

Clinical outcome of fiber post and fiber-reinforced resin composite for the full crowns of anterior endodontically treated teeth: a 5-year randomized clinical trial

Marco Ferrari^a, Ovidiu Ionut Saracutu^{b,*}, Denise Irene Karin Pontoriero^b, Giorgio Gastaldi^c, Giulia Verniani^b, Daniele Manfredini^b, Edoardo Ferrari Cagidiaco^{b,d}

^a Department of Medical, Surgical and Neurological Sciences, University of Siena, Siena, 53100, Italy

^b Department of Medical Biotechnologies, University of Siena, Siena, 53100, Italy

^c Department of Dentistry, Vita-Salute San Raffaele University, Milan, Italy

^d Sbarro Institute for Cancer Research and Molecular Medicine and Center for Biotechnology, College of Science and Technology Temple University, Philadelphia PA 19122, USA

ARTICLE INFO

Keywords:

Bruxism
Endodontically treated teeth
Prosthodontics
Oral behavior checklist
STAB
Lithium disilicate
Short fiber-reinforced composite

ABSTRACT

Aim: To compare the outcome of short fiber reinforced composites, as a core material, with respect to conventional fiber post, for the reconstruction of anterior endodontically treated teeth (ETT), covered by a lithium disilicate crown.

Materials and methods: Patients in need of endodontic treatment and a single-unit full crown restoration for anterior teeth (incisors or canines) were recruited. Only teeth with >50% of residual tooth structure were included. The teeth were required to be in occlusal function with a natural antagonist tooth and in interproximal contact with two adjacent natural teeth. A simple randomized design with 2 arms was adopted to evenly allocate patients to the two experimental groups. The fluctuation of oral behaviors was assessed via the Oral Behavior Checklist. For the assessment of the prosthodontic outcome, the modified US Public Health Service criteria were used. Statistical analysis was set at $p < 0.05$.

Results: The statistical analysis showed no significant association between the type of build-up material, the high risk for oral behaviors ($p = 0.197$), and the prosthodontic failures ($p = 0.471$).

Conclusion: This randomized clinical trial shows no significant difference in the outcome of anterior ETT with >50% of residual tooth structure restored with fiber post or fiber-reinforced composite, covered by a lithium disilicate crown, at 5 years of follow-up.

Clinical significance: Short fiber-reinforced composites represent a valid alternative material to fiber post, for the build-up of anterior endodontically treated teeth, with at least 50% of residual tooth structure, covered by a lithium disilicate crown.

1. Introduction

The long-term prognosis of endodontically treated teeth (ETT) is influenced by the type of restoration performed, and often poses important challenges for general practitioners [1]. Over the past years, many new procedures, techniques, and materials have been introduced, opening the way to new opportunities and discussions.

A debated topic in this matter concerns the choice between a direct

and an indirect restoration material for ETT [2]. The available evidence suggests that clinicians should base their decisions on a range of clinical variables, including the amount of residual tooth structure, endodontic conditions, tooth anatomy, and tooth position in the arch [3–5]. Additionally, another variable to consider when planning the restoration of ETT regards the use of a fiber post [6–8]. While the literature clearly shows that fiber posts perform better clinically than traditional materials, such as metal posts, the debate over whether fiber posts actually

* Corresponding author at: Viale Mario Bracci, 16, Siena, Italy, 53100.

E-mail addresses: ferrarm@gmail.com (M. Ferrari), ovidiu.saracutu@unisi.it (O.I. Saracutu), denise.pontoriero@unisi.it (D.I.K. Pontoriero), gastaldi.giorgio@unisi.it (G. Gastaldi), giulaverniani96@gmail.com (G. Verniani), daniele.manfredini@unisi.it (D. Manfredini), edoardo.ferrari.cagidiaco@gmail.com (E. Ferrari Cagidiaco).

<https://doi.org/10.1016/j.jdent.2026.106850>

Received 26 April 2026; Received in revised form 14 June 2026; Accepted 22 June 2026

Available online 23 June 2026

0300-5712/© 2026 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

improve tooth prognosis is ongoing. The available guidelines suggest that the decision to use a fiber post should be based on a series of clinical factors, including the position of the ETT, occlusal forces, and static and dynamic movements of teeth [9,10]. A recent article showed that, in posterior ETT with at least 50% of residual tooth structure, no significant difference in the clinical outcome was found between teeth restored with or without a fiber post covered by a lithium disilicate partial crown [11].

In parallel with these ongoing debates, an emerging alternative to fiber post seems to be represented by the short fiber-reinforced composites (SFRCs), a material that has the potential to increase the fracture resistance of ETT [12]. SFRCs have recently been proposed for intracanal anchorage in post-endodontic reconstruction, given their push-out strength and retentive force similar to those of traditional fiber posts [13]. SFRCs are made by a series of randomly oriented discontinuous fibers, typically short E-glass fibers, immersed in a resin matrix. In vitro laboratory studies have shown that the addition of such reinforced fibers can enhance fracture toughness, improve flexural properties, and resist crack propagation compared with the conventional composite material used for the build-up of ETT [12]. From a theoretical point of view, by mimicking the anisotropic and hierarchical structure of dentin, SFRCs aim to be a biomimetic restorative material that can replace tooth structure by redistributing stress in a pattern similar to that of dentin [12]. In vitro studies have shown that SFRCs not only possess higher fracture resistance than conventional composites but also tend to have a favorable, repairable clinical outcome, similar to fiber posts [14,15]. Nevertheless, in vivo clinical trials on the outcomes of SFRCs as post-and-core material for ETT are still lacking and needed.

In addition, an important emerging shortcoming of randomized clinical trials (RCTs) in prosthodontics is the exclusion of patients who report bruxism [16], a group of masticatory muscle activities that are common in the general population. In the prosthodontic literature, the role of bruxism and oral behaviors as risk factors for the long-term outcome of prosthodontic restorations is well agreed at the expert level [17–19]. Thus, researchers have consistently excluded patients with a report of a high frequency of oral behavior when testing new materials [16]. While such a choice can be justified to limit risk factors that may affect the clinical performance of newly tested dental materials and restorative techniques, it inevitably creates a vicious cycle that widens the knowledge gap on the topic [16]. Under these premises, questions arise as to whether the frequency of oral behaviors can affect the long-term survival of anterior ETT.

What further complicates the clinical scenarios is that oral behaviors tend to fluctuate in a very unpredictable manner [20] and can occur in up to 50% of patients with temporomandibular disorders and systemic diseases [21,22]. Such fluctuations can often be the result of the natural changes occurring in the psychological sphere during life or be related to symptoms such as anxiety [23,24], depression [25], and stress [26]. Additionally, they can also be a consequence of certain medical conditions belonging to the broad group of sleep disorders, such as obstructive sleep apnea [27] and gastroesophageal reflux disease [28].

One of the most widely used tools to assess the frequency of oral behaviors is the Oral Behavior Checklist (OBC) [29]. The OBC is a validated [30] comprehensive tool, translated into multiple languages [31–33], containing 21 items split into two groups: 2 items for sleep-time behaviors (teeth clenching and grinding, and sleep position) and 19 items for the evaluation of wake-time behaviors.

