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Posterior partial crowns out of lithium disilicate (LS2) with or without posts: A randomized controlled prospective clinical trial with a 3-year follow up

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ABSTRACT

Objectives: The objective of this randomized controlled trial was to assess the influence of use of posts as well as the type of posterior tooth (premolars vs molars) for the treatment with lithium disilicate (LS2) partial crowns.
Materials and methods: A total of 60 patients were treated with posterior LS2 partial crowns. Two groups (n = 60) were made based on the type of restored tooth: Group 1, premolars and Group 2, molars. The samples of each group were divided into 2 subgroups (n = 30): Subgroup A restored with fiber posts and Subgroup B without them. Clinical and intraoral radiographic examinations were assessed during each recall (6 months and, 1, 2, and 3 years). Kaplan-Meier log-rank test and Cox regression analysis (Pp < 0.05) were applied.
Results: Three subgroups showed 100% of survival while group 2 A exhibited the lowest performance (93.3%). The Cox regression analysis showed that the presence of the post was not a significant factor for survival time (Hazard Ratio HR = 0388; CI95% Confidence Interval for H R = 0,1- to 1,5; pp = 017).

Tooth type had an influence on survival time that was at the limit of statistical significance (Hazard Ratio HR = 0123; CI95% Confidence Interval for HR = 0 0015- to 0997; p = 005). Particularly, failure risk was greater for premolars. 'Post by tooth type' interactions were not statistically significant (p = 0126).
Conclusions: over a 3-year observation period, the clinical performance of endodontically treated teeth restored with lithium disilicate partial crowns was not significantly affected by the use of a fiber post and by the type of tooth (premolars or molars).

1. Introduction

How to restore endodontically treated teeth (ETT) is still an issue in dentistry. The question if full or partial crowns can be used, in combination with the placement of a post or not, is rising from daily practice.

Restoration of ETT is well documented to be performed by luting fiber posts into root canals. Fiber posts are most commonly used because of their favorable physical properties and excellent biocompatibility [1,2].

Clinical effectiveness of ETT restored with fiber posts and composite core combinations has been widely investigated evaluated and proved over the past 20 years. Although high rate of survival and acceptable clinical behavior were reported, all the available randomized clinical trials (RCT) were mainly related to single full crowns luted on premolars [3–8].

However, no RCT are available on single crowns on molars and on using esthetic partial crowns luted on posterior teeth as well after being restored with or without posts.

Lithium disilicate material was proposed to restore anterior and posterior teeth in need of partial or/and full single crowns [9,10]. Lithium disilicate is available in two different formulations, pressed (e.max press, Ivoclar) and in block for CAD-CAM (e.max cam, Ivoclar) chairside procedures [9–11]. More recently, a new lithium disilicate material was proposed into the market (LiSi Press, GC) and it showed similar properties of e.max [12].

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Therefore, the aim of this clinical study trial was to assess evaluate the clinical performances of lithium disilicate partial crowns used to restore endodontically posterior teeth, built up with or without fiber post and to evaluate if differences were found between molars and premolars.

The null hypothesis tested was that the use of the post and the type of the tooth had no effect on the three-year survival of ETT restored with single partial crowns.

2. Materials and methods

2.1. Study design

In total, 120 patients who consecutively presented from the pool of patients accessing the Department of Prosthodontics and Dental Materials of the University of Siena-Italy for receiving endodontic treatment and single-unit partial crown restoration of posterior teeth participated in the study. The study population consisted of 55 men and 45 women (age range, 18 to 69 yr). After receiving clear information about the purpose of the trial, according to a preliminarily approved protocol, all patients provided written, informed consent before entering the study and the approval of ethical committee was obtained (ClinicalTrials.gov number CT01532947). Only one tooth in each patient was considered. In total, 120 teeth, 56 maxillary and 64 mandibular teeth, equally divided in molars and premolars, with at least 50% of remaining coronal structure, were selected for the study, creating two cohorts of 50 teeth each. The inclusion criteria – occlusal function with a natural tooth and an interproximal contact with 2 adjacent natural teeth – had to be met by the selected teeth (Table 1). In order to avoid bias, tThe calculation evaluation of the remaining coronal structure was done made after the abutment preparation and only ETT with 50% or more coronal residual structure were included in the study. Radiographs made at the baseline of the teeth included in the study did not show any signs of periapical lesions.

