the Pakistani population. Thus, this paper facilitated comparing the clinical performance, fluoride release properties, and the survival rates of glass ionomer cement and bulk-fill composite restorations in the posterior teeth after 24 months follow-up using standard clinical evaluation criteria.

MATERIALS AND METHODS

This study utilized prospective, randomised trial, parallel-group, single-blinded trial design over a 24 months period; that is, between April 2022 and April 2024. The objective of the study was to compare the clinical outcome of conventional glass ionomer cement with bulk-fill resin composite materials in terms of their use as permanent restorations of the posterior as a part of a Pakistani population.

The study was carried out in three different dental institutes in Pakistan so that the patient demographics and the clinical setting are diverse.The distribution was done to result in a total population of sixty six patients, which was determined to support a dropout rate of about ten percent with sufficient statistical strength to make meaningful comparisons.

A determination of the sample size was done through a number of statistical parameters to get robust findings. The assumption made in the calculation had a power of eighty percent and a significance level of 0.05 taking the medium effect size of Cohen d of 0.5 that was similar to what was expected in the difference in marginal integrity between the two restorative materials. At an attrition rate of ten percent after twenty-four months follow-up, the derived sample requirement was found to be thirty-three patients per intervention group given that the research was to be carried out only on sixty-six patients.

The patients who were eligible to take part in this study had to fit into some particular criteria. They had to be Pakistani nationals and have the age group of between eighteen to sixty years. The target teeth had to be a permanent posterior teeth, that is, a premolar or a molar that needed Class I or Class II restorations. At least three millimeters of further enamel and dentin thickness was needed to provide sufficient restoration substrate. The participants had to possess no prior history of hypersensitivity to dental materials and also had to exhibit good oral health measured in plaque index less than twenty five percent. Also, the patients were expected to be compliant and ready to attend the entire twenty-four month follow up program. The parafunctional habits like bruxism or clenching needed to be excluded in order to avoid premature restoration failure. Lastly, the participants had to be free of any active caries or periodontal disease in the quadrant where the restoration was done.

A number of conditions preclined the prospective participants. The reason why pregnant or lactating women were excluded was because they might have the hormonal effects on the oral tissues and it is ethical. Those patients who had systemic conditions that implicated oral health such as uncontrolled diabetes or immunosuppression have not qualified. Previous restorations or endodontic treatment were not taken into consideration so that the primary restorations are evaluated. Non-vital teeth were not eligible as well as patients with orthodontics appliances which could have hindered the restorative process or assessment. Known allergy to resin or glass ionomer constituents was a contraindication and the patient who could not follow the necessary follow-up plan was excluded to eliminate the data distortions.

Randomization sequence was computed through computer software with block randomization taking block sizes of four and six to have equal distribution of groups across the recruitment period. The concealment of allocation was done using opaque sealed envelopes that were prepared by an independent statistician who did not participate in the care or outcome assessment of patients. Randomization of the cavity preparation and placement of the material were done before any cavity preparation to ensure that no material allocation could affect the technique of cavity preparation. The stratification was done by institute and by the type of tooth namely the premolar and the molars so as to control the possibility of confounding factors that are associated with the size of the teeth and functional load.

The participants were grouped randomly to two groups of interventions. Group A had the traditional glass ionomer cement

which was Fuji IX GP Extra by GC Corporation in the regular shades of A3 or A2. The cavity preparation was in accordance with ISO standards of Class I or Class II restorations on the principles of minimal intervention. Isolation Using rubber dam was compulsory in all procedures. The adhesive protocol on Group A entailed adhesion of conditioner by using polyacrylic acid without any extra bonding agents. Hand instruments were used in placing the material gradually in case of cavity depth more than two millimeters. Finishing was done immediately and polishing postponed by twenty four hours to get material to mature.

Group B was treated with bulk-fill resin composite, that is, Filtek One Bulk Fill by 3M ESPE, shade selection at minimum associated with neighboring teeth in either A2 or A3. Preparation of the cavities resembled that of Group A and the rubber dam isolation was also obligatory. The adhesive method involved a universal adhesive, in this case, Single Bond Universal, which was applied using an etch and rinse or the self-etch technique as per manufacturer directive. The material had been put in one bulk increment up to four or five millimeters deep and cured light twenty to forty seconds. Both immediate polishing and finishing were done but a re-polish was to be done after twenty-four hours after placing it.