Based on these considerations, the present RCT aims to compare, at 5 years of follow-up, the outcomes of two different techniques for the restoration of anterior ETT covered by a lithium disilicate crown: traditional fiber posts versus SFRCs used as post-and-core material. Additionally, the investigation aims to assess the potential impact of oral behavior frequency on the two types of restoration protocols.

The first null hypothesis stated that no significant association exists between the type of material used for the build-up of anterior ETT and the prosthodontic failure, at 5 years of follow-up. The second null

hypothesis stated that no association exists between the prosthodontic failure and the frequency of oral behaviors, at 5 years of follow-up.

2. Materials and methods

2.1. Patient recruitment

For the present RCT the CONSORT statement guidelines were followed [34]. Patients in need of endodontic treatment and a single-unit full crown restoration for anterior teeth (incisors or canines) were recruited from the Department of Prosthodontics at the University of Siena. After being fully informed about the study's purpose, in accordance with a pre-approved protocol, all participants provided written informed consent in accordance with the Helsinki Declaration and understood that they were free to withdraw from the study at any time. Ethical approval was obtained (ClinicalTrials.gov n. CT01532947). The sample size was based on a previous study [11]. With 95% confidence and 80% power, the number of participants required in each group was 32. This was increased to 56 participants to allow for dropouts. Fig. 1 shows the CONSORT flowchart of the present RCT.

The inclusion criteria for the RCT were having an age between 18 and 80 years and being in good general and periodontal health. Only teeth with >50% of tooth structure were included. The teeth were required to be in occlusal function with a natural antagonist tooth and in interproximal contact with two adjacent natural teeth. Additionally, to be included in the trial, patients were required to have a “no risk” or “low risk” score for oral behaviors based on the OBC administered before inclusion. Patients were excluded from the clinical trial based on the following baseline conditions: age <18 years, disability, pregnancy, systemic diseases or severe medical conditions, temporomandibular disorders, plaque index >20, xerostomia, language barriers, and a high-risk OBC score. Patients with temporomandibular disorders were excluded using the TMD Pain Screener [35]. The exclusion of other ongoing medical/dental conditions was applied using the University of Siena Hospital records, available in electronic format, which contain all updated information on patients' general and dental health.

2.2. Study design

For the present RCT, a simple randomized design with 2 arms was adopted to evenly allocate patients to the two experimental groups, with equal sample sizes. For the randomization process, Excel spreadsheet software (2021, Microsoft) was used by a blind operator not directly involved in the recruitment or assessment processes. Randomization was performed using a computer-generated random number sequence to assign participants to the four groups with equal probability (1:1 allocation ratio). Given the type of interventions, patients and operators could not be blinded in the present study.

Patients were divided into the following two groups:

Group 1: ETT restored with a fiber post (FP, GC Corp., Tokyo, Japan), build up with GRADIA CORE (GC, GC Corp.) and a crown (LS, Initial LiSi Press luted with G-CEM LinkForce (LF, GC Corp.));

Group 2: ETT restored without a post, build up with short-fiber reinforced flowable resin composite (EXF) and a crown (LS, Initial LiSi Press luted with G-CEM LinkForce (LF, GC Corp.));

2.3. Clinical procedures

2.3.1. Endodontic procedure (group 1 and group 2)

A single experienced operator (M.F) performed all the prosthodontic tooth restoration. After the endodontic treatment was performed using Flexmaster rotary instruments (sizes 15-20-25-30-35-40; VDW), obturation of canals was performed with the continuous wave of condensation technique, up to 4 to 5 mm from the apex, with a System B heat source (SybronEndo). Thermoplastic gutta-percha was used for back-filling the canals with the Obtura II Unit (Obtura Co.). The canal access

was sealed with glass-ionomer cement (Fuji IX; GC Corp.). At the second appointment, at least 24 h after endodontic treatment, the patients followed one of the four restorative protocols. All procedures, including endodontic treatments and restorations, were performed after isolating the operative field with a rubber dam. Patients followed a strict oral hygiene program with periodical recalls every 6 months.

2.3.2. Post space preparation and fiber post cementation and build-up of abutment (group 1) (Fig. 2)

For Group 1, precalibrated drills (GC FIBER POST, GC Corp.) were used to prepare the post space, leaving at least 4 mm of intact apical seal. The best post was selected to fit the canal diameter (post diameters: 1.2 mm, 1.4 mm, or 1.6 mm). The silane coupling agent (GC CERAMIC PRIMER, GC Corp.) was applied to the post surface, and the post was luted using the GRADIA CORE system (GC Corp.), following the manufacturer's instructions. GRADIA CORE was dispensed into the root canal via an Automix Endo tip. After the post was inserted, the excess material was removed, and the post was light-cured.

2.3.3. Build-up of abutments with short fiber-reinforced flowable resin composite (group 2) (Fig. 3)

In Group 2, Gates-Glidden burs were used to remove the gutta-percha leaving at least 4–5 mm of intact apical seal. For the application of the SFRCs, as a post-and-core material, the modified Bioblock technique introduced by Fráter et al. was adopted [36], following the application of the universal adhesive (G-Premio BOND, GC Corp.), in combination with the dual-cure activator (G-Premio BOND DCA, GC Corp.), adopting the manufacturer's instructions.

The build-up was made with the bulk shade everX Flow (EXF) in layers approximately 1 mm thick to fill the root chamber. For optimal polymerization, a light-transmissible post (0.8 mm GC Fiber post, GC Europe, Leuven, Belgium) was placed into the root canal to facilitate the

transmission of the light to the apically positioned layers of EverX flow. To avoid contact with the uncured material, the light-transmissible post was withdrawn 0.5–1 mm from the surface of the SFRCs layers. Each layer was cured for 80 s till reaching the level of the cemento-enamel junction (CEJ). The rest of the pulp chamber was filled with subsequent 1 mm layers, light-cured for 40 s each, till reaching the occlusal surface.

2.3.4. Crown prosthodontic procedures (group 1 and group 2)

Tooth preparation was performed using a 1-mm tip, round-end, medium grit diamond bur to provide a 1-mm chamfer finish line placed at the level of the gingival margin. Preparation depths were 1 mm axially and 2 mm incisally. Margins were kept mainly in enamel. In both Group 1 and Group 2, the final impressions were performed using an elastomeric material (EXA'lence GC Corp.), and the impressions were then poured in Type IV (FUJIROCK GC Europe N.V.). Single-unit lithium disilicate crowns were fabricated (Initial LiSi Press, GC Corp.), sand-blasted, etched with fluoridric acid 10% for 1 min, washed, air-dried, and silanized with MultiPremier (GC Corp.) and luted with resin cement (G-CEM LinkForce, GC Corp.).