The two groups (n = 60) were randomly defined according to the placement of a fiber post or not to build up the abutments.

Group 1 – ETT restored with a post

Group 2 – ETT restored without a post

Each Group was divided in two Subgroups accordingly with type of tooth: Subgroup A = premolars; Subgroup B = molars.

Within each group, in half of the teeth (Group 1; n = 60), fiber posts (GC Fiber Post; GC Corp., Tokyo, Japan) were luted using a dual-cured composite for core build-up and post luting (Gradia Core, GC Co.), whilst the half of the teeth (Group 2) were restored without post.

In order to assign teeth to each group, randomization was dome using a Microsoft Excel Mac 2011, (Office 365) spreadsheet (DISTRIB.BETA.N). When premolars of Group 1 had 2 roots, only 1 post was placed. In all samples, a single-unit lithium disilicate partial crowns was luted (LiSi Press, GC Co.).

Table 1
Inclusion and exclusion criteria.

Inclusion criteria
-Males and females aged 18-70 years in good general and periodontal health were included.
-No periodontal untreated diseases.
-In need for at least one partial crown on posterior teeth (molars and premolars) after being endodontically treated.
−50% or more coronal residual structure.
Exclusion criteria
Patients with the following factors were excluded from the clinical trial: 1. Not proper age (< 18 years); 2. Pregnancy; 3. Disabilities; 4. Potential prosthodontic restoration of the tooth; 5. (Profound, chronic) periodontitis; 6. Heavy occlusal contacts or history of bruxism; 7. Systemic disease or severe medical complications; 8. Allergic history concerning methacrylates; 9. Rampant caries; 10. Xerostomia; 11. Lack of compliance; 12. Language barriers; 13. Plaque index higher than 20.

All restorations were performed luted between May 2015 and October 2015 by a single experienced operator (M.F.), with expertise on both endodontics and prosthodontics.

2.2. Clinical procedures

2.2.1. Endodontic treatment (Group 1 and 2)

Canal instrumentation was perfomed with K-files (8-10-15; Dentsply Maillefer) and Flexmaster rotary instruments (15-20-25-30-35-40; VDW) mounted on the endodontic motor (Endo IT professional; Aseptico) to a working length of 0.5 mm from the apex. Then, Irrigation with 5.25% sodium hypochlorite using a long 27-gauge needle at each change of instrument was done and the final rinse with deionized water and patency of the canal maintained with a No. 10 K-file. Canals were dried with multiple paper points and the obturation made with gutta-percha using the continuous wave technique up to 4 to 5 mm from the apex with a System B heat source (SybronEndo). The canals were backfilled with termoplastic gutta-percha using the Obtura II Unit (Obtura Co.). Finally, the canal access was filled with glass-ionomer cement (Fuji IX; GC Corp.)

2.2.2. Post space preparation (Group 1)

In Group 1, at least 24 h after endodontic treatment, the post space was prepared 7–8 mm in depth with precalibrated drills provided by the manufacturer (GC Fiber Post, GC Corp.), and at least 4 mm of intact apical seal were left. The best post was selected to well fit the diameter of the canal (diameter of the post 1.2 mm, 1.4 mm or 1.6 mm) and the post was calibrated to the post space shortening it with a diamond bur. The post surface was pretreated with a silane coupling agent (GC Ceramic Primer, GC Co.)

2.2.3. Fiber post cementation (Group 1)

Then, the Self-Etching Bond and the Gradia Core luting material (GC Co.) were used strictly following manufacturer's instructions in order to lute the post into the canal. The bonding was applied inside the post space and on the residual coronal structure, left undisturbed for 30 s, gently air-dried, and light-cured for 10 s in a visible-light-curing unit (GC Light, GC Co.). Gradia Core was dispensed into the prepared root canal through an Automix Endo tip. The post was inserted, possible excess was removed, and then light-cured (5 s) to fix it.