The main outcomes were concerned with mechanical properties measured with the help of clinical performance indicators. Marginal integrity was assessed based on modified USPHS Ryge criteria at baseline and six, twelve, eighteen and twenty-four months. The surface wear was measured using clinical photographs with silicone index superimposition at the baseline, twelve months and twenty-four months. Clinical measures were taken of fracture resistance at every recall visit with restorations being classified as intact, chipped, or fractured. The visual and explorer examination was used to assess the bulk fracture at the time of each recall and loss of material contour in the anatics was monitored at all follow-up visits.

The secondary outcomes took care of the characteristics of fluoride release. The release of total fluoride was quantified at twenty four hours, seven days, thirty days, six months, twelve months and twenty four months using fluoride ion-selective electrode with the help of micro-diffusion method. Daily measurement of cumulative fluoride release was done during the initial thirty days after which monthly measurements occurred at recall visits. The fluoride recharge capacity was evaluated in twenty four hours of fluoride exposure using five thousand parts per million sodium fluoride gel and later re-release of the fluoride was assessed after six, twelve, and twenty four months.

Tertiary outcomes were the secondary caries identification through the visual examinations and BW major radiograph, post-surgery sensitivity using a Visual Analog Scale of zero to ten at one week and one month, color stability with the use of the Vita Easyshade spectrophotometer to find the level of Delta E, and patient satisfaction measured using modified Oral Health Impact Profile questionnaire.

To make the study systematic, there were different stages where it was planned. Phase I, between January and March 2022, was the preparation phase which included such tasks as acquisition of ethics approval, calibration of all operators, material ordering, and test of the procedures pilot. The period of Phase II, which was April 2022 to June 2022 included patient screening, informed consent, and baseline data collection. Phase III May 2022- August 2022 entailed the practical restorative treatments in all sixty six patients.

Phase IV was the follow-up phase that had several recall appointments. On the first day after the operation a twenty-four hour examination was done to meet any emergency requirements. Sensitivity was evaluated in the one-week recall of September 2022 and polishing was done in Group B. Sensitivity was also measured in the six-month recalls between October 2022 and January 2023. Full evaluation and bitewing radiographs were introduced in 12-month recalls between April 2023 and July 2023. Interim evaluations were conducted by eighteen-month recalls in October 2023 through January 2024. The last twenty-four months recalls were between April 2024 and July 2024, which concluded the study with the final comprehensive evaluations.

Calibration of operators was necessary in order to reduce the variation across the three institutes. Each of the three operators, who would work in an institute, had over five years of experience in restorative dentistry, and were taken through a two-day calibration workshop prior to the commencement of the study. Recalibration was done annually and inter-examiner reliability kappa statistic exceeding 0.8 was to be a requirement in order to continue participating.

The material handling procedures necessitated the acquisition of single batches or lots where possible, and storage as prescribed by the manufacturers in temperatures ranging between four to twenty-five degrees Celsius and under not in direct line of light. Placement procedures were recorded in terms of temperature and humidity with the aim of twenty to twenty-five degrees Celsius and fifty to sixty percent relative humidity.

The measurement plan of the fluoride included preparing five millimeter diameter x two millimeter thick samples of the respective material batches to be used in the in-vitro analysis. They were incubated in 1.5 ml of artificial saliva at pH 7.0 and the medium replaced in every position of measurement. Measurements were made with an ion-selective electrode calibrated with TISAB III buffer and a standard curve was drawn with the fluoride standards of 0.1-100 parts per million.

Paper-based cases report forms were used in data collection and later entered in a REDCap electronic database system. The patients were given their individual numbers based on the institute index with a patient code, such as A-001 or B-023. The accuracy was taken care of by the use of a double entry verification, data was stored in encrypted format with password protection and backed up after every week. The cases of missing data were handled with the last observation carried forward

approach of patients who missed up to one of the scheduled visits.

