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Original Article

Effects of glass fibers reinforced and non-reinforced composite resin on fracture behavior of severely destructed primary incisors and restored with post and core system

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ABSTRACT

Objective: To evaluate fracture resistance and failure type of coronally rehabilitated primary incisors with EverX Flow or Grandio Core post and core with or without fiber post.

Materials and Methods: Forty-eight extracted maxillary primary incisors were root canal treated and obturated with Metapex. The coronal 4-mm of Metapex was removed to create 3-mm intracanal post space. Next, coronal enamel and radicular dentin surfaces were acid-etched, and a bonding agent was applied and light-cured. Based on intracanal post and 2-mm height core buildup materials, specimens were divided equally ($n = 12$) into 4 groups as follow; Group I (EverX Flow), Group II (Grandio Core), Group III (Fiber post, and EverX Flow), and Group IV (Fiber post and Grandio Core). The coronal restorations were finalized to 4-mm height using G-aenial Anterior composite and specimens were tested for fracture resistance. Force required to induce fracture was recorded and failure type was examined.

Results: Fracture resistance of Fiber post and EverX Flow group was statistically significant high than other tested groups. However, fracture resistance of EverX Flow group showed non-statistically significant difference from that of Fiber post and Grandio Core group. Regarding failure type, no specimen presented root fracture, and all failures were favorable and repairable.

Conclusion: EverX flow post and core with or without fiber post enhanced fracture resistance of restored primary incisors compared to Grandio Core alone.

Clinical relevance: EverX flow post and core system with or without fiber post could be a promising restorative option for severely destructed primary incisors.

1. Introduction

Severe destruction of maxillary primary incisors is a common sequela of early childhood caries and in available literature, no standardized restorative technique has been documented for these teeth (Alamdari et al., 2023; Baghalian et al., 2014; Memarpour and Shafiei, 2013; Mehra et al., 2016). Different types of post have been proposed as intracanal retention when restoring severely destructed primary incisors (Mittal et al., 2015; Vafaei et al., 2016). However, the development of fiber post was a turning point in the restoration of severely destructed anterior teeth (Sawant et al., 2017). The close modulus of elasticity and mechanical properties of fiber post to those of dentin decreased possibility of root fractures associated with metallic posts (Jacob et al., 2021).

Insertion of fiber posts inside root canal requires use of post drills which not only remove additional radicular dentin beyond need for root

canal treatment but also produce cracks inside root canal (Fernandes et al., 2021; Fráter et al., 2020). In addition, the space originally occupied by dentin is replaced with mechanically inferior cement than that of dentin (Lassila et al., 2020a). For these reasons, post-debonding was frequently associated with adhesively cemented fiber posts (Salama et al., 2021).

Grandio Core (GC Group, Tokyo, Japan) is a flowable dual-cure composite material that combines quick self-curing as well as on-demand light-curing features (Säilynoja et al., 2021). The higher filler content of this material improved its mechanical properties and showed promising results alone or with fiber posts in permanent teeth (Fráter et al., 2021a; Lassila et al., 2020a). Accordingly, Grandio Core could overcome post-debonding failure and ensure the longevity of restored anterior primary teeth (Jacob et al., 2021).

Direct composite post is another way to overcome post-debonding

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failure as it makes an exact copy of canal space without need for luting cement (Fráter et al., 2021a). However, high polymerization shrinkage and low fracture toughness of particulate-filled composite (PFC) were the main causes of failure (Ibrahim and Nourallah, 2020; Salama et al., 2021). Short fiber-reinforced composites (SFRCs) are bulk-fill materials that contain randomly oriented glass fibers embedded within resin matrix which could eliminate need for post (Alshabib et al., 2022).

Recently, EverX Flow (GC Dental Corp., Tokyo, Japan) is a flowable version of SFRCs that can be used in limited spaces, such as root canals (Alshabib et al., 2022). The application of EverX Flow with fiber post improved fracture behavior of restored bovine or human incisors (Sun et al., 2023; Uctasli et al., 2021). Accordingly, the application of EverX Flow could improve resistance of restored primary incisors to fracture. Therefore, the present study aimed to assess fracture resistance of restored primary incisors with EverX Flow or Grandio Core post and core foundation with or without fiber post under the PFC veneer layer. It was hypothesized that resistance to fracture and type of failure of restored primary incisors with tested post and core buildup techniques would be different.

