ORIGINAL RESEARCH PAPER

Dental Sciences

COMPARATIVE EVALUATION OF FRACTURE RESISTANCE OF FOUR DIFFERENT COMPOSITE RESINS IN INCISAL THIRD RESTORATION OF FRACTURED MAXILLARY CENTRAL INCISORS"----AN IN VITRO STUDY

KEY WORDS: composite resins, fracture resistance, micro-filled, micro-hybrid, nanohybrid, nanofilled

Dil Mohammad*	Post-Graduate Student, Department of Conservative Dentistry and Endodontics, Haldia Institute of Dental Sciences and Research, Banbishnupur, Balughata, West Bengal-721631. *Corresponding Author
Anirban Bhattacharyya	Professor and Head, Department of Conservative Dentistry and Endodontics, Haldia Institute of Dental Sciences and Research, Banbishnupur, Balughata, West Bengal-72163.
Aditya Mitra	Professor, Department of Conservative Dentistry and Endodontics, Haldia Institute of Dental Sciences and Research, Banbishnupur, Balughata, West Bengal-721631.
Asim Bikash Maity	Professor, Department of Conservative Dentistry and Endodontics, Haldia Institute of Dental Sciences and Research, Banbishnupur, Balughata, West Bengal-721631.
Gayatri Majumder	Assistant Professor, Department of Conservative Dentistry and Endodontics, Haldia Institute of Dental Sciences and Research, Banbishnupur, Balughata, West Bengal-721631.

ABSTRACT

Objectives: This in-vitro study aimed to assess the fracture resistance of four different composite resins used in the restoration of the incisal third of fractured maxillary central incisors. **Materials And Methods:** The study involved 40 intact human permanent maxillary central incisors, which were divided into four groups: A, B, C, and D. The incisal third of each tooth was sectioned using a diamond disc. Group A was restored with microfilled composite resin, Group B with microhybrid composite resin, Group C with nanofilled composite resin, and Group D with nanohybrid composite resin. Fracture resistance was measured by applying load incisally to the fracture line using a Universal Testing Machine. The force required to fracture each tooth was recorded. Statistical analysis was conducted to compare fracture resistance among and within the groups. **Results:** Group D exhibited the highest fracture resistance (346±15.1 N), followed by Group C (283,8±18.2 N), Group B (261±17.7 N), and Group A (172±11.3 N). Statistical analysis using one-way ANOVA indicated a significant difference in fracture resistance among the groups ($F(3,36) = 208.7$, $P < 0.0001$). *Post-hoc* Tukey's HSD test revealed statistically significant differences between all the groups ($P < 0.01$). **Conclusion:** Within the limitations of this study, nanohybrid composite resin demonstrated the highest fracture resistance (346±15.1 N), while microfilled composite resin exhibited the lowest fracture resistance (172±11.3 N). The order of fracture resistance from highest to lowest was: Nanohybrid > Nanofilled > Microhybrid > Microfilled.

INTRODUCTION

Anterior crown fractures are prevalent among children and adolescents, with various anatomical and sociobehavioural factors contributing to their incidence[1]. Anatomic factors such as substantial maxillary incisor overjet and inadequate lip coverage, along with sociobehavioural factors including gender, adverse psychosocial environment, and increased participation in sports, are known to increase the risk of anterior teeth injuries [2,3]. It is estimated that 15–25% of individuals under 18 years of age experience injuries to their upper and lower incisors, with uncomplicated crown fractures being the most common type [3,4].

Maxillary central incisors, being highly visible during normal functioning, significantly impact an individual's quality of life when affected by trauma [5-7]. Immediate treatment of such conditions is essential, and various techniques have been developed to restore fractured crowns, including pin-retained resins, composite resins, porcelain veneers, and jacket crown [8].

Fracture resistance, a crucial aspect in restoration materials, is essential to withstand high impact stresses, especially in restoring the incisal angle. Despite efforts to improve fracture resistance using different bonding agents and restorative techniques, previous methods have achieved only 50–60% of intact enamel's fracture resistance.In recent years, incorporating different fibre types into composite materials has been explored to enhance their physical and mechanical properties. Among these, polyethylene fibres have shown promise in improving impact strength, modulus of elasticity, and flexural strength while maintaining aesthetics due to their invisibility within the resinous matrix [9,10].

This study aimed to compare the fracture resistance of microfilled Durafill® (Heraeus Kulzer), composite resin, microhybrid(Filtek TM Z-250) composite resin, nanofilled(Filtek TM Supreme XT) composite resin, and nanohybrid (TPH13) composite resin used for the restoration of fractured incisal edges. Additionally, the mode of fracture of the restorations was evaluated to provide insights into their performance and durability.