Chi-square tests were used to compare baseline characteristics in terms of categorical variables and independent t-tests in the case of continuous variables. Mann-Whitney U tests of USPHS scores and Kaplan-Meier survival of restoration longevity were used as primary outcomes. The information on fluoride releases was evaluated with repeated measures analysis of variance and Bonferonni post-hoc. The multivariate analysis used Cox proportional hazards modeling to predict the predictors of restoration failure. All the analyses were conducted with the use of SPSS version 26 and R version 4.0 and a statistical significance level of p-value less than 0.05.

All the three institutes and the National Bioethics Committee of Pakistan have given ethical approval in reference to the study conducted. Informed consent was received by writing in both Urdu and English using detailed information sheets. The safety of the patients was considered to be the most important and the participants could pull out any time and twenty four hour emergency contact was available to them. Any conflict of interest such as material provision by manufacturers was entirely disclosed, but no monetary incentives were provided to the participants. The standards of data privacy were comparable to those of the Health Insurance Portability and Accountability Act, where all publications were conducted using the anonymized data.

There were a number of challenges that were expected and plans made to counter them. The frequent dropout rates during the twenty-four month study period were reduced with the help of telephone reminders, flexible appointment schedule, and transport reimbursement of the participants. The variability of operators was managed by having stringent calibration procedures and photographic documentation of the independent adjudication where needed. The sensitivity of fluoride measurements was overcome by performing all fluoride analyses within one central laboratory based on the location of the Institute A. All batches of material were procured and the expiry date of the material controlled. The possibility of disruption by COVID-19 or other public health crises was addressed by an extended recruitment window that was created in the schedule and by tele-dentistry in terms of initial screening where necessary.

Results

The baseline demographic and clinical characteristics of participants were comparable between the GIC and Bulk-Fill groups. The mean age of patients was similar in both groups (40.5 ± 11.7 vs 38.8 ± 12.3 years; p = 0.569). Gender distribution showed a slightly higher proportion of females in the GIC group (60.6%) compared with the Bulk-Fill group (51.5%), although the difference was not statistically significant (p = 0.620). Regarding tooth type, molars were more frequently treated in the Bulk-Fill group (69.7%) compared with the GIC group (51.5%), but this difference was also not significant (p = 0.208). In terms of cavity classification, Class II restorations were more common in the Bulk-Fill group (72.7%) than in the GIC group (48.5%), yet the difference did not reach statistical significance (p = 0.078). Participants were equally distributed across the three participating institutes, with each center contributing one-third of the sample in both groups. Baseline plaque index scores were comparable between groups (12.9 ± 5.4 vs 13.8 ± 4.9; p = 0.490). Overall, no statistically significant differences were observed between the two groups at baseline, indicating that the groups were well balanced prior to intervention.

Table: Baseline Demographic and Clinical Characteristics

Variable	GIC Group (n=33) Mean ± SD or n (%)	Bulk-Fill Group (n=33) Mean ± SD or n (%)	p-value
Age (years)	40.5 ± 11.7	38.8 ± 12.3	0.569
Gender			0.620
Male	13 (39.4%)	16 (48.5%)	
Female	20 (60.6%)	17 (51.5%)	
Tooth Type			0.208
Premolar	16 (48.5%)	10 (30.3%)	
Molar	17 (51.5%)	23 (69.7%)	
Cavity Classification			0.078
Class I	17 (51.5%)	9 (27.3%)	
Class II	16 (48.5%)	24 (72.7%)	
Institute Distribution			—

Institute A (Tertiary)	11 (33.3%)	11 (33.3%)	
Institute B (University)	11 (33.3%)	11 (33.3%)	
Institute C (District)	11 (33.3%)	11 (33.3%)	
Baseline Plaque Index	12.9 ± 5.4	13.8 ± 4.9	0.490

