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COMPRESSIVE STRENGTH OF CONVENTIONAL, BULK FILL AND SELF ADHESIVE BULK FILL COMPOSITE RESINS

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Abstract

Bulk-fill composite materials have been developed to streamline the composite placement procedure and decrease chairside duration, providing advantages for both dentists and patients. This study aimed to compare and assess the compressive strengths of three composite materials: conventional composite (Filtek Z250), Bulk-fill non-self-adhesive composite (SureFil), and recent self-adhesive bulk-fill composite (Surefil one). This study included thirty discs, ten for each of the three restorative materials: the conventional composite (Filtek Z250), the bulk-fill composite (SureFil), and the self-adhesive bulk-fill composite (Surefil one). A compressive force was applied to the specimens until fracture occurred to assess the compressive strength using a universal testing machine. The collected data were first assessed for outliers, then subjected to a normality evaluation at a significance level of 0.05, utilizing the Shapiro-Wilk and/or Kolmogorov-Smirnov tests. A statistically significant difference in compressive strength was observed among the three tested restorative materials (ANOVA, $p<0.001$) among the Filtek Z250 group (mean=164.2MPa), SureFil group (mean=121.0MPa), and Surefil one group (mean=55.7MPa). Self-adhesive bulk-fill Surefil one composite showed the lowest compressive strength among the three materials.

Keywords: Composite Resins, Compressive Strength, Surefil one, SureFil.

INTRODUCTION

In recent decades, there has been a significant rise in the utilization of composite resins in restorative dentistry. The demand for aesthetically pleasing restorations drives the fundamental objective of restorative materials to replicate the biological, functional, and aesthetic characteristics [1]. A variety of composite materials are utilized in restorative dentistry due to their favorable mechanical properties and esthetic outcomes. However, polymerization shrinkage presents a considerable challenge, as it can induce stress that results in debonding, microleakage, secondary caries, pulp irritation, and diminished restoration longevity [2]. The incremental application of composite resins in 2 mm layers aims to reduce polymerization shrinkage stress. Nevertheless, this method presents several drawbacks, including void formation, contamination, bond failure, and time consumption, particularly in deep cavities [3]. Bulk-fill composites are a recent advancement in resin-based materials, designed with altered physico-mechanical

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properties to minimize polymerization shrinkage and eliminate the need for the time-consuming incremental layering technique. Advances in resin monomer technology have enhanced light penetration, cure depth, and decreased polymerization shrinkage [4]. Bulk-fill composites are typically applied in a single 4-5 mm increment; however, certain studies indicate that applying them in two layers of 2 mm may improve bond strength [5]. Bulk fill composites exhibit a higher weight percentage attributed to larger filler sizes, which reduce the refractive index, facilitating greater light penetration and increased cure depth [6]. Self-adhesive composites were introduced to simplify and expedite clinical procedures. Recently, researchers introduced “Surefil one “(Dentsply Sirona, Charlotte, NC, USA) as a self-adhesive bulk-fill hybrid material. It integrates the advantages of bulk-fill and self-adhesive composites to address issues of shrinkage and leakage while reducing the number of clinical steps required.

Cavity preparation and filling are the only necessary steps, negating the requirement for etching, bonding, or conditioning, offering handling characteristics comparable to amalgam, fluoride ion release comparable to Glass Ionomer Cements (GICs), and enhanced esthetics [7]. While etching is not required, research indicates that pre-etching may improve the bond strength to enamel and dentin [8]. This material combines the rapid application, ease of use, and fluoride release characteristic of glass ionomer with the durability associated with bonded composite.

Consequently, it streamlines workflow by eliminating errors in the etching and bonding processes. The material exhibits a dual-cured characteristic, enabling bulk fill to be polymerized at various depths. Therefore, it minimizes chairside time by eliminating incremental placement and exhibits favorable mechanical properties, such as shear bond strength, surface hardness, and durability [9]. Compressive strength represents a significant mechanical property in dental research.

Assessing the maximum stress that a composite material can endure prior to fracture under compressive loading provides valuable insights into its behavior regarding intraoral compressive strength. Due to the substantial replacement of tooth structure by bulk-fill materials, the compressive strength is a critical factor in the selection and assessment of dental restorative materials [10]. In pediatric dentistry, securing sustained patient cooperation is crucial for successful treatment outcomes. Self-adhesive bulk-fill composites serve as beneficial restorative materials in this context.