2.2.4. Build up of abutments (Group 1 and 2)

The coronal structure was etched with 37% phosphoric acid for 15 s, washed and air-dried. G-Premio Bond universal bonding system (GC Co.) was applied and then air-dried, light cured for 20 s and Gradia Flow (GC Co.) was applied in several layers of approximately 1 mm thickness and light cured for 20 s.

2.2.5. Crown preparation (Group 1 and 2)

The partial crown preparation was designed to cover occlusal cusps and with one or two interproximal boxes based on the height and thickness of the remaining dentin (Fig. 1A with post and B without post).rp

Cavities' preparation provided at least 0.5–1 mm space at the margin and 1.0–1.5 clearance occlusaly and box(es) were placed interproximally. Margins were mainly into enamel (only interproximal box may have cervical margin on dentin-cementum). After the final preparation, a traditional impression (Ex'llence, GC Co.) of the prepared tooth was taken and sent to the laboratory, pured in stone (FujiRock, GC Co.) and then waxed and pressed in lithium disilicate.

Group 1: In Gradia Core Self- Etching Bond was applied after dispensing one drop of Liquid A and B into the dispensing dish, where it was mixed thoroughly for 5 s with the micro-tip applicator. The mixture was applied inside the post space and on the residual coronal structure, left undisturbed for 30 s, gently air-dried, and light-cured for 10 s in a visible-light-curing unit (GC Light, GC Co.). Gradia Core (GC Corp.) was

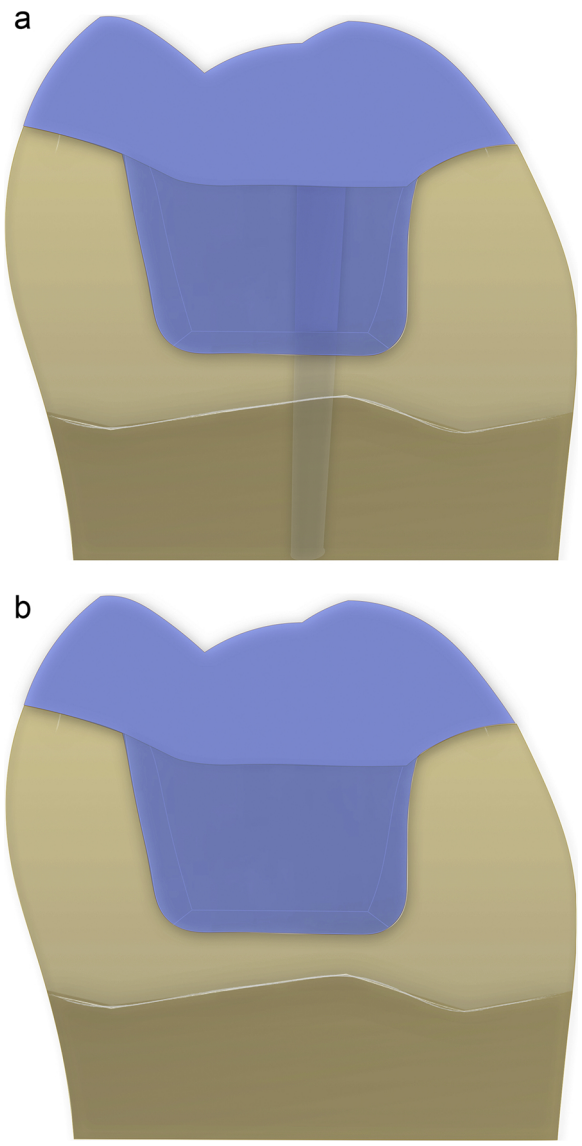

Fig. 1. Diagram of the partial crown covering endodontically treated tooth restored with (A) and without (B) post.

dispensed into the prepared root canal through an Automix Endo tip. The post was inserted and light-cured (5 s) to fix its position temporarily. The paste was then dispensed around the post to form the core. Light- curing from the vestibular and lingual sides (10 s each side) was performed for final setting.

Group 2: The root chamber was filled with Gradia Flow (GC Corp.) in layers of approximately 1 mm in thickness till the abutment build-up was completed.

The partial crown preparation was designed to cover occlusal cusps and with one or two interproximal boxes depending on the height and thickness of the remaining dentin.

