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Clinical Follow-up of Ribbond-reinforced Direct Composite Restorations in Endodontically Treated Posterior Teeth

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Abstract

Objectives:

This study aimed to evaluate the 1-year clinical performance of Ribbond-reinforced direct composite restorations placed in different orientations in endodontically treated posterior teeth.

Materials and Methods:

This clinical observational study was approved by the Selçuk University Faculty of Dentistry Ethics Committee (Approval No: 2023/54). Eighty-five patients (59 females, 26 males; aged 18–50 years) with 90 endodontically treated posterior teeth were included. Restorations were performed using a two-step self-etch adhesive (Clearfil SE Bond), a highly filled injectable composite (G-aenial Universal Injectable), a nanohybrid composite (G-aenial A'CHORD), and polyethylene fiber (Ribbond). Based on cavity configuration, fibers were placed in three orientations: circumferential (O-shaped), mesiodistal (MD), and buccolingual (BL). Clinical performance was assessed using modified USPHS criteria at 1 week, 6 months, and 12 months. Statistical analyses were performed using R software (v4.1.2) ($p < 0.05$).

Results:

All restorations demonstrated high clinical success, with no significant time-dependent deterioration. No statistically significant differences were observed among fiber orientation groups for any evaluated parameter ($p > 0.05$).

Conclusions:

Ribbond-reinforced composite restorations showed consistently favorable clinical performance over 12 months. Fiber orientation did not significantly influence outcomes, suggesting that clinically simplified placement strategies may be sufficient in the restoration of endodontically treated posterior teeth.

INTRODUCTION

Endodontically treated teeth are structurally compromised due to cumulative loss of tooth structure caused by caries, trauma, and endodontic procedures. This reduction in structural integrity significantly decreases fracture resistance, particularly in cavities involving multiple walls. While occlusal preparations may reduce tooth stiffness by 14–44%, mesio-occluso-distal (MOD) cavities can lead to reductions of up to 63% [1]. Therefore, preservation of the remaining tooth structure and the use of minimally invasive restorative approaches are critical for long-term success.

The prognosis of endodontic treatment is strongly dependent on the quality of the coronal restoration, as inadequate sealing may result in microleakage and reinfection [2]. Direct composite restorations are widely preferred due to their conservative nature, ability to preserve sound dental tissues, and favorable esthetic and

mechanical properties [3]. However, polymerization shrinkage and associated interfacial stress remain major challenges, potentially leading to marginal breakdown, cuspal deflection, and restoration failure [4].

To mitigate these limitations, fiber-reinforced composite techniques have been introduced. Polyethylene fibers have been shown to improve stress distribution, reduce crack propagation, and promote more favorable fracture patterns above the cemento-enamel junction, thereby enhancing the restorability of teeth [6]. In addition, fiber placement along cavity walls may increase fracture resistance and energy absorption, particularly in teeth with extensive structural loss [7].

Although numerous in vitro studies have demonstrated the benefits of fiber reinforcement [8–10], clinical evidence remains scarce. More importantly, the influence of fiber orientation relative to cavity configuration has not been adequately investigated under clinical conditions, representing a significant gap in the literature.

Therefore, this clinical observational study aimed to evaluate the 12-month clinical performance of Ribbond-reinforced direct composite restorations placed in different orientations circumferential (O-shaped), mesiodistal, and buccolingual, in endodontically treated posterior teeth using modified USPHS criteria [11]. The null hypothesis was that fiber orientation would not significantly affect clinical outcomes.

MATERIAL AND METHODS

Study Design and Ethical Approval

This study was designed as a clinical observational study conducted at the Department of Restorative Dentistry. The study protocol was approved by the Selçuk University Faculty of Dentistry Ethics Committee (Approval No: 2023/54) and registered at ClinicalTrials.gov (NCT06346769). The study was reported in accordance with the STROBE guidelines. Written informed consent was obtained from all participants before inclusion.

Patient Selection

Patients who underwent Ribbond-reinforced direct composite restorations on endodontically treated posterior teeth at the Restorative Dentistry Clinic of Selçuk University Faculty of Dentistry were screened for eligibility.