2. Materials and methods

2.1. Ethical approval and Sample size

The present study was conducted after approval of Dental Research Ethics Committee of the Faculty of Dentistry, Mansoura University with Code number (M109023PP). Sample size of the present study was calculated based on the previously published studies of Alamdari et al who compared fracture resistance of incisors restored with different post and core materials (Alamdari et al., 2023). The analysis was performed using G*Power program version 3.1.9.7. at 80 % power with 0.05 significance and showed that fracture resistance of each group could be evaluated using 12 primary incisors.

2.2. Specimens' collection

Forty-eight extracted primary maxillary central incisors collected from outpatient dental clinics were used in this study. The incisors were selected based on presence of at least intact two-thirds of root length and sound cervical third of the crown and the absence of any previous pulp therapies. The collected incisors were cleaned, disinfected in 0.5 % thymol, and kept in normal saline until used.

2.3. Specimens' preparation and pulpectomy procedure

The coronal portion of incisors was cut 1-mm above cemento-enamel junction (CEJ) with low speed diamond disc and the orifices of root canals was enlarged with size 3 Mani Gates-Glidden bur (Mani Inc, Japan). With working length of 1-mm short than apex, the canals were manually instrumented using Mani H-files (Mani Inc, Japan) up to size 35 and irrigated with normal saline after each file. After cleaning and shaping, canals were obturated with Metapex (Meta Biomed Co., Republic of Korea) as it is the most effective and applicable obturating material. Then, coronal 4 mm of Metapex was completely removed from root canals, and 1-mm glass ionomer cement was placed over its apical part (GC Fuji I; Tokyo, Japan).

2.4. Post and core restorative techniques and grouping

The enamel border and intracanal dentin of incisors were acid-etched for 15 sec with 37 % Scotchbond gel (3 M, MN, USA), water rinsed, and air dried but left moist. According to manufacturer's instructions, G-Premio Bond (GC Group, Tokyo, Japan) was applied over etched areas, air dried, and light cured for 20 sec. Next, prepared incisors were divided equally ($n = 12$) into 4 groups based on post and core materials as follows:

Group I: EverX Flow. Approximately 3 mm of EverX Flow was injected into canal and light cured for 40 sec. Then, 2 mm core height was built up for each incisor with EverX Flow and light cured for 20 s.

Group II: Grandio Core. The post and core were directly built up with Grandio Core as described in group I.

Group III: Fiber post and EverX Flow. A 5-mm length of Fiber Post (GC Group, Tokyo, Japan) was cut with high-speed diamond bur under water spray. The post surface was conditioned for 15 s with 37 % Scotchbond etchant, water rinsed, and air dried. The EverX Flow was first injected inside root canal and followed by fiber post, and EverX Flow was light cured for 40 s. Then, 2-mm EverX Flow core was built up and light cured for 20 s.

Group IV: Fiber post and Grandio Core. Post and core buildup were performed as described in group III except Grandio Core was used.

2.5. Final restoration and thermocycling

The coronal restoration of incisors was finalized to 4-mm height using G-aenial Anterior composite (GC Group, Tokyo, Japan), light-cured for 20 s, and finally finished with Sof-Lex discs (3 M, MN, USA). Then, each incisor was vertically inserted up to 1 mm below CEJ in acrylic resin block, and all specimens were thermocycled for 1000 cycle between 5°- 55 °C and 30 s dwell time.

2.6. Fracture resistance test and failure type

After that, the restored incisors were subjected to loading forces at 148 ° to their long axis and 0.5 mm/min cross-head speed using Instron machine (model 8500, Instron Co, USA) with 2-mm diameter metallic rod. The rod tip was applied to mid -palatal surface of restoration and force-inducing fracture was recorded in Newton. All specimens were examined visually for failure type that was categorized into: type 1; partial fracture of coronal restoration but intact post, type 2; coronal fracture of post and restoration, type 3: post-debonding with restoration, and type 4; root fracture (Pamato et al., 2023).

2.7. Statistical analysis

The data was analyzed statistically using SPSS software program version 25 (SPSS for Windows, Chicago, USA). One-way ANOVA and Tukey's Post Hoc test were used to compare between mean fracture resistance values of four groups at P-value ≤ 0.05 .