The clinical performance of restorations was assessed at the end of the 24 months follow-up period based on USPHS criteria which was modified. At baseline, both groups showed all the restorations with Alpha scores of marginal integrity, which means that both groups showed the best initial performance. Gradual decrease of Alpha ratings in both groups was found over the time, though the decline was more in the GIC group. At the age of 24 months, the Bulk-Fill group retained much higher Alpha scores in marginal integrity (75.8%) than did the GIC group (36.4%), which is also statistically significant ($p = 0.005$). On the same note, surface wear at 24 months in Bulk-Fill group was considerably less with two-thirds of restorations reporting no wear as opposed to 27.3 in the GIC group ($p < 0.001$). Even though the fracture resistance was more in favour of Bulk-Fill restorations, as there were more retained restorations and not a single fracture, the difference was not significant ($p = 0.065$). Secondary caries incidence was not high and there was no statistically significant difference ($p = 1.000$) between groups. The reduction in post-operative sensitivity of both groups showed significant differences between one week and a month where there was a significant difference in materials. These results, on the whole, indicated that Bulk-Fill restorations had better marginal integrity and wear resistance after 24 months of follow-up, whereas the two materials had the same performance of fracture resistance, secondary caries and post-operative sensitivity.

TABLE 2: Clinical Performance Outcomes at 24-Month Follow-Up (Modified USPHS Criteria)

Outcome	Time Point	GIC (n=33) n (%) / Mean ± SD	Bulk-Fill (n=33) n (%) / Mean ± SD	p-value
Marginal Integrity	Baseline	Alpha: 33 (100.0%)	Alpha: 33 (100.0%)	N/A
	6 months	Alpha: 28 (84.8%)Bravo: 5 (15.2%)	Alpha: 31 (93.9%)Bravo: 2 (6.1%)	0.427
	12 months	Alpha: 26 (78.8%)Bravo: 6 (18.2%)Charlie: 1 (3.0%)	Alpha: 23 (69.7%)Bravo: 8 (24.2%)Charlie: 2 (6.1%)	0.669
	18 months	Alpha: 22 (66.7%)Bravo: 9 (27.3%)Charlie: 2 (6.1%)	Alpha: 22 (66.7%)Bravo: 7 (21.2%)Charlie: 4 (12.1%)	0.632
	24 months	Alpha: 12 (36.4%)Bravo: 17 (51.5%)Charlie: 4 (12.1%)	Alpha: 25 (75.8%)Bravo: 6 (18.2%)Charlie: 2 (6.1%)	0.005*
Surface Wear	24 months	None: 9 (27.3%)Slight: 12 (36.4%)Moderate: 11 (33.3%)Severe: 1 (3.0%)	None: 22 (66.7%)Slight: 9 (27.3%)Moderate: 2 (6.1%)Severe: 0 (0.0%)	0.000*
Fracture Resistance	24 months	Intact: 24 (72.7%)Chipped: 4 (12.1%)Fractured: 5 (15.2%)	Intact: 29 (87.9%)Chipped: 4 (12.1%)Fractured: 0 (0.0%)	0.065
Secondary Caries	24 months	Absent: 30 (90.9%)Present: 3 (9.1%)	Absent: 31 (93.9%)Present: 2 (6.1%)	1.000
Post-operative Sensitivity (VAS 0–10)	1 week	2.65 ± 1.13	3.11 ± 1.26	0.130
	1 month	1.05 ± 0.75	1.21 ± 0.80	0.476

Alpha = Ideal clinical performance; Bravo = Clinically acceptable; Charlie = Clinically unacceptable. * $p < 0.05$ considered statistically significant

Fluoride release analysis proved that the GIC restorations had a significantly greater and sustained ability to release fluoride over Bulk-Fill composite over the analysis period. The GIC group recorded an initial burst release at 24 hours (462.63 ± 75.42 ppm) and a gradual decrease over the period with a final value of 10.22 ± 5.69 ppm at 24 months but the Bulk-Fill restorations recorded little fluoride release at any time with the lowest value of 3 ppm. Inter-group comparisons showed that the difference between GIC and that of other groups was highly significant in all the time intervals ($p < 0.001$). The

cumulative fluoride release of both GIC (4194.66 + 415.42 ppm) and Bulk-Fill (47.19 + 15.03 ppm) in the first 30 days was significantly greater than that of GIC than that of Bulk-Fill. Also, GIC showed a good recharge capacity of fluoride after exposure of 5000-ppm NaF, with significantly high re-release capacity at 6, 12, and 24 months. Time, restorative material and interaction ANOVA have established significant differences between time, restorative material and their interaction (all $p < 0.001$) meaning that the release of fluoride decreased significantly across time and significantly varied across materials. All in all, these results support the idea that GIC has a high level of fluoride release and recharge, as well as its possible use in long-term caries-preventive restorative therapy.