2.4. Assessment of clinical outcomes and oral behaviors risk

Clinical and intraoral radiographic examinations were performed at baseline and at 5 years of follow-up. Survival and success rates were evaluated based on clinical and intra-oral radiographic examinations at the follow-up. Evaluation of the radiograph was performed independently by two blinded, well-trained examiners, at 5x magnification (E.F. C., D.I.K.P.). For the assessment of the prosthodontic outcome, the modified US Public Health Service [USPHS] criteria were evaluated based on clinical and intra-oral radiographic examinations at each follow-up. For each parameter, a score of Alpha, Bravo, or Charlie was assigned. Based on the USPHS criteria, the prosthodontic outcomes were

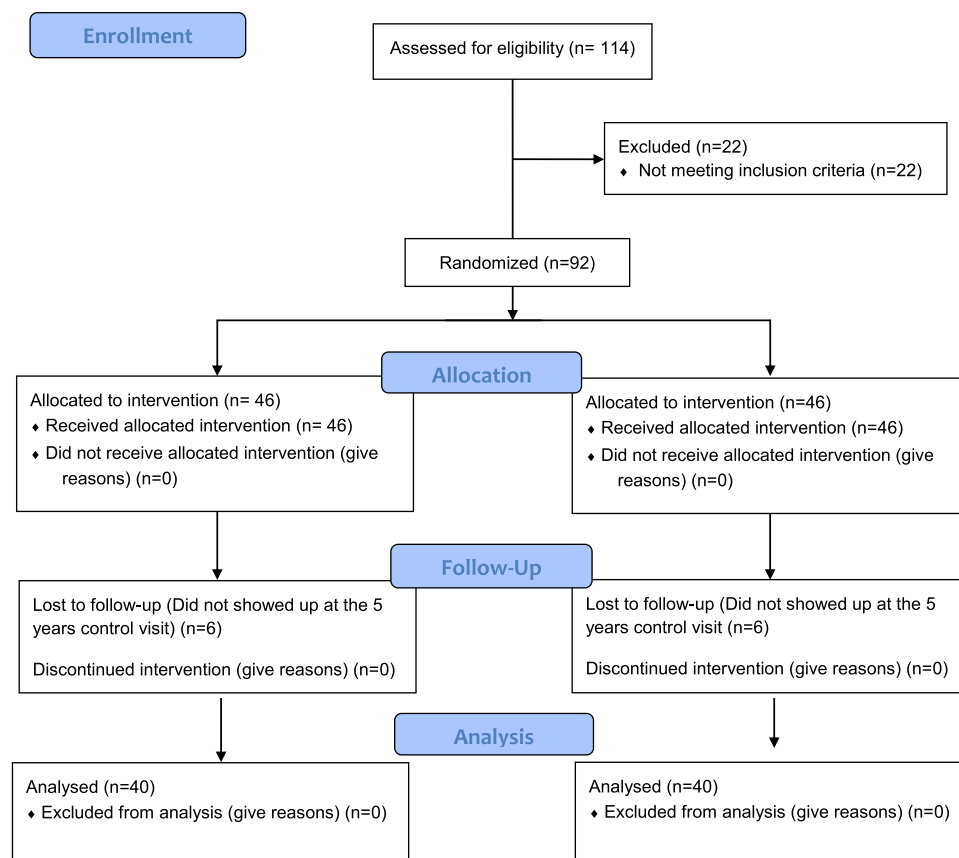


Fig. 1. CONSORT Flow-chart of the Randomized Clinical Trial.

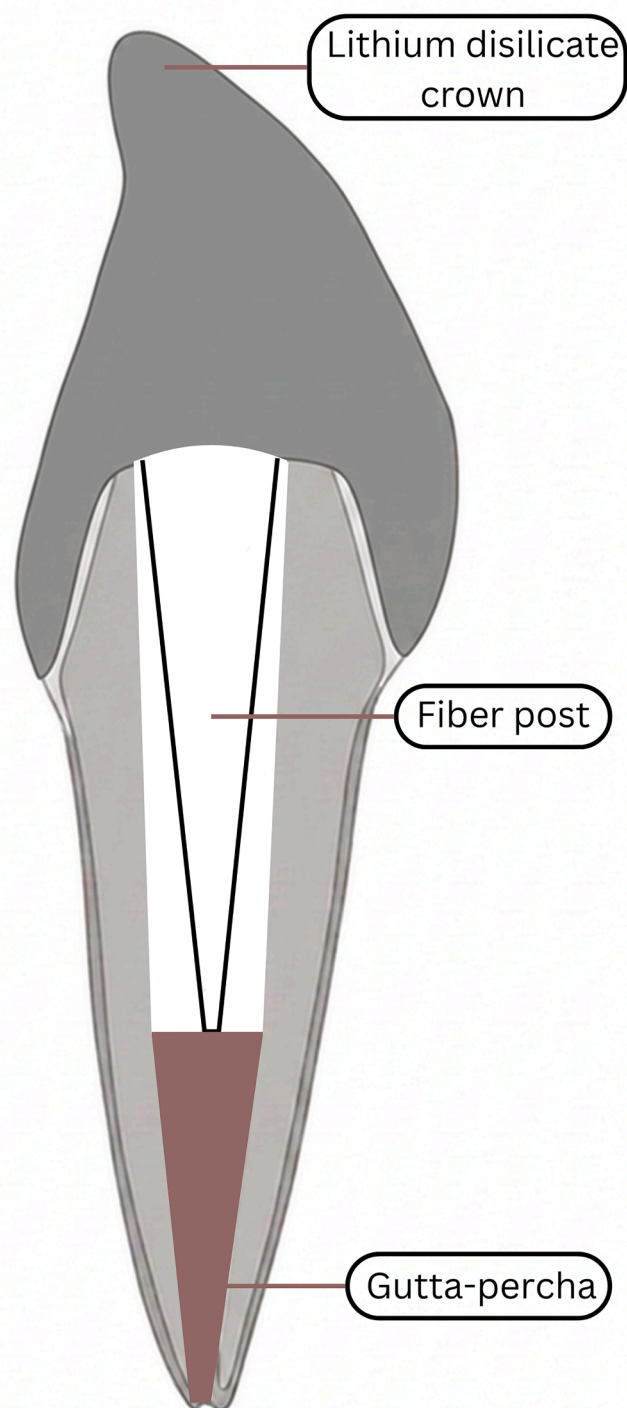


Fig. 2. Schematic representation of the restorative protocol adopted for Group 1.

dichotomized into two categories: clinically perfect or not clinically perfect but not in need of replacement (score Alpha or Bravo, respectively) and restoration in need of replacement (score Charlie), as proposed in a previous scientific paper [11]. The following parameters from the USPHS criteria were adopted to assess at follow-up, the need for restoration replacement and were marked as prosthodontic failure (Charlie): post-debonding, post-fracture, fractured restoration, debonded restoration, vertical or horizontal root fracture, crown