3. Results

3.1. Fracture resistance

Table 1 illustrates mean values of fracture resistance and standard

Table 1
Mean and standard deviations (SD) of fracture resistance values in Newtons(N) for four tested groups.

Groups	N	Mean \pm SD	F-value	P-value*
Group I (EverX Flow)	12	413.3 \pm 75.35		
Group II (Grandio Core)	12	299.2 \pm 68.55	15.769	P < 0.001
Group III (Fiber post and EverX Flow)	12	504.2 \pm 77.63		
Group IV (Fiber post and Grandio Core)	12	368.7 \pm 72.65		

* Level of significance was set at P-value ≤ 0.05 .

deviations (SD) for four tested groups in Newtons(N). Highest fracture resistance values were recorded in Fiber post and EverX Flow group and lowest values were in Grandio Core group. Regarding fracture resistance, ANOVA revealed statistically significant differences among four groups ($P < 0.001$). while results of Tukey's post hoc (Table 2) revealed that fracture resistance of Fiber post and EverX Flow group was statistically significant high than those of EverX Flow, Grandio Core, and Fiber post and Grandio Core groups ($P = 0.021, 0.000$, and 0.002 respectively). However, fracture resistance of EverX Flow group was not different significantly from that of Fiber post and Grandio Core group ($P = 0.811$).

3.2. Failure types

Table 3 summarizes frequency and percentage of failure types among four groups. Partial fracture of coronal restoration was predominately observed in EverX Flow group and Fiber post and EverX Flow group (66.6 % and 83.3 % respectively) as shown in Fig. 1 A and B. While coronal fracture of post with restoration was 75 % in Grandio Core group (Fig. 1 C), post-debonding was 58.3 % in Fiber post and Grandio Core group (Fig. 1 D).

4. Discussion

Rehabilitation of severely destructed primary incisors is a clinical challenge for pediatric dentists and their residual tooth structures necessitate need for post and core (Mehra et al., 2016). Although restoration of anterior permanent teeth with fiber post increased their fracture resistance, their fracture rate is three times more than that of posterior teeth due to great horizontal force (Garcia et al., 2019; Jurema et al., 2022). The application of EverX Flow inside root canal of primary incisors has not been studied yet in literature, so it might be essential to evaluate effects of EverX Flow on fracture resistance of restored primary incisors with post and core system.

In this study, an attempt was made to rehabilitate severely destructed primary incisors with restorations that mimic lost dentin-enamel structure (Uctasli et al., 2021; Singer et al., 2023). EverX Flow contains random microscale glass fibers embedded within resin matrix which

Table 3

Number (N) and Percentage (%) of failure types among four tested groups.

Groups	type 1 N (%)	type 2 N (%)	type 3 N (%)	type 4 N (%)
Group I (EverX Flow)	8 (66.6 %)	4 (33.3 %)	–	–
Group II (Grandio Core)	2 (16.6 %)	9 (75 %)	1 (8.3 %)	–
Group III (Fiber post and EverX Flow)	10 (83.3 %)	1 (8.3 %)	1 (8.3 %)	–
Group IV (Fiber post and Grandio Core)	4 (33.3 %)	1 (8.3 %)	7 (58.3 %)	–
Total	24(50 %)	15(31.25 %)	9 (18.75 %)	–

could mimic dentin collagen fibers within hydroxyapatite matrix (Lassila et al., 2020b). Besides close fracture toughness of EverX Flow to that of dentin, its protruding fibers at its interface with PFC layer could mimic dentin-enamel junction (Fráter et al., 2021c; Lassila et al., 2020b). Moreover, SFRCs remain attached after fracture and preserve their strength even after repair more than other bulk-fill composite (Alshabib et al., 2022).

In this study, post-depth was standardized to 3 mm and separated from Metapex with 1-mm base to avoid interaction with composite materials (Ravikumar et al., 2017). Also, fiber post that could fit coronal third of root canal without using post drills was selected to preserve radicular dentin as it could affect fracture resistance of incisors (Fráter et al., 2021a). In addition, fiber post surface was conditioned for 15 sec as this enhanced its adhesion without damaging its integrity (Jacob et al., 2021).

The rationale behind placement of PFC final restoration instead of crown was that crown could mask fracture resistance of post and core foundation (Uctasli et al., 2021). The loading force was applied to mid-palatal surface at oblique angle (148°) to long axis of restored incisors to simulate normal incisal force (Alamdari et al., 2023). In addition, applying force at this angle represents worst-case scenario of fracture resistance as it places heavy stress on coronal portion of incisor as well as post-root canal interface (Fráter et al., 2021b).