Inclusion criteria

- Age ≥ 18 years
- Good general health and oral hygiene
- Endodontically treated premolar or molar teeth
- Ability to attend follow-up visits

Tooth-related criteria

- Presence of occlusal contact with opposing dentition
- Exposure to functional occlusal loading

- Absence of apical pathology or periodontal symptoms
- Cavities involving one to three missing walls restored with Ribbond-reinforced composite

Exclusion criteria

- Poor oral hygiene
- Active periodontal disease
- Severe bruxism
- Pregnancy or lactation

A total of 85 patients (59 females, 26 males; aged 18–50 years) with 90 restorations were included. Follow-up evaluations were performed at 1 week, 6 months, and 12 months.

Eligible patients were informed in detail about the study protocol, and written informed consent was obtained from those who agreed to participate. Patients were informed about the scheduled follow-up visits and instructed to contact the clinic if they had any complaints related to the treated teeth before the recall appointments.

A total of 85 patients aged between 18 and 50 years were enrolled in the study. A total of 90 teeth were considered. Clinical evaluations of the restorations were performed at 1 week, 6 months, and 12 months after placement.

Restorative Materials Used

In this study, a two-step self-etch adhesive system (Clearfil SE Bond), universal composite resins (G-aenial Universal Injectable [GCI] and G-aenial A'CHORD [GCA]), and polyethylene fiber (Ribbond) were used. The manufacturers and compositions of the restorative materials employed in the study are presented in Table 1.

Table 1
Restorative materials used in the study and their compositions

Material	Manufacturer	Composition
Clearfil SE Bond / Self-etch adhesive system	Kuraray Med Inc, Tokyo, Japan	**Primer**: 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP), 2-hydroxyethyl methacrylate (HEMA), hydrophilic aliphatic dimethacrylate, dl-camphorquinone, N,N-diethanol-p-toluidine, water. **Bond**: 10-methacryloyloxydecyl dihydrogen phosphate (MDP), bisphenol A diglycidyl methacrylate (Bis-GMA), 2-hydroxyethyl methacrylate (HEMA), hydrophobic aliphatic dimethacrylate, dl-camphorquinone, N, N-diethanol-p-toluidine, colloidal silica.
G-aenial Universal Injectable / High-filled universal flowable composite	GC/ Tokyo, Japan	**Monomers**: UDMA, Bis-MEPP, TEGDMA. **Fillers**: 69 wt%, 50 vol%; silicon dioxide, flowable strontium glass.
G-aenial A'CHORD / Universal nanohybrid composite	GC/ Tokyo, Japan	**Monomers**: UDMA, Bis-MEPP, TEGDMA. **Fillers**: 80 wt%; silicon dioxide, strontium glass, pigments.
Ribbond THM	Ribbond Inc, Seattle, WA, USA	Ultra-high–molecular-weight polyethylene fiber

Restorative Procedures

All restorations included in the study were performed by a single operator (F.K.). The routine restorative procedure for Ribbond-reinforced composite restorations in endodontically treated teeth that met the inclusion criteria of this study was as follows:

a) Cavity Preparation

Patients present to the clinic after completion of their periodontal and endodontic treatments. Upon admission, all patients undergo radiographic and intraoral examinations, and the teeth requiring restorative treatment are identified.

Cavity preparation is performed on the teeth to be restored using a high-speed handpiece under water cooling. Access to the cavity is obtained using appropriately-sized diamond round burs (green band No. 12C; SWS Dental, Turkey), followed by refinement of the cavity margins with diamond fissure burs. Cusps at risk of fracture are reduced using diamond burs until adequate dentin support is achieved.

Temporary cement remnants or residual carious tissue that may have been overlooked are removed using a slow-speed micromotor with appropriate carbide or steel round burs. After completion of cavity preparation, the cavity is thoroughly rinsed and dried. Isolation is achieved using a rubber dam (Sanctuary Dental, Indonesia).

A suitable matrix system [Supermat Matrix System, Kerr/USA; Tofflemire Contour Matrix, Kerr/USA; Quickmat Deluxe Segmented Matrix System, Polydentia/Switzerland; Saddle Contoured Metal Matrix, TorVm/Russia] and a

wooden/anatomical plastic wedge [Interdental Wooden Wedge, TorVm/Russia; Plastic Wedge, Citizen, China] are selected.