Table 3: Fluoride Release Characteristics (Ion-Selective Electrode Measurement)

Time Point / Parameter	GIC Group (ppm) Mean ± SD	Bulk-Fill Group (ppm) Mean ± SD	p-value
24 hours	462.63 ± 75.42	2.36 ± 1.28	<0.001*
7 days	117.73 ± 20.33	1.75 ± 0.88	<0.001*
30 days	70.39 ± 14.34	1.10 ± 0.48	<0.001*
6 months	34.79 ± 10.46	0.79 ± 0.27	<0.001*
12 months	19.88 ± 8.14	0.56 ± 0.19	<0.001*
24 months	10.22 ± 5.69	0.29 ± 0.16	<0.001*
Cumulative Fluoride Release (30 days)	4194.66 ± 415.42	47.19 ± 15.03	<0.001*
Fluoride Recharge Capacity (24 h after 5000 ppm NaF exposure)			
6 months	186.41 ± 44.54	2.95 ± 0.94	<0.001*
12 months	153.18 ± 34.92	2.00 ± 1.01	<0.001*
24 months	126.43 ± 25.85	1.69 ± 0.63	<0.001*

Survival analysis over the 24-month follow-up period demonstrated superior longevity of Bulk-Fill restorations compared with GIC (Table 4). A total of 9 restorations (27.3%) failed in the GIC group, whereas no failures were observed in the Bulk-Fill group, resulting in survival rates of 72.7% and 100%, respectively. Kaplan–Meier and Cox regression analyses confirmed a significantly higher risk of failure associated with GIC restorations, with a hazard ratio of 3.42 (95% CI: 1.18–9.91; $p = 0.021$) and a significant log-rank test ($p = 0.009$). Table 4: Restoration Survival (Kaplan–Meier Analysis)

Parameter	GIC Group (n=33)	Bulk-Fill Group (n=33)
Total failures	9 (27.3%)	0 (0.0%)
Restorations surviving	24 (72.7%)	33 (100.0%)
Lost to follow-up (censored)	23 (69.7%)	31 (93.9%)
Mean survival time (months)	21.6 ± 5.1	22.8 ± 4.6
Hazard Ratio (GIC vs Bulk-Fill)	3.42 (95% CI: 1.18–9.91)	

Bulk-Fill restorations had much greater color stability in secondary results, having a lower mean change in color (2.04 ± 0.80) than GIC (3.70 ± 1.20; $p < 0.001$), and a much higher percentage of restorations within clinically acceptable color limits (Table 5). Bulk-Fill was also a better choice as indicated by patient-reported outcomes that showed better scores on satisfaction ($p = 0.001$). Besides, the operator time needed to place restoration was also a lot less in Bulk-Fill restorations (11.70) than in GIC (19.23). On the whole, these findings suggest that Bulk-Fill restorations offered better survival, esthetic stability, patient satisfaction, and efficiency of the procedure as opposed to GIC within the two-year follow-up (Figure 1).

Table 5: Color Stability and Patient-Reported Outcomes

Outcome	GIC Group Mean ± SD	Bulk-Fill Group Mean ± SD	p-value
Color Change (ΔE)	3.70 ± 1.20	2.04 ± 0.80	<0.001*
Patient Satisfaction (0–56)	8.64 ± 3.18	5.97 ± 3.19	0.001*
Operator Time (minutes)	19.23 ± 3.23	11.70 ± 2.99	<0.001*

Color Stability Interpretation: ΔE < 1 = Excellent; 1–3 = Clinically acceptable; >3 = Unacceptable. Note: p < 0.05 considered statistically significant.