The null hypothesis of this study was accepted as results of fracture resistance showed statistically significant differences between Fiber post and EverX Flow group and other tested groups. However, fracture resistance of EverX Flow group was not significant different from that of Fiber post and Grandio Core group which could indicate similar biomechanical behavior of fiber post with Grandio Core to that of micro-glass fibers with resin matrix of EverX Flow (Fráter et al., 2021a; Säilynoja et al., 2021). Regarding failure type, partial fracture of coronal restoration was predominant in EverX Flow groups, especially Fiber post and EverX Flow group and this fracture can be simply re-restored with same composite material without additional cost (Alshabib et al., 2022; Fráter et al., 2021c). On other hand, complete fracture of coronal restoration or post-debonding was predominant in Grandio Core groups (Doshi et al., 2019). This failure can be re-restored, but it increases cost for patient and dentist (Uctasli et al., 2021).

In existing literature, no previous studies have evaluated effect of EverX Flow on fracture resistance of restored primary incisors with post and core system. However, the outcomes of this study were partly supported by Fráter et al., (2021a), Lassila et al., (2020a), and Suni et al (2023) studies, where application of EverX Flow as core or post-luting material improved fracture resistance of restored incisors.

In line with this study, Alamdari et al (2023) revealed that Fiber post and EverX Flow core increased fracture resistance of restored incisors

Table 2

Pairwise comparison between mean and standard deviations (SD) of fracture resistance values for four tested groups.

Groups	P value*
Group I (EverX Flow) Versus Group II (Grandio Core)	0.002
Group I (EverX Flow) Versus Group III (Fiber post and EverX Flow)	0.021
Group I (EverX Flow) Versus Group IV (Fiber post and Grandio Core)	0.811
Group II (Grandio Core) Versus Group III (Fiber post and EverX Flow)	0.000
Group II (Grandio Core) Versus Group IV (Fiber post and Grandio Core)	0.028
Group III (Fiber post and EverX Flow) Versus Group IV (Fiber post and Grandio Core)	0.002

* Level of significance was set at $P\text{-value} \leq 0.05$.

