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Survival of hollow metal post-retained restorations: A long term clinical follow-up

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ABSTRACT

Aim Aim of the research was to evaluate the long term results of an innovative system for the restoration of endodontically treated teeth.

Material and methods A prospective evaluation was performed on 246 post and core build-ups. A total of 189 patients (57 lost) underwent clinical and radiological follow up from 1 up to 11 years. Tooth shape, post length and the presence of prosthetic crowns were recorded. Causes of failure considered were: root fracture, build-up detachment, restoration fracture, marginal infiltration and post fracture. The proposed restorative technique exploits the resin cement injection through a metal cylinder placed into the post space. The carrier was incorporated into the composite after polymerization.

Results The statistical analysis showed how the global success rate of the technique is 96.8%. The failures were caused by marginal infiltration (2,65%) or core fracture (0.53%). The Cox regression shows that success is not related to post length (p=0.786) nor to the prosthetic crown (p=0.120). In the upper jaw the success was statistically related to the presence of the crown (p=0.47). Hazard ratio curves, related to the shape of treated teeth, underlined how premolars and molars are characterized by a higher risk of fracture when compared to incisors and canines. Log rank test does not gishowves any significant difference between the treated teeth.

Conclusion The follow-up results highlighted a low incidence of failures of the procedure. The presence of prosthodontic crowns increases the success rate.

KEYWORDS Follow-up; Hollow post; Metal carrier; Post-endo restoration.

INTRODUCTION

Post-endodontic restorations using fiber posts cemented with light-cured composite resins are believed to possess mechanical properties ensuring the best possible distribution of masticatory stress and reducing the risk of fractures (1,2). The literature demonstrates that the insertion of fiber posts can improve the survival of endodontically treated premolars (3-5).

To ensure long-term success it is necessary to avoid excessive elasticity or deformability of the post, which causes less fatigue resistance of the restoration with possible decementation, fracture, mobilization and infiltration. Conversely, a structural organization with elasticity equal to higher than Young's modulus of dentin (13,3 $\pm$ 4 GPa) allows to create an overall homogeneous restoration, avoiding excessive stress of the adhesive interface or composite (6-8).

Characteristics of the post (length, taper, diameter, material) are predictors of post-endodontic restorations survival (9). The greater the stainless steel posts diameter, the lesser the force required to bring about root fracture, whereas the diameter of fiber posts doesn't have a significant influence on fracture load and stress distribution (10). Even the post surface is an essential feature for the good quality of the adhesive interface (11).

These restorative methods, however, still involve risk factors that contribute to clinical failure, such as detachment related to dissipation of traction/compression forces in the marginal area and the presence of air bubbles in the interface or in the adhesive resin cement (6, 8, 12-14). However, a recent review (15) reported a survival rate of 90% for metal posts while that of fiber posts is 83.9%. The fiber posts resulted in a higher incidence of dentinal crack or micro-fractures than metal posts. Santos et al. reported that the use of fiber posts involves a greater stress on deep structures compared with metal posts, especially when the adhesive bond between the fiber and the canal surface fails (16). Furthermore, prefabricated metal and carbon fiber posts showed a twofold increase in the incidence

rate of fractures compared with gold and fiber glass posts (15).
There is the possibility that the failures are determined not only by the mechanical and structural characteristics of the post but by all components of complex restorative treatment with various mechanisms.
Adhesion varies in relation to dentin interface morphology and quality (presence of debrids and the smear-layer) (17, 18, 19). Several authors reported anatomical variations of dentin tubules both in number and in size, from the coronal root portion to the more apical one (17, 20, 21).
Polymerization shrinkage, the difficulty of polymerization in reaching deeper areas and the dentin humidity control required to apply the adhesive system, are factors to be considered in a post-endodontic restoration (22, 23).
The different elasticity modulus of cement, root dentin, post and composite resin, causes excessive load and stress which are intolerable in the long term (24), which can be clinically detected as the presence of considerable thickness of resin cement.
A good matching between post and post-space diameter improves post retention and stress distribution due to a thin and uniform resin cement layer (25, 26).
The aim of the research is to evaluate, through a clinical-statistical analysis, long-term results of an innovative post-endodontic restoration and its retentive ability using a bonding resin (27).