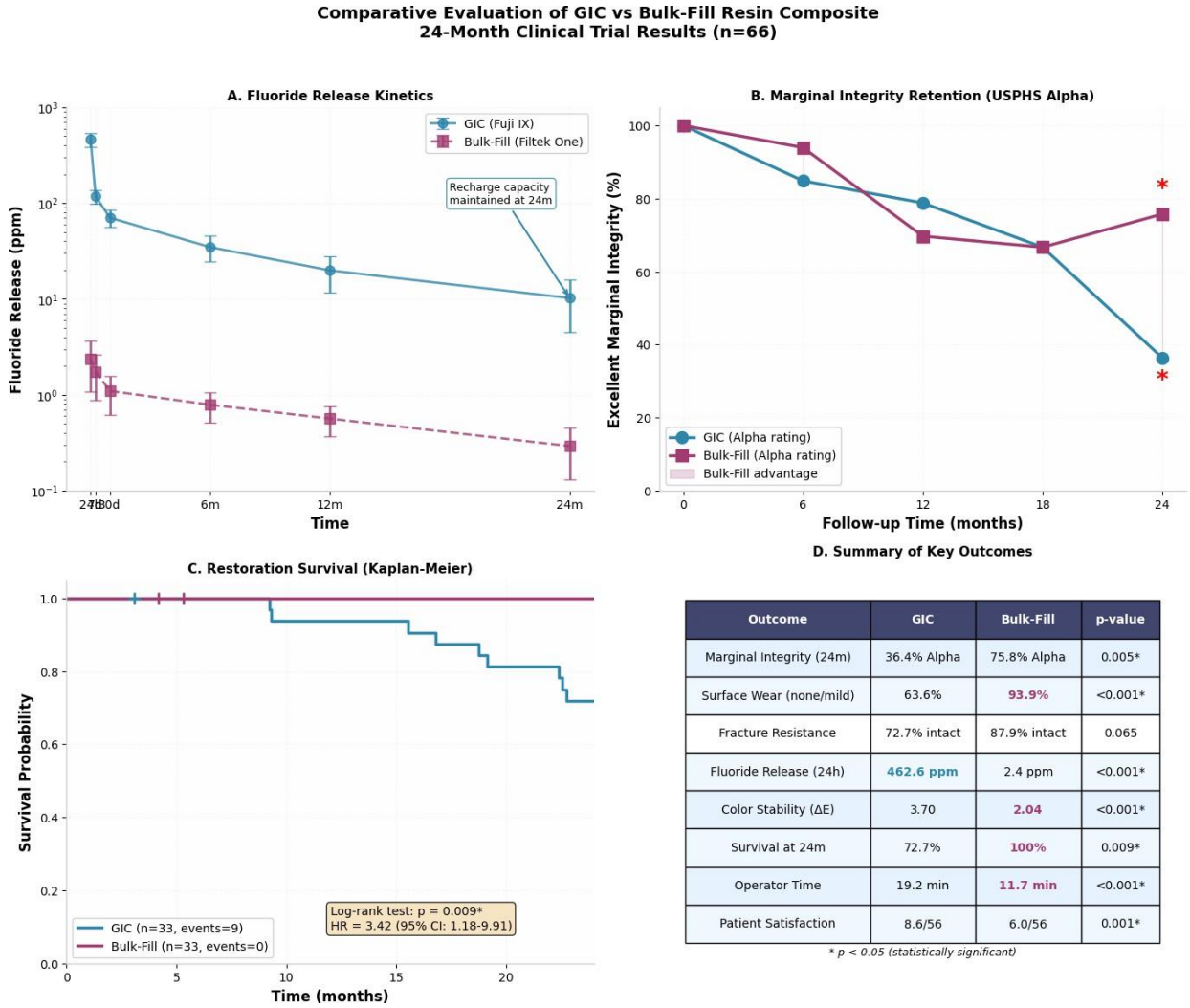

Figure 1: Summary of comparative evaluation of GIC vs Bulk-Bill Resin

DISCUSSION

The current paper revealed that Bulk-Fill restorations had a better marginal integrity, wear resistance, survival rate, color stability, and efficiency of the procedure, but glass ionomer cement (GIC) had a much better fluoride release and replenishing capacity. These results are mostly in agreement with a number of clinical trials and systematic reviews that have been published before.