The primer of the two-step self-etch adhesive system is applied for 20 s to the enamel and dentin surfaces of the prepared cavities using an applicator, followed by gentle air-drying for 5 s to ensure uniform distribution over all cavity surfaces. Subsequently, the bonding agent is applied for 10 s with a new applicator and gently air-thinned for 5 s, after which it is light-cured for 10 s using an LED curing unit (Valo LED curing light, Ultradent, USA).

Following application of the adhesive system, the canal orifices are sealed with a highly filled injectable composite resin. Thereafter, the missing cavity walls are reconstructed using a conventional universal composite resin with the aid of the selected matrix systems, thereby converting the cavity into a Class I configuration.

b) Placement of Ribbond into the Cavity

Depending on the number of missing cavity walls and the size of the cavity, fibers are placed in different orientations: O-shaped (circular) in cavities with two or three missing walls; a mesiodistal (MD) orientation is applied in cavities with missing mesial and distal walls; and a buccolingual (BL) orientation is used in cavities with missing buccal and lingual walls (Fig. 1). Ribbond is measured along the cavity walls and cut with the manufacturer's dedicated scissors.

The Ribbond is impregnated with the hydrophobic bonding agent of the two-step self-etch adhesive system. Excess bonding agent is gently removed using the air component of an air/water spray without pressure. The Ribbond is then positioned onto the cavity walls which had been previously lined with a highly filled flowable composite, and light-cured for 20 s.

The remaining portion of the cavity is restored using a universal nanohybrid composite with an incremental layering technique (in 2mm layers).

Finishing and polishing procedures for completed restorations are performed with a high-speed handpiece and a slow-speed micromotor. Red- and yellow-banded diamond burs are used to contour the restorations in accordance with the tooth's anatomical form and occlusal relationships. Premature occlusal contacts are identified using articulating paper and removed, followed by final contouring.

Interproximal finishing and polishing of the restorations are carried out using polishing discs (OptiDisc, Kerr, Switzerland) and polishing rubbers (Enhance polishing systems, Dentsply, Canada). After completion of the procedures, patients receive oral hygiene instructions, and follow-up appointments are scheduled. The restoration process and its 12-month follow-up are shown in Fig. 2.

Determination of Experimental Groups

The 90 restorations included in the study were allocated into three groups according to the orientation of Ribbond placement along the cavity walls (n = 30 per group):

Group 1

This group included restorations with two or three missing cavity walls, in which Ribbond was placed circumferentially in an O-shaped configuration along the cavity walls.

Group 2

This group included restorations with missing mesial and/or distal walls, in which Ribbond was placed in an I-shaped configuration along the mesiodistal cavity walls.

Group 3

This group included restorations missing buccal and/or lingual walls, in which Ribbond was placed in an I-shaped configuration along the cavity walls in the buccolingual direction.

Clinical Evaluation of Restorations

Follow-up examinations were performed at 7 days, 6 months, and 12 months after restoration placement. Intraoral photographs were taken at each follow-up visit. Routine radiographic examinations were not performed for all patients; radiographs were obtained only when deemed clinically necessary.

A clinical evaluation of the restorations was conducted at the dental unit under reflector light using a mirror and explorer, in line with the Modified USPHS criteria. The assessments were performed by an experienced examiner who was blinded to the study protocol and had not participated in the restorative procedures. During the evaluation, adjacent teeth were isolated with cotton pellets.

The restorations were clinically assessed and scored for color match, marginal discoloration, anatomical form, marginal adaptation, secondary caries, surface texture, and retention.

Statistical Analysis

All statistical analyses were performed using the R Statistical Language (version 4.1.2; The R Foundation for Statistical Computing, Vienna, Austria; https://www.r-project.org). Findings for the categorical variables in the study are presented as frequencies (n) and percentages. The time-dependent changes in clinical scores with regard to direct composite restorations, grouped by fiber orientation (O, MD, and BL), at 7, 6, and 12 months were evaluated using the Cochran Q test with Bonferroni correction. The Alpha score ratios of restorations with fiber placement in different directions at the same measurement time were compared using the Fisher-Freeman-Halton test ($p < 0.05$).

RESULTS

A total of 85 patients were included in the study, comprising 55 females (64.7%) and 30 males (35.3%). The 90 restorations included in the study were clinically evaluated and scored according to the Modified USPHS criteria at 7 days, 6 months, and 12 months (Table 2). At the end of 12 months, all patients attended their follow-up appointments, and all restorations were evaluated (100%). Table 3 shows the distribution of direct composite restorations, performed by placing Ribbond in three different directions, according to the teeth.