Single-unit lithium disilicate partial crowns were fabricated (LiSi Press, GC Corp.) sandblasted, etched with fluoridric acid 10% for 1 min, washed, air-dried and silanized with MultiPremier (GC Corp.) and luted with proprietary's resin cement (LinkForce, GC Corp.) strictly following manufacturer's instructions.

2.3. Follow up

All patients were enrolled in an oral hygienist recall program every 6 months and annual follow-up. Clinical and intraoral radiographic examinations were performed made at baseline (after luting the crown) immediately and after one, two and three year of loading (follow-up).

2.4. Evaluation parameters

Success and survival rate were based on clinical and intra-oral radiographic examinations at each follow-up after (6, 12, 24, and 36 mo). Periapical radiographs were taken with the modified parallel technique and Ultra- Speed films (Eastman Kodak Company, Rochester, NY, USA), and examined at 5x magnification. Evaluation was performed independently by two blinded, well- trained examiners (EFC and RSSG), other than the operator who had carried out the restorative treatment. The following parameters were considered as failures: [1] post debonding [2], post fracture [3], vertical or horizontal root fracture [4], crown dislodgement [5], crown fracture [6], periapical lesions not requiring endodontic re-treatment (because no clinical symptoms were reported and the radiographic sign of the present lesion at the baseline was still present but reduced in size and consequently was considered to be under healing process), and [7] periapical lesions requiring endodontic re-treatment. These occurrences were then categorized as 'relative' or 'absolute' failures. Root fractures leading to tooth extraction, crown fracture and periapical lesion requiring retreatment were considered as 'absolute' failures. Success was defined as the outcome in the absence of absolute and relative failures, while survival was defined as the outcome in the absence of absolute failures [13]. The CONSORT (Consolidated Standards of Reporting Trials) flow diagram is reported.

2.5. Statistical analysis

For descriptive purposes, Kaplan-Meir log-rank test was constructed. The Cox regression analysis was applied in order to assess the influence on failure rate of the presence or absence of the post, as well as of the type of restored tooth. The level of significance was set at = 0.05, and statistical calculations were handled with SPSS software (SPSS Inc., Chicago, IL, USA).

3. Results

Results of this clinical trial are reported in Table 2. Data were not affected by any loss at follow-up. The overall 3-y survival rate of ETT restored with fiber post (Group 1) or without post on molars (SubGroup B) was 100%. Teeth with post had no mechanical complications, whilst only premolars (Group 2, SubgGroup A) without posts showed 2 mechanical failures due to fracture of the abutment and root after two years. In all SubGroups several biological complications (periapical lesions) were reported. However, because periapical lesions were detected at one recall by X-Ray but in absence of clinical symptoms, no teeth were endodontic retreated. Table 3 reports survival and success rates after a 3-y observation period in the two experimental groups. For descriptive purposes, Kaplan-Meier plots were constructed (Fig. 2A, B). The Cox regression analysis showed that the presence of the post was not a significant factor for survival time (Hazard Ratio HR = 0388; 95% Confidence Interval for HR = 0,1 to 1,5; p = 017). Tooth type had an influence on survival time that was at the limit of statistical significance (Hazard Ratio HR = 0123; 95% Confidence Interval for HR = 0015 to 0997; p = 005). Particularly, failure risk was greater for premolars. 'Post by tooth type' interactions were not statistically significant (p = 0126).

4. Discussion

The findings of this clinical trial show that the risk of failure in ETT restored with partial crowns was not significantly influenced affected by the type of posterior tooth that was restored during 3-y of clinical service. Also, the survival analysis did not show statistically significant

Table 2
Recall rates, failure modes, survival rates and success rates recorded in experimental groups over 36-months observation period. PAL = periapical lesion without need of retreatment; RoFr = root fracture.