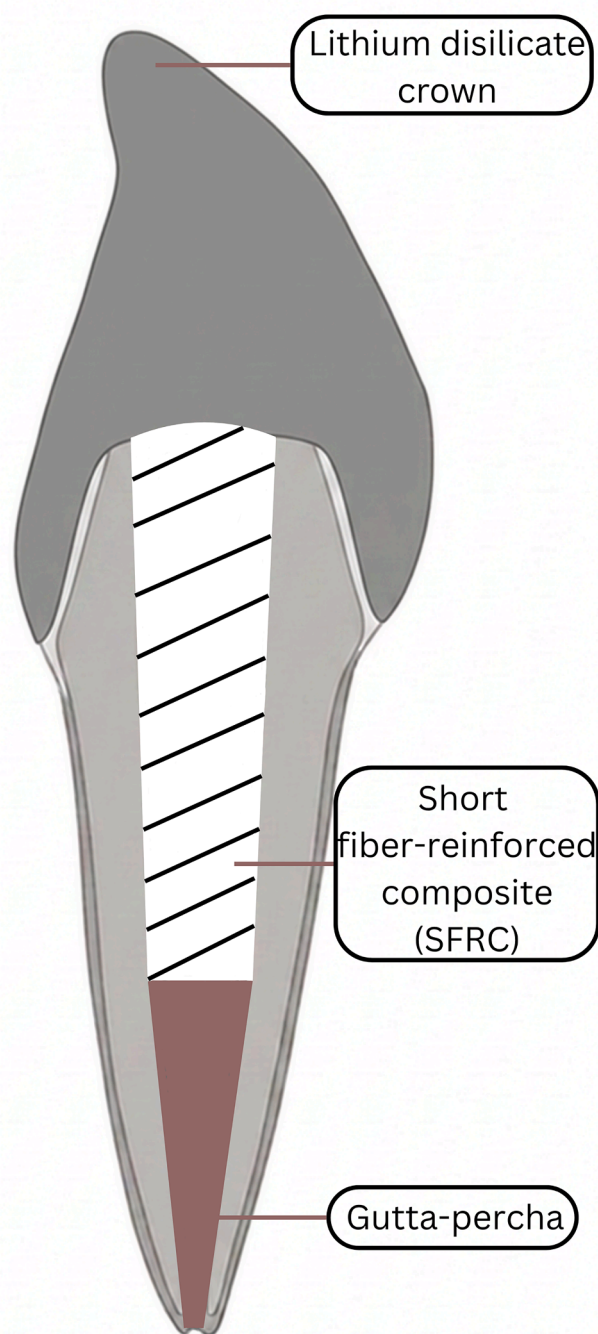


Fig. 3. Schematic representation of the restorative protocol adopted for Group 2.

dislodgement, crown fracture [11].

The frequency of oral behaviors was assessed at the moment of patients' recruitment. To do so, an operator (D.M.) administered the OBC questionnaire [29]. Each item of the OBC is scored on a 5-point rating scale (0–4), with different response options, based on the frequency of reported behaviour over the past month, for sleep-time and wake-time behaviours. For the sleep-time behaviours, the options are none of the time, <1 night/month, 1–3 nights/month, 1–3 nights/week, and 4–7 nights/week, while for wake-time behaviors the options are none of the time, a little of the time, some of the time, most of the time, and all of the

time. The tool is based on a specific grading system where the total sum score ranges from 0 to 84 and, based on the suggested interpretation, is divided into three risk grades: ‘No risk’ with a total score of 0, ‘Low risk’ with scores ranging from 1 to 24, and ‘High risk’ with scores ranging from 25 to 84. The OBC was made available in 2006 and later translated into many languages [31–33]. It is nowadays part of the Standardized Tool for the Assessment of Bruxism (STAB), the most comprehensive tool kit for the evaluation of bruxism [37–39].

Only participants with no risk and low risk were included in the present clinical trial. At the 5-year follow-up, the same operator administered the same OBC questionnaire, blinded to the clinical assessment. Based on the OBC scoring, patients were thus divided into three risk grades: ‘No risk’ with a total score of 0, ‘Low risk’ with scores ranging from 1 to 24, and ‘High risk’ with scores ranging from 25 to 84, following the official instructions of the tool [29].

2.5. Statistical analysis

Based on the OBC grading system, the patients were divided into three categories: no risk, low risk, and high risk. According to the modified USPHS criteria, patients were dichotomized into two broad categories: those who did not need to replace the restoration and those who did. For the statistical analysis, a *t*-test was used to compare the ages between the two groups. The chi-square test was used to assess the sex differences between the two groups. The Cramer’s V test was used to assess the association between the type of restoration, the OBC risk category, and the prosthodontic failure. Statistical analysis was set at *p* < 0.05 for all the analyses. All statistical procedures were performed using the SPSS 25.0 software (IBM, Milan, Italy).

3. Results

For the present RCT, a total of 114 patients were recruited. Of them, 16 patients were excluded due to undergoing periodontal disease, 5 patients due to TMD symptoms, and 1 patient due to pregnancy. In the end, 92 patients were considered eligible for the study. The patients were equally randomized into the two different types of prosthodontic restoration (Fig. 1). Of them, 12 patients declined to undergo follow-up at 5 years and dropped out of the study. In total, 80 patients (43 males and 37 females, with a mean age of 52.5 ± 3.8 years) were evaluated at the follow-up. Of the 80 teeth included in the study, 49 were incisors, and 31 were canines. The average time of the tooth restoration in function was 5.6 ± 0.2 years (Table 1).

At 5 years of follow-up, at re-administration of the OBC, a total of 6 patients were classified as “no risk” for oral behaviors. Of the remaining, 42 presented a low risk, while 32 presented a high risk for oral behaviors (Table 2). Of the total number of patients at high risk for OBC, 14 were in Group 1, while the remaining 18 were in Group 2. In total, only two prosthodontic failures were found, both in Group 2. In both cases, the failure was due to debonding of the build-up material. The statistical analysis showed no significant difference in age or gender between patients with tooth failure and those without (*p* = 0.81). No significant association was found between the type of tooth restored and the number of prosthodontic failures (*p* = 0.471). The Cramer’s V test showed no significant association between the use of the GC FIBER POST (Groups 1), the use of fiber-reinforced composite (Group 2), and the presence of a high risk for oral behaviors and prosthodontic failures

Table 1
Statistical indices of mean, standard deviation, minimum age, maximum age, and comparison between Group 1 and Group 2.

Group	Women n (%)	Men n (%)	Total	Mean	Standard Deviation	Minimum	Maximum
Group 1	17 (42.5)	23 (57.5)	40	53.6	4.21	48	59
Group 2	21 (52.5)	19 (47.5%)	40	51.3	2.87	45	61

Chi square test for gender: $\chi^2=0.21$. *P* = 0.429.
Independent *t*-test for age: *T* = 0.38, *p*-value=0.782.

Table 2
OBC score at baseline and at 5 years of follow-up.

OBC Risk Score	OBC score at baseline	OBC score at 5 years of follow-up
High Risk n (%)	0 (0)	32 (40)
Low Risk n (%)	69 (86.3)	42 (52.5)
No Risk n (%)	11 (13.8)	6 (7.5)

OBC: Oral Behaviors Checklist.

Table 3
Cramer’s V test association between the use of the fiber post, fiber reinforced composite, high risk for oral behaviors and prosthodontic failure.