Methodology

Sample Collection And Preparation:

Human non-carious permanent maxillary central incisors extracted for periodontal problems were collected after obtaining ethical clearance from the institution's ethical committee. Teeth were cleaned thoroughly to remove debris and calculus using scalers and stored in a 1% chloramine solution. Teeth with visible cracks were excluded from the study. Selected teeth were randomly divided into four groups of 10 teeth each: Microfilled composite group (Group A), microhybrid composite group (Group B), nanofilled composite group (Group C), and Nanohybrid composite group (Group D).

Fracture Simulation:

Forty sound human central upper incisors of comparable external crown size were randomly divided into four groups of 10 specimens each. Tooth fracture was simulated by horizontally cutting the specimens 3 mm below the incisal edge using a diamond blade with a thickness of 0.25mm (Minitom, Stuers, Copenhagen, Denmark). Impressions were made with transparent polyvinylsiloxane material (Memosil, Hereaus, Hanau, Germany) before cutting to preserve the original external crown shapes during the restorative process (Figure 1).

Figure 1: Incisal third/3mm from incisal edge cut with diamond disk.

Restoration Procedures:
The fracture surface of each tooth was etched for 20 seconds with a 37% phosphoric acid etch gel (DMG, Hamburg, Germany), rinsed thoroughly, and air-dried gently. Primer (ED primer, Kuraray, Osaka, Japan) was applied, and composite resins (Panavia F, Kuraray, Osaka, Japan) were applied according to the manufacturer's instructions. Composite resin was placed on the simulated fracture side and light-cured for 20 seconds. An oxygen blocker was applied for 3 minutes. Restoration was built up identically and finished with polishing discs (Sof-Lex, 3M Espe, St. Paul, MN, US.

Load Test And Assessment:
All specimens were embedded in acrylic (Palapress, Heraeus, Hanau, Germany) with the tooth long axis at a 45-degree angle to the horizontal plane. Vertical static load was applied using a universal testing machine (858 Mini Bionix II, MTS, Eden Prairie, MN, USA), 2 mm below the incisal edge, at a crosshead speed of 0.5 mm/min. Load was applied with a stylus of 10-degree taper until fracture occurred. Fractures were visually inspected, and failure modes were recorded (Figure 2).

Figure 2. Universal Testing Machine With Sample

Statistical Analysis
The collected data was tabulated in a spreadsheet using Microsoft Excel 2019 and then statistical analysis was carried out using the GraphPad Prism for Windows, Version 9.5 (GraphPad Software, La Jolla California USA). A Shapiro-Wilk's test and a visual inspection of the histograms, standard Q-Q plots, and box plots showed that the collected data were approximately normally distributed for all the study variables Descriptive statistics were used to report the quantitative variables in terms of mean (central tendency) and Standard deviation(SD). Parametric tests were carried out for inferential statistics. A one-way Analysis of Variance (ANOVA) with the *post-hoc* Tukey HSD test was used to analyze the differences between the four groups. The *P* value of ≤0.05 was considered as the level of significance.

RESULTS:
It was observed that the highest amount of fracture resistance was exhibited by Group D (346±15.1 N), followed by Group C (283.8±18.2 N), then Group B(261±17.7 N), and the least by Group A (172±11.3). The mean fracture resistance is illustrated in Figure 3.

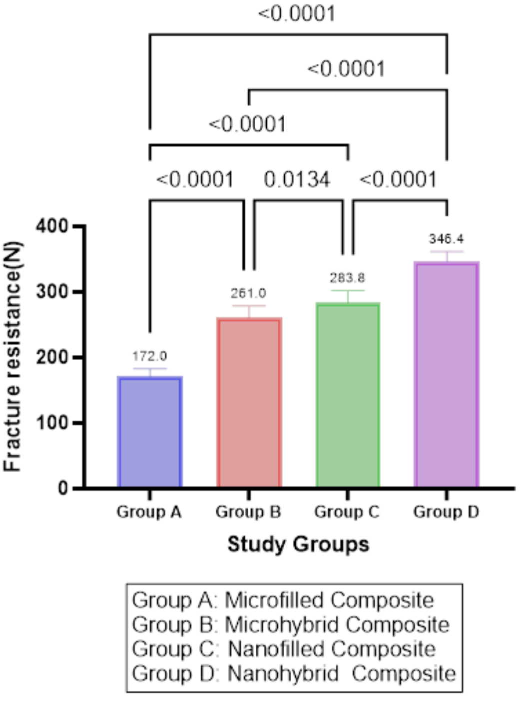

Figure 3: Bar Graph showing Inter-group comparison of the fracture resistance(N) between the study groups with significant differencesano