Table 2
Clinical evaluation of restorations according to modified USPHS criteria at different follow-up periods

Modified USPHS Criteria	USPHS scores	O, *n*			MD, *n*			BL, *n*		
		Day 7	6 mo	12 mo	Day 7	6 mo	12 mo	Day 7	6 mo	12 mo
Retention	*Alpha*	30/30	30/30	29/30	30/30	30/30	29/30	30/30	30/30	29/30
	Bravo	-	-	1/30	-	-	-	-	-	1/30
	Charlie	-	-	-	-	-	1/30	-	-	-
Color Match	Alpha	30/30	30/30	30/30	30/30	30/30	29/29	30/30	30/30	30/30
	Bravo	-	-	-	-	-	-	-	-	-
	Charlie	-	-	-	-	-	-	-	-	-
Marginal Discoloration	Alpha	30/30	30/30	28/30	30/30	30/30	29/29	30/30	30/30	30/30
	Bravo	-	-	2/30	-	-	-	-	-	-
	Charlie	-	-	-	-	-	-	-	-	-
Anatomical Form	Alpha	30/30	30/30	29/30 1/30	30/30	30/30	29/29	30/30	30/30	29/30 1/30
	Bravo	-	-	-	-	-	-	-	-	-
	Charlie	-	-		-	-	-	-	-	
Surface Texture	Alpha	30/30	30/30	27/30 3/30	30/30	30/30	29/29	30/30	30/30	30/30
	Bravo	-	-	-	-	-	-	-	-	-
	Charlie	-	-		-	-	-	-	-	-
Marginal Adaptation	Alpha	30/30	30/30	29/30	30/30	30/30	29/29	30/30	30/30	28/30
	Bravo	-	-	1/30	-	-	-	-	1/30	2/30
	Charlie	-	-	-	-	-	-	-	-	-
Secondary Caries	Alpha	30/30	30/30	30/30	30/30	30/30	29/29	30/30	30/30	30/30
	Delta	-	-	-	-	-	-	-	-	-

Table 3
Distribution of teeth according to fiber orientation

Fiber Orientation	Premolar	Molar	Total
O (Circumferential)	13	17	30
MD (Mesiodistal)	9	21	30
BL (Buccolingual)	10	20	30

At the 7-day and 6-month follow-up evaluations, all restorations in the O and MD groups were scored as Alpha for all criteria. (Figs. 3a and 3b) In the BL group, only one restoration received a Bravo score for the marginal

adaptation criterion.

At the 12-month evaluation, all restorations received Alpha scores for color match and secondary caries. With regard to the retention parameter, one restoration in the O group and one restoration in the BL group were scored as Bravo, while one restoration in the MD group was scored as Charlie. (Fig. 8) The retention loss observed in the MD group was due to the patient concerned biting hard nuts. The remaining retention losses were observed in the marginal areas. In the O and BL groups, the minor retention losses manifested as small fractures at the margins and were corrected by smoothing and recontouring with polishing discs. No repair or replacement procedures were required. However, the restoration in the MD group that exhibited retention loss was renewed and was therefore excluded from the study.

Regarding marginal discoloration, only two restorations in the O group received Bravo scores. (Fig. 4) In terms of the anatomical form criterion, one restoration in the O group and one restoration in the BL group were scored as Bravo. The evaluation of surface texture revealed that only three restorations in the O group received Bravo scores. (Figs. 5 and 6) With regard to the marginal adaptation criterion, one restoration in the O group and two restorations in the BL group received Bravo scores. (Fig. 7)

The comparison of the proportions of Alpha scores among direct composite restorations reinforced with Ribbond placed in three different orientations at the same evaluation time points is presented in Table 4. According to the results, the proportions of Alpha scores of restorations evaluated using the Modified USPHS criteria at the same time intervals were statistically similar (all $p > 0.05$).