Residual coronal dentin	Type of restorations/teeth		Baseline	6 months	12 months	24 months	36 months
Group 1: Post	**SubGroup A. Premolars**	**Recall rate**	30/30 (100%)				
		Cause and % of failure	0/30 (0%)	*1 PAL* 1/30 (3.3%)		*1 PAL* 2/30 (3.3%)	
		Success rate	30/30 (100%)	29/30 (96.6%)		28/30 (93.3%)	
		Survival rate	30/30 (100%)	30/30 (100%)		30/30 (100%)	
	SubGroup B. Molars	**Recall rate**	30/30 (100%)				
		Cause and % of failure	0/30 (0%)	0/30 (0%)	*1 PAL* 1/30 (3.3%)	*1 PAL* 1/30 (3.3%)	*2 PAL* 2/30 (6.6%)
		Success rate	30/30 (100%)	29/30 (96.6%)	29/30 (96.6%)	29/30 (966%)	28/30 (93.3%)
		Survival rate	30/30 (100%)	30/30 (100%)	30/30 (100%)	30/30 (100%)	30/30 (100%)
Group 2: No Post	**SubGroup A. Premolars**	**Recall rate**	30/30 (100%)				
		Cause and % of failure	0/30 (0%)		*1 PAL* 3/30 (10%)	*2PAL* *2 RoFr* 4/30 (13.3%)	*2 PAL* *2 RoFr* 4/30 (13.3%)
		Success rate	30/30 (100%)		27/30 (90%)	26/30 (866%)	26/30 (86.6%)
		Survival rate	30/30 (100%)		30/30 (100%)	30/30 (100%)	28/30 (93.3%)
	SubGroup B. Molars	**Recall rate**	30/30 (100%)				
		Cause and % of failure	0/30 (0%)	0/30 (0%)	0/30 (0%)	*1 PAL* 1/30 (3.3%)	*1 PAL* 1/30 (3.3%)
		Success rate	30/30 (100%)	30/30 (100%)	30/30 (100%)	29/30 (96.6%)	29/30 (96.6%)
		Survival rate	30/30 (100%)	30/30 (100%)	30/30 (100%)	30/30 (100%)	30/30 (100%)

differences among the groups. For that, the null hypothesis was accepted.

Also, this study trial shows the satisfactory overall 3-y survival rate of ETT in posterior regions restored with or without fiber posts and lithium disilicate partial crowns regardless of the type posterior tooth when all samples teeth had a similar amount of at least 50% of coronal residual structure.

These data are new clinical information on how restore posterior ETT. Previously no data were available till now when ETT where restored with partial crowns [6–8,14–17] but mainly was reported on the clinical performances of fiber post-restored teeth with full crowns.

The survival of teeth ranged between 100% (sub-group 1 A, 1B, 2B) and 93.3% (in sub-group 1B). Only when a premolar was restored without using a fiber post, irreversible failures were recorded in two cases, although there were not statistically significant differences among the two groups. All these failures on sub-group 1B were premolars part of group lateral guidance movements; although there is no data on the role of occlusion on restored ETT, and also considering the limited clinical service reported in this RCT, it might be speculated that the use of a fiber post on premolars in particular when these teeth are part of lateral group guidance of lateral movements is suggested.

Root fractures were observed in sub-group 1B for the first time after 2 years of clinical loading; the % percentage of irreversible failures recorded in this study was low when compared to previously reported RCTs [6,7,18] in which a higher rate was recorded. It was previously confirmed that higher incidence of failures was recorded as the observation time increased [6,7,18]. Throughout 3 years of clinical service, 2 teeth of 120 (2.5%) were extracted in sub-group 1B. A longer observation time of the samples of this RCT is already planned in order to observe possible other failures or confirm these promising results.

In this RCT, accordingly with the esthetic need of patients, all restored teeth were restored with a luted lithium disilicate partial crown. Because of the protocol, the degree of hard tissue loss was less than 50% of coronal residual structure. The literature reports that prosthetic restorations placed on posterior teeth with a higher degree of tissue loss had at least 2 times higher risk of failure compared to teeth with more tooth structure at the coronal level in vitro [19–21] and in clinical studies [6,7,16,18,22] pointing out that more coronal structure remained, more positive prognosis of ETT can be expected. The results of this clinical trial cannot be transferred to posterior teeth with a loss of coronal structure higher than 50%. Also, it must be considered that it was reported that posterior teeth in need to be treated endodontically show a severe loss of coronal structure in 70% of cases [23].