Minimizing application steps and reducing chair time, these materials provide practical advantages for managing young or less cooperative patients, while maintaining the mechanical strength and durability required for long-term clinical success [11]. Therefore, this study aimed to assess and compare the compressive strength of three composite materials: the conventional composite (Filtek Z250), the non-self-adhesive bulk-fill composite (SureFil), and the recent self-adhesive bulk-fill composite (Surefil one). The null hypothesis posits that there is no significant difference in compressive strength between Surefil one and the other two restorative materials.

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METHODS

The study procedures were approved by the Research Ethics Committee (REC) of the Suez Canal University Faculty of Dentistry under authorization number 618/2023. The study included 30 discs of three different restorative materials. The sample size was calculated using G*Power software (ver. 3.1.9.2) [12, 13], with an effect size of 0.60, with a power of 80% under levels of 0.05 and 0.20 for alpha (α) and beta (β), respectively. Consequently, the estimated minimum sample size (n) was a total of 30 specimens.

Sample grouping

Thirty specimens were equally divided into three groups (10 specimens each) [11, 14]. The experimental methodology, as outlined in (Fig. 1a, b, c, d, e, f, g, h &i), commenced with the positioning of a 5 mm diameter, 4 mm height Teflon mold (Fig. 1a) against a glass slab (Fig. 1b). Filtek Z250 was applied in 2 mm increments (Fig. 1c). In contrast, SureFil and Surefil one was inserted in a single 4 mm increment (Fig. 1d and e). Each specimen was light-cured with a 0 mm tip distance (Fig. 1f), and finished with a yellow Sof-Lex Disc (Fig. 1g) before undergoing compressive loading along their long axis (Fig. 1h) until fracture occurred (Fig. 1i).

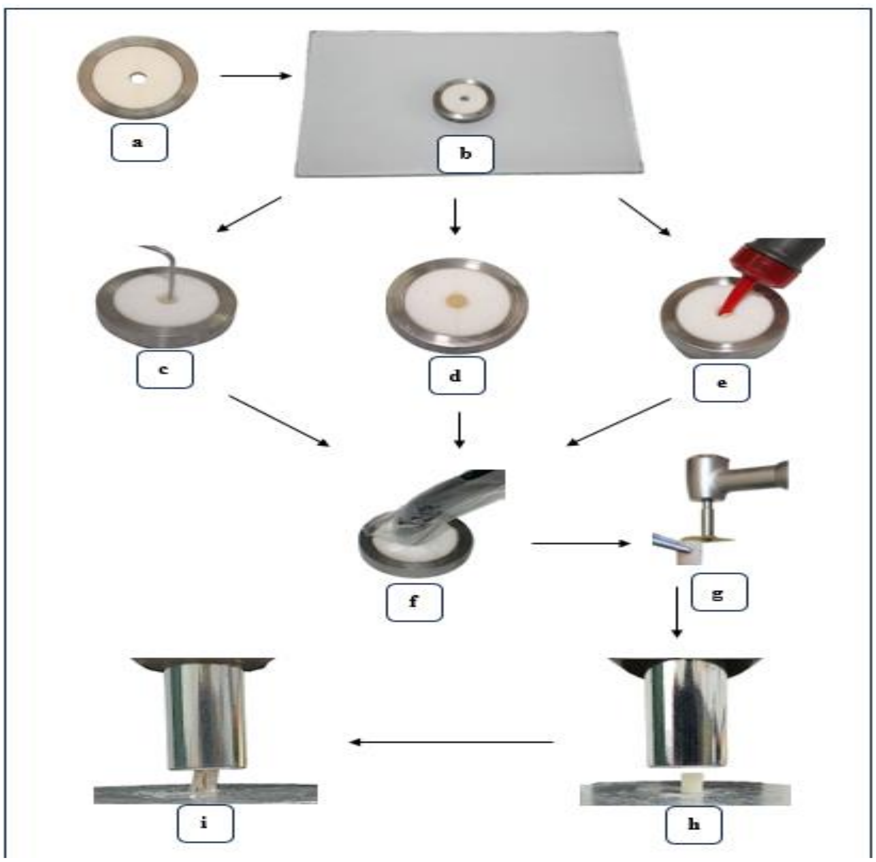

Figure 1: a, b, c, d, e, f, g, h & i an overview of the experimental methodology for composite specimen preparation and testing

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Study Procedures

The compressive strength assessment was conducted on thirty specimens, with ten specimens allocated to each of the three resin composites (Filtek Z250, SureFil, and Surefil one), as follows:

- Cylindrical specimens of these materials (5 mm in diameter and 4 mm in height) were prepared using a special split Teflon mold against a glass slab (Fig. 2a & b) [15].