Variables	<i>p</i> -value
Fiber Post	0.161
Fiber Reinforced Composite	0.161
High risk for oral behaviors	0.197

(Table 3). Given these results, no logistic regression analysis was performed.

4. Discussion

The present investigation aimed to test the clinical outcomes of two different restorative procedures for anterior ETT covered by a full crown. The clinical trial evaluated the outcome of ETT restored with a fiber post, compared with ETT restored with SFRCs, both covered by a lithium disilicate crown, at 5 years of follow-up. Additionally, the paper aimed to assess whether the risk for oral behaviors could affect the prosthodontic outcomes.

For this purpose, a total of 92 restorations were made on single anterior teeth. Of them, 80 were evaluated at the 5-year follow-up. The null hypothesis stated that no significant association exists between ETT failure, the type of restoration protocol used for the build-up, and the frequency of oral behaviors. Based on the findings of the present study, none of these hypotheses could be rejected. The use of fiber posts, the use of fiber-reinforced composite, and the presence of a high frequency of oral behaviors were not significantly associated with prosthodontic failures. Of the total number of restored teeth, only 2 failed at 5-year follow-up, both from the group in which the build-up was performed with SFRCs. Nevertheless, the difference between the two groups was not statistically significant. Such findings are in line with *in vitro* tests showing no significant differences in the mechanical behavior between adaptation and bonding to root canal dentin of a discontinuous glass fiber-reinforced composite and a traditionally cemented fiber post [40–42].

Based on the results of the present paper, it can be concluded that at 5 years of follow-up, no difference in clinical performance exists between the two proposed restorative protocols in anterior teeth with at least 50% residual tooth structure. It is known that the use of fiber posts, due to their low modulus of elasticity and properties similar to dentin, is associated with a low risk of root fracture [43,44]. However, due to complex clinical steps needed for their correct cementation, their success has also been shown to be operator-dependent [45]. Thus, in the authors’ view, given the lack of a significant difference between the outcomes of the two protocols, general practitioners should adopt the

technique that is more familiar and comfortable with. It should be noted that the most commonly reported failure of an ETT restored with a fiber post is debonding at the post-dentin interface [46]. In this view, the use of SFRCs as a post-and-core material allows the elimination of some of the variations that may increase technical sensitivities of prefabricated fiber posts without affecting clinical outcomes. It must be acknowledged that the present investigation included only teeth with at least 50% of residual tooth structure. Future studies should confirm these findings in patients with extensive tooth structural loss. Additionally, future studies should assess the clinical outcomes of ETT restored with the combination of fiber post and SFRCs as a build-up material. In this regard, laboratory studies have also shown that another potential benefit of using flowable SFRCs is that, compared to direct composite, it presents a more favorable failure pattern in posterior teeth [40–42]. Such findings can be justified by the properties of SFRCs, which exhibit higher fracture resistance than those of nanohybrid and bulk-fill composites. The E-glass fibers incorporated into the resin matrix enhance fracture resistance and prevent crack propagation [12], reinforcing the internal core of the restoration and redistributing stress similarly to a fiber post. An important consideration in the present study is that all restored teeth had at least 50% of residual tooth structure, indicating that an adequate ferrule was present to ensure an ideal long-term biomechanical behavior of the abutments covered by lithium disilicate full crowns. Thus, the results of the present study should not be generalized to teeth not having the minimum requirement of ferrule to undergo tooth restoration [4].

Both prosthodontic failures happened in the group where SFRCs were used as a post-and-core material, due to debonding. The most likely cause of debonding could be related to the incomplete curing of the most apical applied layers of SFRCs, due to the inability of the light to fully reach such layers, perhaps due to an accentuated curvature of the canal. To overcome such limitations, a dedicated fiber optic transillumination tip for intracanal light curing of SFRCs has been proposed for laboratory use [47], however they are not approved yet for clinical use. Future studies should consider testing different types of polymerization strategies for intracanal SFRCs.

The present RCT was the first study to test in vivo the outcome of SFRCs as a post-and-core material alternative to fiber posts in abutments with sufficient ferrule. In this view, future investigation should consider testing the use of SFRCs in teeth with <50% residual tooth structure and assessing the long-term prognosis of such teeth.

Additionally, in the present study, the high risk for OBC was not significantly associated with anterior ETT failure. However, all failures occurred in the subgroup of patients at high risk for oral behaviors. Evidence shows that oral behaviors and bruxism are not considered to be masticatory muscle activities associated with specific occlusal feature schemes [48] and that occlusal features are not a predictor of them [49, 50]. Instead, the literature suggests that bruxism is a condition strongly influenced by personality features, medical conditions, and disorders, all of which can have an unexpected onset and fluctuate over their lifetimes [25]. The relationship between bruxism and cigarette smoking remains controversial as well, considering that while tobacco smoking has been associated with bruxism [51], smoking cessation has not been linked with a decrease [52,53].

It must be emphasized that one limitation of this clinical study, regarding the association between prosthodontic failure and oral behaviors, is the use of the assessment tool, viz., the OBC [29]. The questionnaire covers a broad range of masticatory muscle activities, from those associated with bruxism to those that can be part of everyday life, such as sustained talking and singing. Given its rigid structure and grading system, and the fact that the scoring system is validated only for the administration of the entire questionnaire, it was not possible to assess the relationship between prosthodontic failure and specific oral behaviors [29].

Future studies should consider adopting more comprehensive assessment tools, such as the Ecological Momentary Assessment (EMA) of awake bruxism [54–56]. Given that the main risk factor for

mechanical failure of prosthodontic restorations is the amount of masticatory muscle activity, a recently introduced 24-hour electromyographic Holter that can measure the entire activity of the left masseter muscle might better serve this purpose than self-reported assessment strategies [57]. The devices, being portable, can collect data both during sleep and wakefulness in the natural environment, without the need for complex polysomnographic laboratory investigations [58,59]. Surface electromyography has also recently been applied in orthodontics and periodontology to examine the potential association between periodontal status and sleep bruxism [60,61]. Its use in prosthodontics to study the possible association between bruxism and prosthodontic failure is surely interesting. A recent RCT that used surface EMG to assess sleep bruxism found no significant difference in prosthodontic outcomes between teeth covered with lithium disilicate crowns and those covered with zirconia crowns [62]. The study, however, was limited by the lack of awake bruxism monitoring and by the evaluation of bruxism only at baseline, underscoring the fluctuation of oral behaviors and, once more, the complex relationship between bruxism and prosthodontic failure.

Other limitations of the present study include the fact that only one follow-up was performed at 5 years and that oral behavior fluctuations were not monitored multiple times during the ongoing trial. Future follow-ups on this cohort of patients will provide even more insight into the clinical performance of fiber-reinforced composite with respect to fiber post and the possible relationship between prosthodontic failures and bruxism fluctuation. Moreover, future investigations on anterior ETTs with <50% remaining coronal structure, restored with full crowns and with direct restorations, are desirable. Other studies should also include the administration of more specific STAB questionnaires [38], in combination with instrumental assessment tools.