Table 4
Comparison of Alpha scores of direct composite restorations reinforced with fibers placed in different orientations according to the Modified USPHS criteria at the same evaluation time points

Restorations	O, *n*	MD, *n*	BL, *n*
Retention			
6 months	30/30	30/30	30/30
12 months	29/30	29/30	29/30
Color Match			
6 months	30/30	30/30	30/30
12 months	30/30	29/29	30/30
Marginal Discoloration			
6 months	30/30	30/30	30/30
12 months	28/30	29/29	30/30
Anatomical Form			
6 months	30/30	30/30	30/30
12 months	29/30	29/29	29/30
Surface Texture			
6 months	30/30	30/30	30/30
12 months	27/30	29/29	30/30
Marginal Adaptation			
6 months	30/30	30/30	29/30
12 months	29/30	29/29	28/30
Secondary Caries			
6 months	30/30	30/30	30/30
12 months	30/30	29/29	30/30

DISCUSSION

In this clinical study, the 12-month clinical performance of Ribbond-reinforced direct composite restorations placed in different orientations in endodontically treated posterior teeth was evaluated. Based on the findings, the null hypothesis of the study was accepted. At the end of the one-year follow-up period, all direct composite restorations reinforced with Ribbond placed in different orientations demonstrated similar and successful clinical performance.

The literature recommends embedding fiber ribbons within a thin layer of flowable composite resin [12]. In recent years, next-generation flowable composites with increased inorganic filler content and improved mechanical and physical properties have been increasingly preferred for this purpose [13]. In the present study, Ribbond was placed along the cavity walls using a highly filled flowable composite (G-aenial Universal Injectable). For the fabrication of the restorations, a universal nanohybrid composite resin (G-aenial A'CHORD), characterized by a wide shade range, favorable translucency, high fracture and wear resistance, was used [14].

According to the literature, long-term clinical follow-up studies on the relatively new composite materials GCA and GCI are limited. In addition, in vitro studies investigating the physical and mechanical properties of these materials remain scarce [13–17]. Review of the in vitro studies evaluating the mechanical properties of the GCI composite reveals inconsistent findings: while one study reported the lowest microhardness values for this material [16], another study demonstrated that it exhibited the highest wear resistance [13]. Variations in the materials used for comparison with GCI across studies may account for these inconsistent results.

When examining studies investigating the mechanical properties of GCA composite, one study reported that the surface roughness of GCA treated with simulated gastric acid for 14 days was clinically acceptable [15]. In another study comparing GCA with different universal composite materials, GCA demonstrated the lowest surface roughness values [14]. Furthermore, in a clinical research presenting one-year follow-up results of Class II restorations performed with GCA, GCI, and a universal composite material, both GCA and GCI were reported to exhibit similar and successful clinical performance [18].

Although the primary objective of the present study was to evaluate the effect of different fiber orientations on restoration success, the composite material used is among the most influential factors affecting restoration performance, particularly in the short term. At the one-year evaluation, all restorations assessed in this study demonstrated clinically-acceptable performance. In line with the existing literature, these findings suggest that GCA's clinical performance is successful.

In the present study, Ribbond, a polyethylene fiber, was selected for reinforcement of the restorations. According to the literature, fibers may be placed on the pulpal floor in either a unidirectional or bidirectional configuration. However, to minimize crack propagation and maximize load resistance, the optimal fiber placement strategy for composite resin restorations has not yet been clearly established [19]. In the endodontically treated teeth included in this study, fiber ribbons were placed in a circumferential (O-shaped) configuration in cases with two or three missing cavity walls; in an I-shaped configuration in the mesiodistal direction when the mesial and distal walls were missing; and in an I-shaped configuration in the buccolingual direction when the buccal and lingual walls were missing, after which the restorations were completed.

In vitro studies evaluating composite restorations reinforced with Ribbond placed in different orientations are available in the literature. Based on these studies, reinforcement with polyethylene fibers of direct composite restorations on endodontically treated or vital teeth has been shown to increase fracture resistance while reducing microleakage. However, the fiber position within the cavity and the amount of fiber applied do not significantly affect fracture resistance or microleakage. Overall, the use of polyethylene fibers has been reported to positively influence the survival rates of composite restorations [9, 10, 20–23]. Although this restorative approach is well supported by in vitro evidence, its clinical validation remains necessary. A review of the literature reveals that only a limited number of clinical studies have been conducted on this topic.