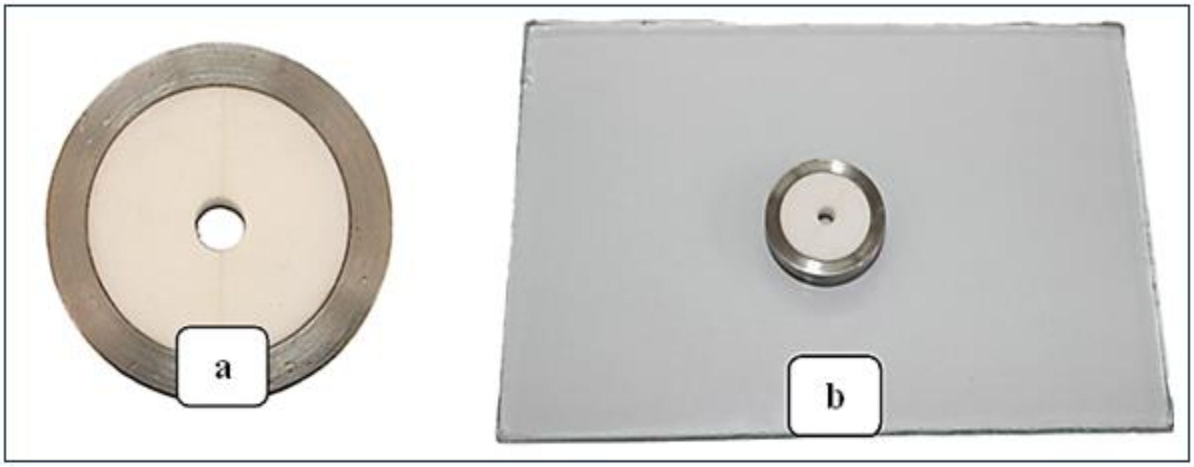

Figure 2: a & b Teflon mold on a glass slab

- Each restorative material was placed in a mold against a glass slab in accordance with the manufacturer's guidelines. For Filtek Z250 group composite was applied in two increments of 2 mm, verified with a calibrated probe (Fig. 3), and each increment was light cured separately for 20 s. In contrast, the SureFil group and Surefil one group were placed in one increment of 4 mm (Fig. 4a & b) and light cured for the 20 s with direct contact of the curing tip to the object (Fig. 5).

Figure 3: Application of 2 mm increment thickness

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Figure 4: a & b SureFil and Surefil one inserted in one increment of 4 mm thickness

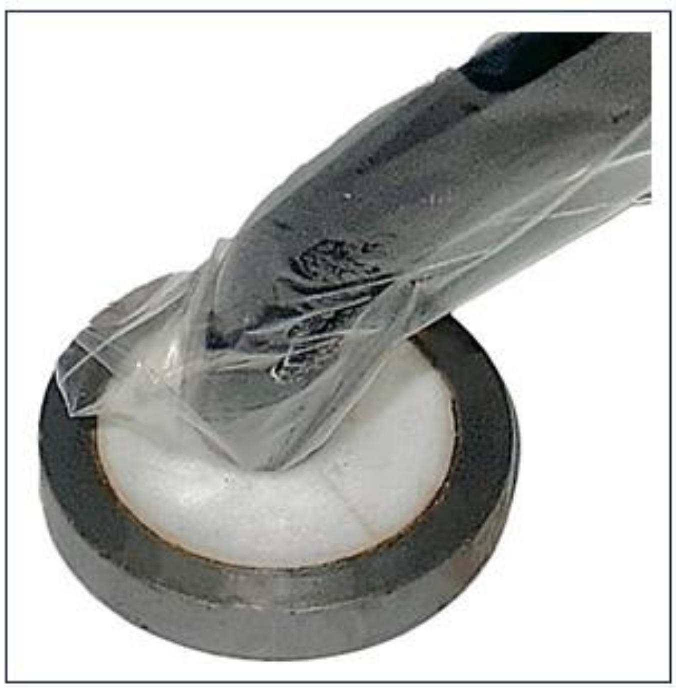

Figure 5: Light cured with 0 mm distance of curing tip to the specimen

- All specimens were finished using yellow Sof-Lex Disc (3M ESPE, St. Paul, MN, USA) (Fig. 6) and subsequently stored in distilled water at room temperature for 24 hours in light-proof containers to ensure complete polymerization without interference from ambient light.