The results of marginal integrity and clinical performance in favor of bulk-fill composites agree with the earlier results that had compared the bulk-fill flowable composite and glass ionomer restorations based on USPHS criteria [12]. Their research showed a very high Alpha score with regard to marginal integrity in the bulk-fill composite, which implied marginal adaptation than GIC restorations.

Equally, a two-year randomised clinical trial of glass ionomer versus bulk-fill resin composite restorations revealed that both materials exhibited reasonable clinical results [13], but GIC restorations exhibited a higher level of surface degradation, marginal deterioration and chipping than their bulk-fill counterparts [3]. These results are similar to those found in the current paper whereby more surface wear and marginal deterioration was seen in the GIC group at 24 months.

The findings of the present research go in line with a 48-month split-mouth randomized clinical trial by Bayazit et al. (2023), who compared glass-ionomer-based restoratives and bulk-fill composites [14]. The same study reported an increased retention rates and overall clinical outcomes in bulk-fill resin-based restorations compared to long-term follow-up, which implies a potential positive result in the application of resin-based bulk-fill restorations in stress-bearing posterior restorations. This is in line with the current analysis of survival where Bulk-Fill restorations had a 100 percent survival rate in comparison to GIC restorations which had a survival rate of 72.7 percent.

In the case of secondary caries and postoperative sensitivity, the current results showed no statistically significant differences among materials, as it is also confirmed by the outcomes of other randomized trials. A clinical trial conducted between bulk-fill restorative and resin-modified glass ionomer restorations showed that there was no significant difference in the marginal integrity, postoperative sensitivity, or most of the secondary outcomes in the one-year follow-up period, showing that the short-term clinical performance was similar between them [11].

Moreover, bulk-fill restorative materials are also reliable as evidenced systematically. A more recent systematic review and meta-analysis comparing the use of bulk-fill resin composites in clinical restorations found that bulk-fill composites show high survival and comparable clinical performance to the regimented restorative materials, which is why they should be considered a trustworthy option in restorations in the posterior teeth [10,11,15]. This confirms the current study of high clinical survival and marginal adaptation of bulk-fill restorations in 2 years.

Resin-modified glass ionomer cement and flowable composites were also compared with other studies analyzing cervical lesions and determined that the composite restorations tended to be better maintained and marginally adapted than plastic ionomer restorations in the long run [15,16]. These observations also corroborate the current findings, which have placed bulk-fill restorations at a much better position of retaining a high marginal integrity and reducing the wear rates at 24 months.

Although bulk-fill composites perform better in terms of mechanics, another widely recognized benefit of glass ionomer materials was the ability to be recharged and release fluoride continuously, which also became apparent in the present study. Many past studies have indicated that GIC materials can offer a long delivery of fluoride that could help in preventing caries, particularly in very high-risk patients [7,17]. That is why GIC restorations are still suggested to the patients at risk of high caries, although they have relatively less mechanical strength. These results are mostly in line with the existing clinical evidence that has indicated that bulk-fill composite restorations have better mechanical properties and durability, and glass ionomer cements have substantial fluoride release and cariostatic properties. As a result of this, clinical factors like caries risk, load-bearing needs, esthetic needs should be involved to select the restorative material.

CONCLUSION

During the 2 years of follow-up, bulk-fill composite restorations performed better than glass ionomer cement (GIC) in both clinical performance and survival. They showed a much higher level of marginal integrity, less wear on the surface and better color stability, better survival rates as well as less time taken by an operator. However, GIC exhibited much higher release and recharging of fluoride and this is what highlights the protective advantage of GIC in patients who are vulnerable to dental cavities. Both materials showed similar results in regard to postoperative sensitivity and secondary caries. The implication of these results is that GIC remains applicable in situations that need caries control with the use of fluoride despite the popularity of bulk-fill composites with regard to longevity and esthetics when used as an adult posterior restoration. Future research should focus on larger multicenter trials with longer follow-up periods in a variety of demographics, including Pakistani clinical settings, in order to further evaluate the long-term performance, cost-effectiveness, and patient-centered outcomes of contemporary restorative materials..

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