In a pilot study by Deliperi et al., Ribbond was placed toward the missing cusp and wall at direct composite restorations of 35 endodontically treated teeth with Class II cavities. All restorations were reported to exhibit successful clinical performance at the end of a 1-year follow-up period [24]. In a clinical study by Mohamed et al., 45 teeth with MOD cavities were restored with everX Posterior, Ribbond-reinforced nanohybrid composite, and fiber-free nanohybrid composite. The restorations were followed for 18 months. In that study, polyethylene fiber was placed circumferentially to include the buccal, lingual, and proximal walls. At the end of an 18-month follow-up period, all restorations demonstrated similar and successful clinical performance [25].

In a clinical study conducted by Özüdoğru and Tosun, Class II direct composite restorations (G-ænial Posterior), either reinforced with Ribbond or without fiber reinforcement, were placed in 75 primary first molars with extensive carious lesions, and the restorations were followed for 24 months. In the Ribbond-reinforced group, fiber was placed in an O-shaped configuration within the cavity. No clinically detectable changes were observed in any of the restorations during the first six months. However, after the 24-month follow-up period, minor changes in marginal adaptation and marginal discoloration were detected in both groups. Nevertheless, all restorations demonstrated similar and satisfactory clinical performance across all evaluation criteria [26].

Evaluation of the one-year clinical data of the restorations in the present study revealed that all restorations were scored as Alpha (ideal restoration) in terms of color match and secondary caries criteria. Minimal retention losses observed at the marginal areas in the O and BL groups were smoothed and corrected using polishing discs and polishing rubbers. In contrast, the retention loss observed in the MD group necessitated restoration replacement. In terms of the marginal discoloration criterion, two restorations in the O group were scored as Bravo; for marginal adaptation, one restoration in the O group and two restorations in the BL group received Bravo scores; for surface texture, three restorations in the O group were scored as Bravo; and for anatomical form, one restoration each in the O and BL groups received Bravo scores. No statistically significant differences were detected over time or between groups for any of the evaluated parameters.

Unlike the present study, all previously reported in vivo studies applied standardized cavity designs. In most of these studies, fiber placement strategies were similar to those preferred in our study, and were based on the number of missing cavity walls and the extent of tooth structure loss [24–26]. Only one study applied a standardized circumferential (O-shaped) fiber placement in Class II cavities with single-wall loss [26]. Despite differences in tooth type, number of restorations, follow-up periods, and composite materials used across studies, all investigations consistently reported that Ribbond-reinforced restorations performed clinically-successfully, in agreement with the present study's findings. Based on these observations, it can be concluded that in vivo studies support the outcomes reported in in vitro investigations.

In a clinical study conducted by Metwaly et al., 240 endodontically treated molar teeth with one or two missing proximal walls and a minimum remaining wall thickness of 2 mm were included. In one group, Ribbond was placed along the proximal walls of the teeth, whereas in the second group, restorations were completed using bulk-fill composite resin without fiber reinforcement. After a 2-year follow-up period, both groups were reported to have similar, clinically-successful outcomes. Based on these findings, the authors suggested that using polyethylene fiber in teeth with moderate tooth structure loss may be time-consuming and costly. In contrast, fiber reinforcement may be more beneficial in cases with extensive structural loss [27].

In the present study, no control group consisting of fiber-free direct composite restorations was included. Moreover, because this clinical study was observational, the wall thickness of the included teeth was not

standardized. In cases where axial wall thickness was less than 2 mm in the teeth included in this study, cusp reduction was performed. Consequently, the present study focused on the clinical follow-up of teeth in which a fiber-reinforced composite restoration was deemed appropriate by clinical judgment. Nevertheless, the finding reported by Metwaly et al., indicating that fiber-free composite restorations and Ribbond-reinforced composite restorations exhibited similar clinical performance, is noteworthy. Accordingly, it may be suggested that fiber reinforcement of composite restorations enhances clinical performance when used under appropriate indications; however, in teeth with moderate tooth structure loss and sufficient remaining wall thickness (≥ 2 mm), fiber reinforcement may not be necessary.