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Figure 6: Specimen finishing with yellow Sof-Lex Disc

Compressive strength assessment

- A Universal Testing Machine (Instron industrial product type 3345, USA) was used to apply a compressive load along the long axis at a crosshead speed of 1 mm/min (Fig. 7).
- Maximum force was recorded as the specimens fractured (Fig. 8).
- The compressive strength was calculated in MPa (N/mm^2) using the formula $CS = 4\,F/\pi\,d^2$, where F represents the failure load and d denotes the specimen's diameter. The data were statistically analyzed [15].

Figure 7: Compressive load along the long axis of the specimen

Figure 8: Fractured specimen post-testing

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Statistical analysis

The Shapiro-Wilk test was used to assess the normality of the data, while the Kolmogorov-Smirnov test was used to determine whether the data were parametric or non-parametric. The compressive strength exhibited parametric characteristics.

Inferential statistics were used to compare in terms of compressive strength, utilizing inferential statistics for parametric data analysis.

Tukey's HSD was conducted, followed by ANOVA. The level of statistical significance was set at 0.05. Statistical analysis was performed using the SPSS software (Statistical Package for the Social Sciences, Inc., Chicago, IL, USA, Version 29, for Mac OS) [16].

RESULTS

The compressive strength of Filtek Z250 group, SureFil group, and Surefil one group is presented in (Table 1) and (Fig. 9).

The analysis revealed a highly significant difference among the three composites ($p<0.001$***), with the highest recorded compressive strength in Filtek Z250 group, followed by the SureFil group, and finally, the Surefil one group.

For further comparisons between groups, Tukey's HSD Test was performed, where at the 0.05 level, Tukey's HSD indicates that the means that are followed by different letters differ significantly.

Additionally, Tukey's HSD showed that the groups differed significantly from one another.

Table 1: Compressive strength of the three different groups

Descriptive statistics	Compressive strength		
	Filtek Z250 group	**SureFil group**	**Surefil one group**
Min	120.4	83.9	34.9
Max	207.4	143.2	78.7
Mean	**164.2**	**121.0**	**55.7**
SD±	22.2	17.1	10.7
SE	5.7	4.4	2.8
Mean±SD	**164.2±22.2**	**121.0±17.1**	**55.7±10.7**
Tukey's HSD	**a**	**B**	**c**
ANOVA	**<0.001*** **		

*, **, ***= significant at different levels $p<0.05$, <0.01, <0.001, respectively.

Ns= non-significant at level $p>0.05$

a,b,c According to Tukey's HSD, the means that are followed by different letters differ significantly.

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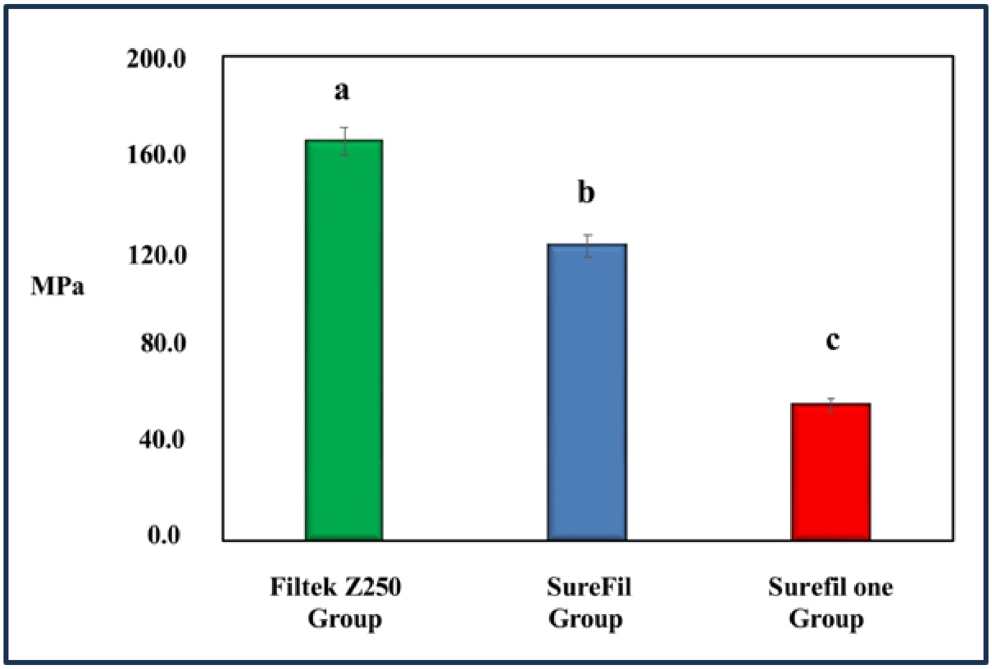