5. Conclusion

The present RCT shows no significant difference in the outcome of anterior ETT with >50% of residual tooth structure restored with fiber post or fiber-reinforced composite, at 5 years of follow-up. No significant association was found between the frequency of oral behaviors and the number of prosthodontic failures.

Informed consent statement

Written informed consent was obtained from all subjects involved in the study.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability

The data that support the findings of this study are not openly available due to reasons of sensitivity and are available from the corresponding author upon reasonable request.

Ethics approval

All participants signed an informed consent form to use their records for this study, which was approved by the Regional Ethics Committee for Clinical Trials of the Tuscany Region (PO005).

CRediT authorship contribution statement

Marco Ferrari: Writing – review & editing, Visualization, Validation, Resources, Methodology, Investigation, Conceptualization. **Ovidiu Ionut Saracutu:** Writing – review & editing, Writing – original draft,

Formal analysis. **Denise Irene Karin Pontoriero**: Writing – review & editing, Investigation. **Giorgio Gastaldi**: Writing – review & editing. **Giulia Verniani**: Methodology, Conceptualization. **Daniele Manfredini**: Writing – review & editing, Visualization, Validation, Investigation, Formal analysis, Data curation. **Edoardo Ferrari Cagidiaco**: Writing – review & editing, Writing – original draft, Visualization, Resources, Methodology, Data curation, Conceptualization.

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. Given his role as Editorial Board member, Marco Ferrari, was not involved in the peer review of this article and had no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to another journal editor.