In the past, only few previous studies articles [6–8] reported about the amount of coronal tooth residual structure after the abutment preparation. Other clinical trials were published in this topic [6,16,24–27] calculated the residual tooth coronal structure before the abutment preparation, which may have determined an overestimation of the amount of tissues remained at the coronal level. In one study, the teeth were categorized according to the expected dentin height after tooth preparation, which in fact represented a prediction made by the operator [18]. In order to avoid bias due to the possible overestimation of the residual coronal structure, it was mandatory to make the calculation of the remaining tooth structure only after the abutment preparation. However, the findings of this study confirmed that the amount of coronal residual structure is a key point when ETT must be restored.

In this study all restorations were luted adhesively. The dental substrate was etched and bonded, the internal surface of the lithium disilicate was etched and silanized and then the crown was luted under rubber dam. The role of etching-bonding-luting procedures might have an important role to adsorb occlusal forces and to protect the ETT from occlusal stress [28].

No RCTs are available on anterior ETT restored with or without posts. The results of this study cannot be extrapolated to anterior teeth.

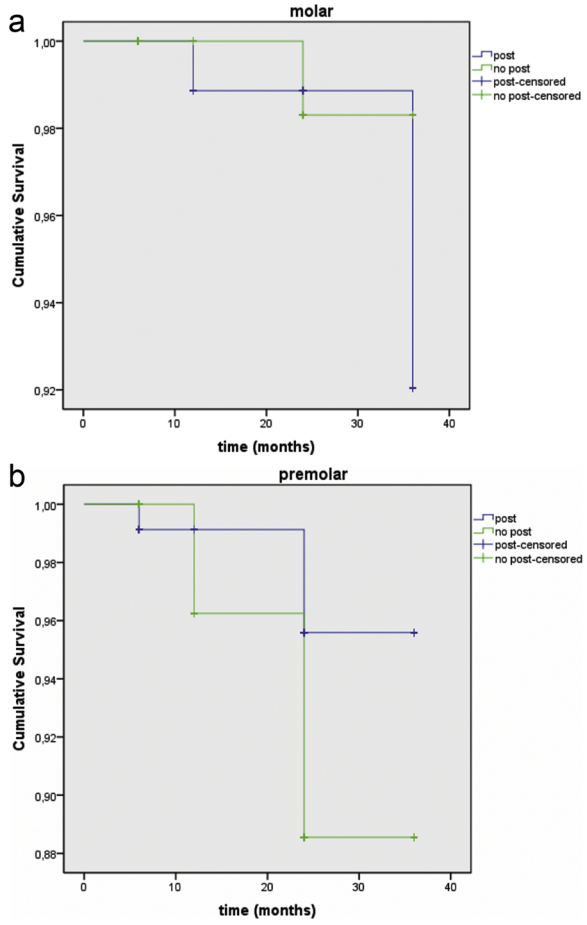

Fig. 2. Kaplan-Meier survival plots (log-rank test, $P < 0.05$). (1**A**) Molar survival. (**B**) Premolar survival.

Anterior teeth are exposed to forces creating tension stress during lateral and protrusive movements whilst posterior teeth are affected much more by perpendicular compressive forces. For that it can be speculated that maxillary anterior teeth are more exposed to possible failures [1,4,29], and consequently further similar clinical studies evaluating the performance of ETT in the anterior region restored with and without fiber posts and covered by partial crowns versus full crowns are needed.

In absence of clear and documented indications about how to prepare partial crowns on ETT, the design of the partial crowns used in this study provided a complete covering of the cusps and to create one or two boxes interproximally, in order to create a ferrule [30], recreate adequate interproximal contact points [31,32] and to stabilize the partial crown during the luting procedures [32].

It must be point out the possible limitations could have influenced the present study: the limited number of samples, the relatively short observation period, only teeth with no periodontal disease and no parafunctions selected, and the sample size calculation was omitted.

5. Conclusions

From the findings of this randomized clinical trial, it can be concluded that over a 3-y observation period, the clinical performance of ETT restored with lithium disilicate partial crowns was not significantly affected by the use of a fiber post and by the type of tooth (premolars or molars).

In order to provide stronger evidence, longer-term data will be collected through further recalls.

Disclosure statement

The authors declare that there are no conflicts of interest.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.jdent.2019.01.004.

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