This study has certain limitations. A 12-month follow-up period is insufficient to determine the long-term clinical success of fiber-reinforced direct composite restorations in teeth with extensive tooth structure loss. Accordingly, long-term follow-up of the restorations included in this study, and dissemination of these outcomes in the literature, would provide valuable evidence on the clinical performance of the materials used and the effectiveness of the restorative approach. In addition, in future studies, the inclusion of direct restorations reinforced with different fiber types or indirect restorative options may yield more comprehensive data on the optimal restorative choice for endodontically treated posterior teeth with extensive structural loss.

CONCLUSION

At the end of the 12-month follow-up period, Ribbond-reinforced composite restorations demonstrated similar and clinically successful outcomes when evaluated in terms of retention, color match, marginal adaptation, marginal discoloration, secondary caries, anatomical form, and surface texture. Based on these findings, it can be suggested that the use of Ribbond has a positive effect on the clinical survival of direct composite restorations in endodontically treated teeth with extensive loss of tooth structure, regardless of fiber orientation.

Declarations

Competing interests

The authors declare no competing interests.

Ethics approval

This study was approved by the Selçuk University Faculty of Dentistry Ethics Committee (Approval No: 2023/54).

Informed consent

Written informed consent was obtained from all participants prior to inclusion.

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Author Contribution

F.K. conceived and designed the study, performed all clinical procedures, collected the data, and wrote the manuscript. M.G. contributed to data analysis, interpretation of the results, and critical revision of the manuscript. Both authors approved the final manuscript.

Data Availability

The datasets generated during the current study are not publicly available due to patient privacy considerations but are available from the corresponding author on reasonable request.