References

- [1] M. Trope, H.L. Ray Jr, Resistance to fracture of endodontically treated roots, *Oral Surg. Oral Med. Oral Pathol.* 73 (1) (1992) 99–102, [https://doi.org/10.1016/0030-4220\(92\)90163-k](https://doi.org/10.1016/0030-4220(92)90163-k).
- [2] M.C.F.M. de Kuijper, M.S. Cune, M. Özcan, M.M.M. Gresnigt, Clinical performance of direct composite resin versus indirect restorations on endodontically treated posterior teeth: a systematic review and meta-analysis, *J. Prosthet. Dent.* 130 (3) (2023) 295–306, <https://doi.org/10.1016/j.prosdent.2021.11.009>.
- [3] W. Tang, Y. Wu, R.J. Smales, Identifying and reducing risks for potential fractures in endodontically treated teeth, *J. Endod.* 36 (4) (2010) 609–617, <https://doi.org/10.1016/j.joen.2009.12.002>.
- [4] J. Juloski, I. Radovic, C. Goracci, Z.R. Vulicevic, M. Ferrari, Ferrule effect: a literature review, *J. Endod.* 38 (1) (2012) 11–19, <https://doi.org/10.1016/j.joen.2011.09.024>.
- [5] M. Ferrari, D.I.K. Pontoriero, E. Ferrari Cagidiaco, F. Carboncini, Restorative difficulty evaluation system of endodontically treated teeth, *J. Esthet. Restor. Dent.* 34 (1) (2022) 65–80, <https://doi.org/10.1111/jerd.12880>.
- [6] K.A. Guldener, C.L. Lanzrein, B.E. Siegrist Guldener, N.P. Lang, C.A. Ramseier, G. E. Salvi, Long-term clinical outcomes of endodontically treated teeth restored with or without Fiber post-retained single-unit restorations, *J. Endod.* 43 (2) (2017) 188–193, <https://doi.org/10.1016/j.joen.2016.10.008>.
- [7] R.S. Schwartz, J.W. Robbins, Post placement and restoration of endodontically treated teeth: a literature review, *J. Endod.* 30 (5) (2004) 289–301, <https://doi.org/10.1097/00004770-200405000-00001>.
- [8] C. Goracci, M. Ferrari, Current perspectives on post systems: a literature review, *Aust. Dent. J.* 56 (Suppl 1) (2011) 77–83, <https://doi.org/10.1111/j.1834-7819.2010.01298.x>.
- [9] M. Ferrari, E. Ferrari Cagidiaco, C. Goracci, R. Sorrentino, F. Zarone, S. Grandini, T. Joda, Posterior partial crowns out of lithium disilicate (LS2) with or without posts: a randomized controlled prospective clinical trial with a 3-year follow up, *J. Dent.* 83 (2019) 12–17, <https://doi.org/10.1016/j.jdent.2019.01.004>.
- [10] D.I.K. Pontoriero, S. Grandini, G. Spagnuolo, N. Discepoli, S. Benedicenti, V. Maccagnola, A. Mosca, E. Ferrari Cagidiaco, M. Ferrari, Clinical outcomes of endodontic treatments and restorations with and without posts up to 18 years, *J. Clin. Med.* 10 (5) (2021) 908, <https://doi.org/10.3390/jcm10050908>.
- [11] E. Ferrari Cagidiaco, G. Verniani, D.I.K. Pontoriero, O.I. Saracutu, D. Manfredini, M. Ferrari, Posterior partial crowns out of lithium disilicate with or without posts: a randomized controlled study at 9 years follow up, *J. Dent.* 161 (2025) 106005, <https://doi.org/10.1016/j.jdent.2025.106005>.
- [12] E. Fernández, L. Díaz, C. Bersezo, J. Martín, R. Cabello, P. Angel, Efficacy of short Fiber-reinforced composite resins in MOD and endodontically treated posterior teeth: a systematic review, *J. Esthet. Restor. Dent.* 38 (2026) 268–286, <https://doi.org/10.1111/jerd.70046>. Published online October.
- [13] M. Ferrari, E. Lettieri, D.I.K. Pontoriero, P. Vallittu, E. Ferrari Cagidiaco, Particulate filler and discontinuous Fiber filler resin composite's adaptation and bonding to intra-radicular dentin, *Polymers (Basel)* 15 (15) (2023) 3180, <https://doi.org/10.3390/polym15153180>.
- [14] R. El Agamy, 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, *Saudi Dent. J.* 36 (3) (2024) 451–455, <https://doi.org/10.1016/j.sdentj.2023.12.003>.
- [15] R.H.A. ElAziz, S.A.A. ElAziz, P.M.A. ElAziz, et al., Clinical evaluation of posterior flowable short Fiber-reinforced composite restorations without proximal surface coverage, *Odontology* 112 (4) (2024) 1274–1283.
- [16] O.I. Saracutu, M. Ferrari, M. Pollis, D. Manfredini, E.F. Cagidiaco, The outcome of prosthodontic treatments in individuals with bruxism and different restoration material. A scoping literature review, *Cranio* 44 (2026) 236–248, <https://doi.org/10.1080/08869634.2025.2477964>.
- [17] Ferrari Cagidiaco E, Saracutu OI, Manfredini D, Ferrari M. The outcome of nanoceramic resin-based material single partial crowns in patients with signs of bruxism. A 7-year retrospective study. *Cranio*. 2026;44(3):571-580. [doi:10.1080/08869634.2025.2569252](https://doi.org/10.1080/08869634.2025.2569252).
- [18] D. Manfredini, The evolution of a field: a challenge and an opportunity, *Cranio* 42 (3) (2024) 251–252, <https://doi.org/10.1080/08869634.2024.2320624>.
- [19] A. Johansson, R. Omar, G.E. Carlsson, Bruxism and prosthetic treatment: a critical review, *J. Prosthodont. Res.* 55 (3) (2011) 127–136, <https://doi.org/10.1016/j.jpor.2011.02.004>.
- [20] M. Ustrell-Barral, C. Zamora-Olave, L. Khoury-Ribas, B. Rovira-Lastra, J. Martinez-Gomis, Relationship between bruxism behaviors and painful and non-painful jaw symptoms in healthy young adults, evaluated using different modes of assessment, *Cranio* 44 (2026) 472–482, <https://doi.org/10.1080/08869634.2025.2548051>.
- [21] N. Stanisic, O.I. Saracutu, A. Colonna, W. Wu, D. Manfredini, B. Häggman-Henrikson, Awake bruxism prevalence across populations: a systematic review and meta-analysis, *J. Evid. Based Dent. Pract.* 25 (3) (2025) 102171, <https://doi.org/10.1016/j.jebdp.2025.102171>.
- [22] S. Kurup, A. Perez-Pino, M. Litt, The association between temporomandibular disorders signs and symptoms, bruxism, and health variables: a cross-sectional study, *Cranio* 43 (2025) 1083–1091.
- [23] M.K.A. van Selms, F. Lobbezoo, The reports of specific waking-state oral behaviours, including awake bruxism activities, and psychological distress have a dose-response relationship: a retrospective medical record study, *Cranio* 43 (6) (2025) 882–893, <https://doi.org/10.1080/08869634.2024.2360865>.
- [24] B. Reda, F. Lobbezoo, L. Contardo, G. Zanon, G. Aarab, D. Manfredini, Association between oral behaviors and generalized anxiety in a sample of university students: a cross-sectional study, *Cranio* 44 (2026) 653–661, <https://doi.org/10.1080/08869634.2025.2591552>.
- [25] L.M. Uehara, J.D.C. Tardelli, A.L. Botelho, M.L. Valente, C. da, A.C. dos Reis, Association between depression and temporomandibular dysfunction in adults - a systematic review, *Cranio* 43 (3) (2025) 461–467, <https://doi.org/10.1080/08869634.2022.2161985>.
- [26] A. Ekman, A. Tiisanoja, R. Näpänkangas, K. Sipilä, Association of health-related factors with self-reported sleep and awake bruxism in Northern Finland Birth Cohort 1966 - a cross-sectional study, *Cranio* 43 (3) (2025) 510–520, <https://doi.org/10.1080/08869634.2023.2198462>.
- [27] H. Hosoya, H. Kitaura, T. Hashimoto, et al., Relationship between sleep bruxism and sleep respiratory events in patients with obstructive sleep apnea syndrome, *Sleep Breath* 18 (4) (2014) 837–844, <https://doi.org/10.1007/s11325-014-0953-5>.
- [28] M. Pollis, F. Lobbezoo, M. Val, M. Ferrari, D. Manfredini, Sleep bruxism and GERD correlation in a general population convenience sample, *Cranio* 44 (1) (2026) 52–58, <https://doi.org/10.1080/08869634.2024.2443697>.
- [29] M.R. Markiewicz, R. Ohrbach, W.D. McCall, Oral behaviors checklist: reliability of performance in targeted waking-state behaviors, *J. Orofac. Pain* 20 (4) (2006) 306–316.
- [30] M.J. van der Meulen, F. Lobbezoo, I.H. Aartman, M. Naeije, Validity of the oral behaviours Checklist: correlations between OBC scores and intensity of facial pain, *J. Oral Rehabil.* 41 (2) (2014) 115–121, <https://doi.org/10.1111/joor.12114>.
- [31] C. Barbosa, M.C. Manso, T. Reis, T. Soares, S. Gavinha, R. Ohrbach, Cultural equivalence, reliability and utility of the portuguese version of the Oral Behaviours Checklist, *J. Oral Rehabil.* 45 (12) (2018) 924–931, <https://doi.org/10.1111/joor.12716>.
- [32] B. Reda, F. Lobbezoo, A. El-Outa, M. Ismail, G. Aarab, D. Manfredini, Translation and cultural adaptation of an arabic version of the OBC-21, *Cranio* 44 (2026) 483–489, <https://doi.org/10.1080/08869634.2025.2548436>.
- [33] N.T. Yildiz, H. Kocaman, H. Bingöl, Validity and reliability of the turkish version of the oral behaviors checklist, *Oral Dis.* 30 (6) (2024) 4014–4023, <https://doi.org/10.1111/odi.15059>.
- [34] S. Hopewell, A.W. Chan, G.S. Collins, et al., CONSORT 2025 statement: updated guideline for reporting randomized trials, *Nat. Med.* 31 (6) (2025) 1776–1783, <https://doi.org/10.1038/s41591-025-03635-5>.
- [35] Y.M. Gonzalez, E. Schiffman, S.M. Gordon, et al., Development of a brief and effective temporomandibular disorder pain screening questionnaire: reliability and validity, *J. Am. Dent. Assoc.* 142 (2011) 1183–1191.
- [36] M. Fráter, L. Lassila, G. Braunitzer, P.K. Vallittu, S. Garoushi, Fracture resistance and marginal gap formation of post-core restorations: influence of different fiber-reinforced composites, *Clin. Oral Investig.* 24 (1) (2020) 265–276, <https://doi.org/10.1007/s00784-019-02902-3>.
- [37] D. Manfredini, J. Ahlberg, G. Aarab, et al., The development of the Standardised Tool for the Assessment of bruxism (STAB): an international road map, *J. Oral Rehabil.* 51 (1) (2024) 15–28, <https://doi.org/10.1111/joor.13380>.
- [38] D. Manfredini, J. Ahlberg, G. Aarab, S. Bender, A. Bracci, P.A. Cistulli, P.C. Conti, R. De Leeuw, J. Durham, A. Emodi-Perlman, D. Ettlin, L.M. Gallo, B. Häggman-Henrikson, C. Hublin, T. Kato, G. Klasser, M. Koutris, G.J. Lavigne, D. Paesani, I. Peroz, F. Lobbezoo, Standardised tool for the assessment of bruxism, *J. Oral Rehabil.* 51 (1) (2024) 29–58, <https://doi.org/10.1111/joor.13411>.
- [39] D. Manfredini, J. Ahlberg, G. Aarab, A. Bracci, J. Durham, D. Ettlin, L.M. Gallo, M. Koutris, P. Wetselaar, P. Svensson, F. Lobbezoo, Towards a standardized tool for the assessment of bruxism (STAB)-overview and general remarks of a multidimensional bruxism evaluation system, *J. Oral Rehabil.* 47 (5) (2020) 549–556, <https://doi.org/10.1111/joor.12938>.
- [40] Á.F. Cascales, A.A. Murillo, R. Ferrando Cascales, et al., Revolutionizing restorative dentistry: the role of polyethylene Fiber in biomimetic dentin reinforcement-insights from In vitro research, *J. Funct. Biomater.* 16 (2) (2025) 38.