Figure 9: Bar chart of the compressive strengths of the three groups

DISCUSSION

Composite resins are frequently utilized as restorative materials due to their outstanding aesthetic qualities and robust mechanical performance. Incremental layering is recommended to control polymerization shrinkage and achieve adequate mechanical properties with these materials; however, it poses risks of void formation and bond degradation between increments, potentially compromising the integrity of the final restoration. The prolonged time required for the polymerization of each layer separately constitutes an additional drawback [17].

Bulk-fill composites were developed to overcome the limitations of incremental layering, incorporating modifications in monomer chemistry, filler size, and composition, as well as polymerization kinetics. These materials facilitate single-layer placement of up to 4mm, thereby streamlining and accelerating treatment, which is especially beneficial for pediatric patients. However, bulk-fill composites are technique-sensitive and necessitate precise bonding procedures to achieve optimal adhesion [18].

Self-adhesive bulk-fill composites represent a significant advancement in restorative materials, combining the effective application of bulk-fill with the streamlined adhesion characteristics of self-adhesive systems. This eliminates the etching and bonding steps, leading to reduced technique sensitivity and potential for errors, as well as shorter chairside time and improved patient cooperation, particularly in pediatric cases [19].

Composite restoration challenges in pediatric dentistry are particularly amplified due to behavioral factors and anatomical limitations. Common issues include excessive

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salivation, restricted mouth opening, and difficulties in achieving effective moisture control, particularly in younger children. Children with special healthcare needs or medical conditions that restrict their cooperation during prolonged dental procedures may find the simplified protocol of self-adhesive systems advantageous. These materials are also beneficial in emergencies that necessitate rapid intervention [20].

This study compares the compressive strength of self-adhesive bulk-fill composite restoration (Surefil one) with that of non-self-adhesive bulk-fill composite (SureFil) and conventional composite (Filtek Z250). Surefil one combines a reduced application time with fluoride release, which distinguishes it from the other two materials [21].

A study by Kamil (2025) [22] revealed that Surefil one exhibits a significant and progressive release of fluoride over time. The results showed that fluoride release increases from 2.619 mg/cm² at 1 day to 6.703 mg/cm² at 4 weeks ($p = 0.000$), demonstrating a sustained release rather than a decline. In addition, fluoride uptake by Surefil one increases over the same period, rising from 2.892 to 4.382 mg/cm², which suggests continued absorption and recharge capability. These findings indicate that fluoride release not only occurs but also continues over time, supporting the material's potential role in long-term caries prevention, particularly in pediatric and high-risk populations.

According to the results of this study, this test is significant in pediatric dentistry, offering predictive insights into the durability of restorations under masticatory forces in the oral environment [23].

In-vitro testing was conducted to manage inter-individual variability and accelerate sample analysis, facilitating the efficient screening of numerous samples [24].

Compressive strength is an essential characteristic of restorative materials, especially in load-bearing regions such as posterior teeth, where masticatory forces are high. High compressive strength is crucial for maintaining the integrity and longevity of restorations subjected to repetitive occlusal stress. It allows the material to endure the forces associated with biting and chewing, thus averting cracks, fractures, or detachment. The evaluation of compressive strength serves as a reliable indicator of the durability of restorative materials [25].