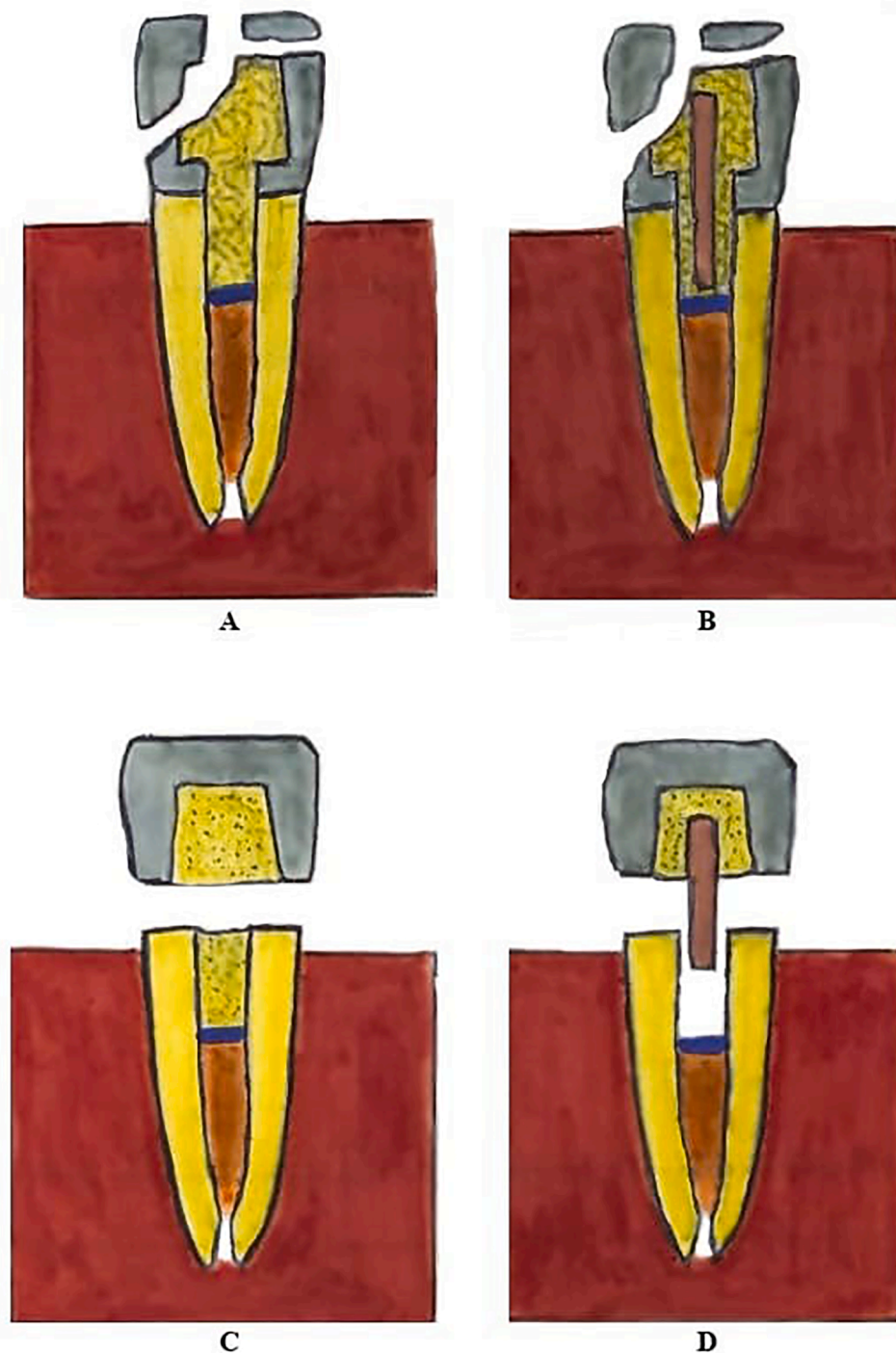


Fig. 1. Schematic diagram illustrating the predominant type of failure among four tested groups. A. Partial fracture of coronal restoration but intact post in EverX Flow group. B. Partial fracture of coronal restoration but intact post in Fiber post and EverX Flow group. C. Coronal fracture of post and restoration in Grandio Core group. D. Fiber post-debonding with restoration in Fiber post and Grandio Core.

more than Bulk fill composite post and core, EverX Flow post and core, Fiber post and Bulk fill composite core, and Conventional composite post and core. Also, [Uctasli et al \(2021\)](#) assessed fracture resistance of restored anterior permanent teeth with different post and core systems using either Grandio Core or EverX Flow as post-luting materials. Their results revealed that EverX Flow increased fracture resistance of incisors compared to Grandio Core.

On other hand, results of this study were inconsistent with those of [Garoushi et al \(2009\)](#) and [Bijelic et al \(2013\)](#) who reported that restored incisors with SFRC post and core showed an increase in their fracture

resistance compared to fiber post with PFC core. However, different restorative materials, tooth specimens, post type, and loading force used in this study could explain this discrepancy.

The favorable outcomes of EverX Flow in this study could be explained on the base of perspectives. Firstly, glass fibers in EverX Flow provided multidirectional isotropic reinforcement of restoration which re-directed crack propagation toward restoration periphery ([Lassila et al., 2020a](#)). Secondly, conditioning of post surface provided micro-mechanical bond between post and EverX Flow ([Fernandes et al., 2021](#)). Thirdly, effective light transmission of fiber post ensured optimal

polymerization of Ever X Flow inside canal (Fráter et al., 2021c). Finally, mechanical interlocking of protruding fibers of EverX Flow core with PFC veneer allowed uniform stress distribution along restoration without detrimental effects (Doshi et al., 2019).

5. Conclusions

1. Restored incisors with Fiber post and EverX Flow system showed promising results regarding fracture resistance.
2. EverX Flow post and core improved restoration resistance more than Grandio Core.
3. Restored incisors with Fiber post and Grandio Core showed fracture resistance comparable to that with EverX flow alone.
4. Restored incisors with EverX flow with or without fiber post showed the least type of fracture.

Ethics approval

This study was conducted after obtaining approval from the Dental Research Ethics Committee of the Faculty of Dentistry, Mansoura University Code No. (M109023PP).

Author contribution

Author Rizk El Agamy declares that he is the only author of this manuscript and this study, and its manuscript are completely performed by himself.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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