- [41] J. Juloski, M. Beloica, C. Goracci, N. Chieffi, A. Giovannetti, A. Vichi, Z. R. Vulicevic, M. Ferrari, Shear bond strength to enamel and flexural strength of different fiber-reinforced composites, *J. Adhes. Dent.* 15 (2) (2013) 123–130, <https://doi.org/10.3290/j.jad.a28362>.
- [42] S. Jafarinia, A. Valanezhad, S. Shahabi, S. Abe, I. Watanabe, Physical and mechanical characteristics of short fiber-reinforced resin composite in comparison with bulk-fill composites, *J. Oral Sci.* 63 (2) (2021) 148–151, <https://doi.org/10.2334/josnurd.20-0436>.
- [43] K. Bosso, A. Gonini Júnior, R.D. Guirardo, S.B. Berger, M.B. Lopes, Stress generated by customized glass fiber posts and other types by photoelastic analysis, *Braz. Dent. J.* 26 (3) (2015) 222–227, <https://doi.org/10.1590/0103-6440201300256>.
- [44] G.S. Amarnath, M.U. Swetha, B.C. Muddugangadhar, R. Sonika, A. Garg, T.R. Rao, Effect of post material and length on fracture resistance of endodontically treated premolars: an In-vitro study, *J. Int. Oral Health* 7 (7) (2015) 22–28.
- [45] G.M. Gomes, O.M. Gomes, A. Reis, J.C. Gomes, A.D. Loguerio, A.L. Calixto, Effect of operator experience on the outcome of fiber post cementation with different resin cements, *Oper. Dent.* 38 (2013) 555–564, <https://doi.org/10.2341/11-494-L>.
- [46] P.K. Vallittu, Are we misusing fiber posts? Guest editorial, *Dent. Mater.* 32 (2) (2016) 125–126, <https://doi.org/10.1016/j.dental.2015.11.001>.
- [47] M. Fráter, J. Grosz, A. Jakab, et al., Evaluation of microhardness of short fiber-reinforced composites inside the root canal after different light curing methods - an in vitro study, *J. Mech. Behav. Biomed. Mater.* 150 (2024) 106324, <https://doi.org/10.1016/j.jmbbm.2023.106324>.
- [48] F. Lobbezoo, A personal perspective on the association between bruxism and dental occlusion, *Cranio* 43 (3) (2025) 369–370, <https://doi.org/10.1080/08869634.2025.2453378>.
- [49] D. Manfredini, N. Landi, M. Romagnoli, M. Bosco, Psychic and occlusal factors in bruxers, *Aust. Dent. J.* 49 (2) (2004) 84–89, <https://doi.org/10.1111/j.1834-7819.2004.tb00055.x>.
- [50] D.J. Rinchuse, S. Kandasamy, D. Manfredini, Canine Protected Occlusion - evidence-based clinical guidance, *Cranio* 44 (2026) 445–452, <https://doi.org/10.1080/08869634.2025.2536784>.
- [51] O.I. Saracutu, M. Pollis, A. Bracci, M. Ferrari, D. Manfredini, Relationship between cigarette smoking and awake bruxism: does smoking increase the frequency of masticatory muscle activities? *J. Oral Rehabil.* 52 (5) (2025) 667–677, <https://doi.org/10.1111/joor.13947>.
- [52] J. Ahlberg, F. Lobbezoo, C. Hublin, M. Piirtola, J. Kaprio, Smoking cessation is not associated with a decline in reported sleep bruxism in middle-aged Finnish twins: data revisited, *J. Oral Rehabil.* 51 (1) (2024) 117–118, <https://doi.org/10.1111/joor.13524>.
- [53] M. Pollis, F. Lobbezoo, O.I. Saracutu, A. Colonna, D. Manfredini, Psychological distress: a mediating factor in the relationship between sleep bruxism and tobacco smoking, *J. Oral Rehabil.* 52 (9) (2025) 1267–1274, <https://doi.org/10.1111/joor.13978>.
- [54] O.I. Saracutu, D. Manfredini, A. Bracci, M. Val, M. Ferrari, A. Colonna, Comparison between ecological momentary assessment and self-report of awake bruxism behaviours in a group of healthy young adults, *J. Oral Rehabil.* 52 (3) (2025) 289–295, <https://doi.org/10.1111/joor.13895>.
- [55] A. Colonna, D. Manfredini, A. Bracci, O.I. Saracutu, M. Ferrari, F. Lobbezoo, The determination of patient-based experiences with smartphone-based report of awake bruxism using a diary, *Clin. Oral Investig.* 29 (1) (2025) 40, <https://doi.org/10.1007/s00784-024-06114-2>.
- [56] A. Colonna, A. Bracci, D. Manfredini, Bracing: the hidden side of the moon, *Cranio* 43 (5) (2025) 711–713, <https://doi.org/10.1080/08869634.2025.2472087>.
- [57] O.I. Saracutu, M. Pollis, L. Bulferi Bulferetti, E. Kaya, E. Ferrari Cagidiaco, M. Ferrari, A. Colonna, D. Manfredini, Comparison between two different registration protocols for the count of sleep bruxism events in a sample of healthy individuals, *Clin. Oral Investig.* 29 (7) (2025) 365, <https://doi.org/10.1007/s00784-025-06394-2>.
- [58] T. Yamaguchi, S. Mikami, M. Maeda, T. Saito, T. Nakajima, W. Yachida, A. Gotouda, Portable and wearable electromyographic devices for the assessment of sleep bruxism and awake bruxism: a literature review, *Cranio* 41 (1) (2023) 69–77, <https://doi.org/10.1080/08869634.2020.1815392>.
- [59] M. Takahashi, T. Yamaguchi, S. Mikami, M. Saito, T. Nakajima, M. Maeda, T. Saito, Number of masseteric electromyographic waveforms during analysis periods with/without excluding time zones after going to bed and before getting up in sleep bruxism assessment, *Cranio* 44 (2026) 184–195, <https://doi.org/10.1080/08869634.2025.2473728>.
- [60] A. Colonna, F. Lobbezoo, G. Gravili, L. Lombardo, J. Ahlberg, D. Manfredini, Effects of orthodontic aligners on 24-hour masseter muscle activity: a multiple-day electromyographic study, *Cranio* 43 (5) (2025) 817–826, <https://doi.org/10.1080/08869634.2024.2357054>.
- [61] T. Gotti, I. De Rubertis, O.I. Saracutu, M. Ferrari, N. Discepoli, D. Manfredini, Electromyographic assessment of sleep bruxism in patients with periodontitis: a case-control study, *Oral Dis.* 32 (2026) 1128–1138, <https://doi.org/10.1111/odi.70186>.
- [62] W. Bömicke, M. Schmitter, M. Waldecker, R. Handermann, C. Labis, P. Rammelsberg, B. Ohlmann, Ceramic crowns and sleep bruxism: 3-year results of a randomized controlled trial, *J. Dent.* 170 (2026) 106691, <https://doi.org/10.1016/j.jdent.2026.106691>.