The Filtek Z250 group exhibited the highest mean compressive strength, followed by the SureFil group, with the Surefil one group recording the lowest mean value. A highly significant difference was observed among the three groups.

The differences in composition among the tested materials account for the variation in compressive strength observed. Filtek Z250 is a microhybrid composite characterized by a high filler load of zirconia and silica particles, providing superior compressive and flexural strength, suitable for anterior and posterior restorations. The balanced resin matrix provides optimal viscosity, minimal shrinkage, and long-term esthetics [26]. SureFil is a packable bulk-fill composite designed for stress-bearing posterior restorations. It enables efficient 5 mm bulk placement while exhibiting strong mechanical performance

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and wear resistance, due to its interlocking particle technology and condensable viscosity [27]. In contrast, Surefil one integrates the characteristics of composite and glass ionomer into a self-adhesive, dual-cure system, facilitating placement and enabling fluoride release. Nonetheless, the water content and hydrophilic components may compromise the resin-filler interface, leading to a reduction in compressive strength [28].

This study's findings agree with those of Gungor et al. (2023) [29], which indicated that conventional composite exhibited greater compressive strength compared to packable bulk-fill material, while the self-adhesive material recorded the lowest compressive strength values.

This study's findings contradict those of Mofidi et al. (2020) [30], who evaluated the compressive strength of two different bulk-fill composite resins (X-tra-fil and X-tra-base) when covered with a layer of conventional composite (Grandio), as well as a conventional composite resin alone, in a mold measuring 4 mm in diameter and 6 mm in height. The study revealed no significant differences in compressive strength values between the conventional composite resin group and the bulk-fill composite material. Contradictory results may arise from variations in composite materials.

The lowest compressive strength value in this study was observed for the self-adhesive bulk-fill Surefil one group material. This finding is consistent with the findings of Thadathil et al. (2024) [31], who indicated that the reduced compressive strength of Surefil one can be attributed to the water content in its structure, leading to diminished resin-filler adhesion.

Surefil one maintains its relevance in specific clinical scenarios where ease of application and reduced chair time are prioritized over optimal mechanical performance. In mobile dental units or outreach settings with time, resource, or equipment constraints, the simplified placement protocol enables clinicians to provide effective care while upholding essential restorative standards. In these cases, particularly for non-load-bearing restorations, the lower technique sensitivity and shorter chairside time may outweigh the need for maximum strength, thus supporting its use in pediatric and underserved populations [32].

A study by Chida et al. (2008) [33] found that the average bite pressure in healthy 4-year-old children with normal occlusion is 43.9 ± 5.5 MPa. The compressive strengths determined in this study for the Filtek Z250 group, SureFil group, and Surefil one group are deemed acceptable for application in primary teeth.

The findings of the study resulted in the null hypothesis led to the rejection of the null hypothesis. The choice of restorative material markedly affects compressive strength, indicating variability in their performance.

Limitations

This study has several limitations. The in-vitro setting and limited sample size may limit the applicability of the results to clinical conditions. Furthermore, only compressive strength was measured, while other essential mechanical properties were not examined.

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CONCLUSION

The current study revealed a significant difference in the compressive strength tests among the three restorative materials. The Filtek Z250 group exhibited the highest compressive strength, followed by the SureFil group and the Surefil one group. Surefil one may present clinical advantages in pediatric dentistry despite its lower compressive strength, owing to its simplified application and reduced chair time, potentially enhancing child cooperation in non-load-bearing restorations.

Recommendations

The low compressive strength of Surefil one renders it appropriate for application as an interim restorative material. Additional research is necessary to assess its comprehensive mechanical and physical properties and to confirm its efficacy through clinical studies involving larger sample sizes.

Authors' contributions

A.A.S. conceptualized the project; Y.S.H. and A.A.S. planned the methodology; G.M.S. and A.A.S. worked on the software. Validation was done by Y.S.H. Formal analysis was executed by G.M.S. and A.A.S.; G.M.S., A.A.S., and Y.S.H. performed the investigation. G.M.S. collected resources; data curation was done by A.A.S.; G.M.S., Y.S.H., and A.A.S. prepared the original draft; G.M.S., Y.S.H., and A.A.S. conducted the review and editing; G.M.S. executed the visualization; G.M.S. secured the funding. All authors reviewed and approved the final manuscript.

Data availability

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

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