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Figures

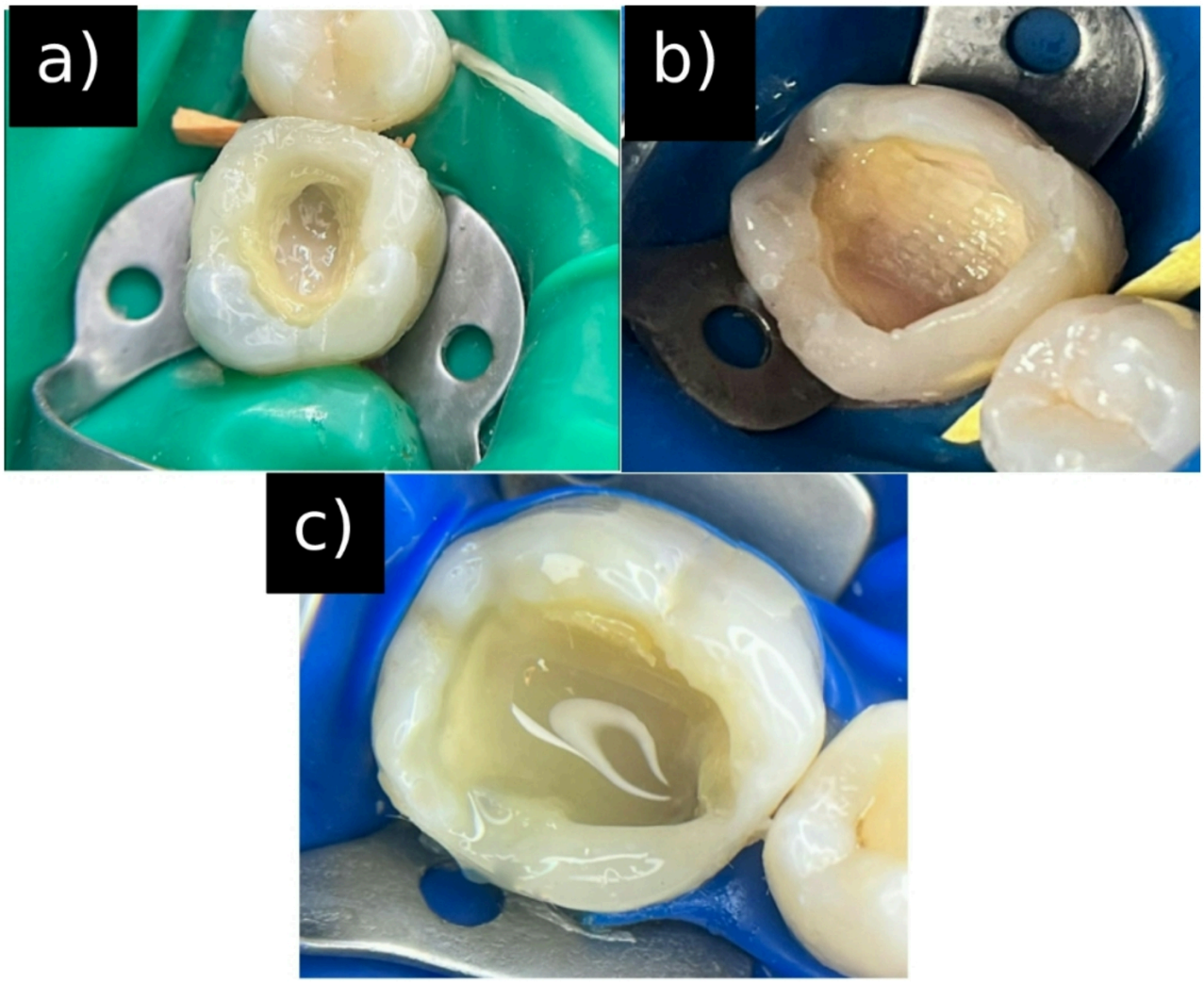


Figure 1

Ribbond fiber placement orientations
(a) Circumferential (O-shaped) placement of Ribbond fiber;
(b) Mesiodistal placement of Ribbond fiber;
(c) Buccolingual placement of Ribbond fiber within the cavity



Figure 2

Restorative procedure stages and 12-month follow-up

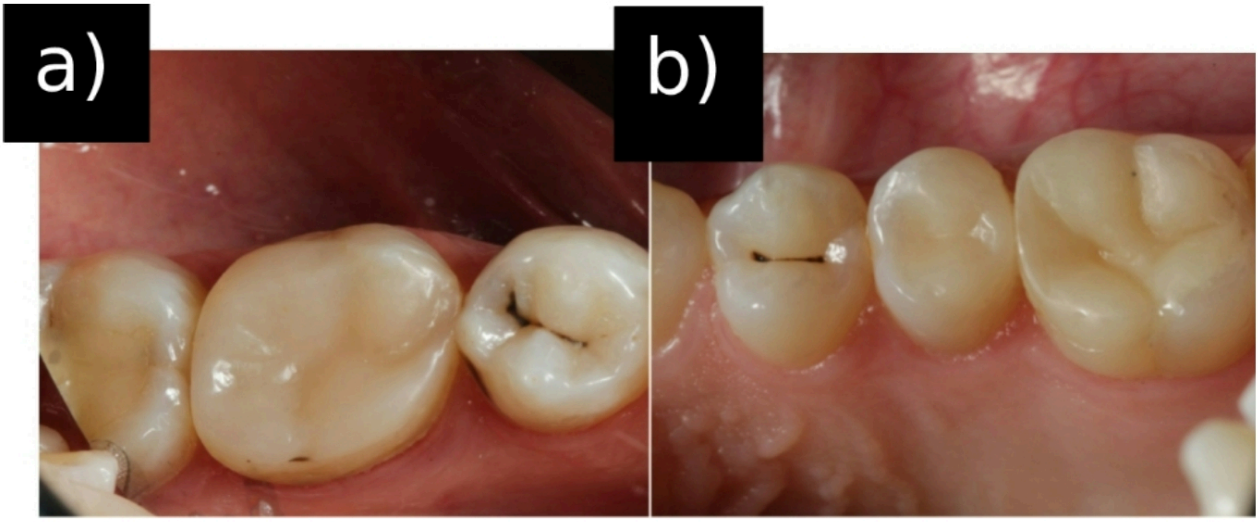


Figure 3

(a) Tooth No. 15: MD group, 12-month follow-up, **Alpha scores for all evaluation criteria, (b)** Tooth No. 46: O group, 12-month follow-up, **Alpha scores for all evaluation criteria**



Figure 4

Tooth No. 27: O group, 12-month follow-up, Bravo score for marginal discoloration



Figure 5

Intraoral view of tooth No. 47 receiving a Bravo score for the surface texture criterion at the 12-month follow-up



Figure 6

Tooth No. 15: O group, 12-month follow-up, Bravo score for surface texture



Figure 7

Tooth No. 26: BL group, 6-month follow-up, Bravo score for marginal adaptation



Figure 8

Intraoral view of tooth No. 37 in the MD group receiving a Charlie score for the retention criterion at the 12-month follow-up