DISCUSSION
For this study, extracted human central upper incisors were used. Inherent differences between specimens relate to external crown size, internal geometry (pulp chamber), enamel thickness and structure of dental tissues. Incisors of comparable external crown size were selected. The tooth fracture is highly prevalent in younger individuals with larger pulp chambers, but the study assumed that the incisors available were originated from older patients, with reduction of pulp chamber sizes because of secondary dentinogenesis and gradual enlargement of the peritubular dentin with intratubular mineral deposits [5,11,12]. However, the literature shows no significant difference in the microtensile bond strength of composite resins to young and aged teeth [11,13].

To simulate uncomplicated tooth fracture, the incisors were cut obliquely with a diamond disc rather than using an impact load which may lead to unpredictable fracture surfaces, causing differences in surface area, fracture location and direction.

Among the commonly used materials in the literature, porcelain veneering or porcelain jacket crown is with the disadvantage of being the operator sensitive, needs the intervention of a third person (technician), has higher cost and is also contraindicated in young children as they have a larger pulp chamber, with thinner dentin that may result in iatrogenic injury to the pulp [14].

Micro-hybrid, Micro-filled, Nano-hybrid and Nano-filled composite resins were used in this study due to their most commonly use in aesthetic restoration. So we need to know which one better for anterior restoration regarding fracture resistance.

Owing to the improvement in the aesthetic and physical properties of modern composite resins, they have become the material of choice for direct anterior restoration but are not recommended for large restorations in regions with high masticatory forces [15,16].

Fracture resistance values were different in each study depending on testing methods and conditions.

Except for testing geometry, other variables affecting fracture resistant exist in dental resin nanocomposites. Those are:

- Type of composites (commercial or experimental);
- Type of matrix polymer;
- Percentage of filler particles(By volume% is the most important than by weight%),
- Filler particle size (nanofiller, micro-filler and hybrid) and its variation;
- Filler particle shape (regular, irregular and spherical);
- Surface treatment of filler, if any and its proportion.

It was observed that the highest amount of fracture resistance was exhibited by Group D (346±15.1N), followed by Group C (283.8±18.2N), then Group B(261±17.7N), and the least by Group A (172±11.3N).

Nanohydrid showed better fracture resistance compared to other composite resin used in this study due to their nano-sized filler particles and higher filler content. According to Endo, nanohybrid surfaces with larger and irregular filler tend to be more protrusive after the curing process, and therefore finishing would produce a flatter surface [17].

Nanofilled composite resin showed lower fracture resistance compared to the Nanohybrid due to their nanomer and nanocluster particles might produce few defects and scratches as a result of friction from the finishing instrument [18].

Microfilled showed least fracture resistance due to lowest filler loading that is 40% by volume.

Nano composite was found to have higher fracture resistance compared to microhybrid composite even though the difference was statistically insignificant, which correlated with the findings of Watanabe et al -It could be due to the more filler loading in nanofilled composite resin [19].

Microhybrid have a larger particle size than nanofill and microfill. Nanofill composite resins are stronger than microfill composite resins. Among the test groups, adhesive failure or cohesive fracture within the restoration without fracture of tooth material was expected. This showed that in spite of change in the filler size and concentration, the resin matrix has failed to achieve fracture resistance of natural tooth.

In some studies, the tooth was loaded at 90 degree angle , whereas in this study, the tooth was loaded to more closely simulate the clinical condition of 135°angle.

A static load test was used as a first step to gather information about the fracture behavior of restored incisal third with composite resins. Obviously, complex clinical conditions cannot be simulated with static load tests. Dynamic load tests might provide more detailed information, but static loading data are required in terms of expected load resistance and fracture behavior. The results of this study can be used as input for dynamic load tests. For alternative testing methods, like viscoelastic models, valid models are not available yet.

When evaluating the results of this investigation, it must be noted that there may be limitation to the direct application of in vitro results to in vivo situation which include lack of thermocycling and water storage. The specimens were tested in dry conditions without thermocycling as this study was intended to measure the fracture resistance of composite resins. The influence of water storage and thermocycling on fracture propagation characteristics needs to be investigated.

CONCLUSIONS

Within the limitation of this study, the highest amount of fracture resistance was exhibited by nanohybrid composite resin (346±15.1N) and the least by micro filled composite resin (172±11.3N).

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