MATERIALS AND METHODS

Prospective clinical research was carried out on 246 posts for endodontic restorations using the Unicore technique (27).
The analysis included 189 patients, treated by the same operator between 2005 and 2016 at the Department of Dentistry at the University of Messina (Italy). The restorations were followed up for mno less than 1 year and up to 11 years; 57 were considered lost.
The inclusion criteria were endodontically treated tooth with large coronal lesions. For each patient clinical parameters (probing depth, mobility) were recorded and radiological findings (presence of periapical lesions) were examined. Parameters such as type of tooth, depth of insertion of the post and presence of prosthetic finalization were also considered.
The success of the technique was yearly evaluated both clinically and radiographically up to a maximum of 11 years. Cases considered as post restoration failures were those with: root fractures, decementation and fracture of the post, fracture of the core, marginal leakage.
Canal retention (27) was achieved with direct injection of high fluidity dual composite resin (Dentsply Core-X ™ flow) into the canal (from the apical region of the post space) with a steel cylinder acting as carrier and as post

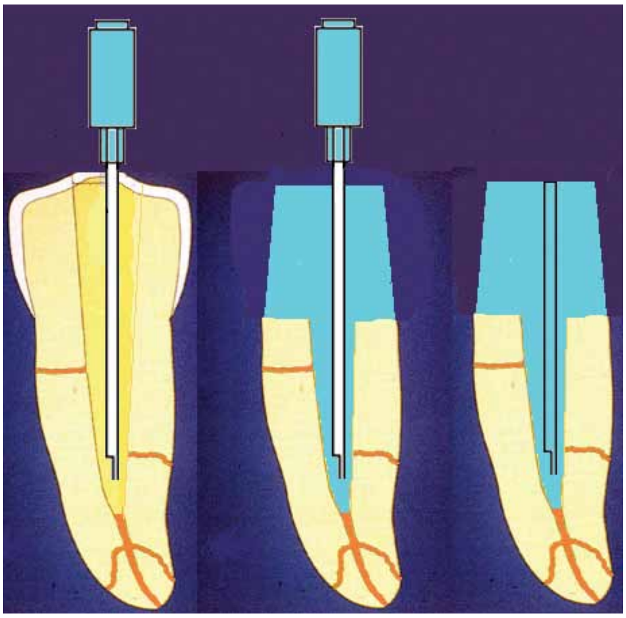


FIG. 1 Composite injection needle/post.

(Fig. 1).
The needle was previously roughened mechanically and etched with hydrofluoric acid at 9%.
The procedure involved the following preliminary operating steps performed under magnification (28, 29, 30).

- Preparation of the post-space using Largo burs # 1 to # 4 extending the preparation up to 5 mm from the working length to ensure the apical seal in gutta-percha.
- Cleaning and removal of debris and smear layer by irrigation with 17% EDTA for 15 seconds and subsequent etching with a 37% phosphoric acid solution with ultrasonic activation (19).
- Application with micro brush of a 3step total-etch adhesive (All-Bond 2® Bisco).

The carrier-needle, connected with the dual cement syringe, was then inserted into the post-space and retracted 1 mm to avoid contact with the root walls. Finally, the direct injection of the dual resin cement was performed.
After self-polymerization, 1-2 light-curing cycles were performed with LED lamp for 10".
The restoration and prosthetic core were finished with conventional procedures.
The prospective evaluation of data was carried out using statistical analysis as detailed below.
Numerical variables (post length and follow-up) were expressed through appropriate indices of position and variability (mean, median, standard deviation, minimum and maximum). Categorical variables (presence of prosthetic crown and clinical success) were expressed as absolute frequencies and percentages. All descriptive statistics were distinguished both by arch and tooth.

The cox regression model was used to evaluate the possible dependence of success in follow-up on two independent variables (length of the post and presence of the prosthetic crown). The regression model was estimated on total data separately by arch.
To describe the follow-up in terms of success/failure of therapy, the Hazard Ratio curve was used, dividing the teeth in 4 groups for each arch: upper/lower incisors, upper/lower canines, upper/lower premolars and upper/lower molars.
Finally, the Log Rank Test was used to assess whether there are statistically significant differences among the target groups considered in the risk functions. Statistical analysis was conducted using SPSS 17.0 for the Windows operating system. A p-value < 0.05 was considered statistically significant.

RESULTS

The descriptive analysis shows that the teeth analyzed were 246: 23 incisors, 15 canines, 113 premolars and 95 molars (Table 1).
In 190 teeth (77.24%) a prosthetic rehabilitation with a single crown (Table 1) was placed.
In the upper jaw the average needle-post length was 6.31 mm (min 3.50 mm - max 10.00 mm), with a mean follow-up of 7.46 years (min 1 year - max 10 years). In the lower jaw the average needle-post length was 5.91 mm (min 2.50 mm - max 9.50 mm), with mean follow-up of 7.72 years (min 1 year- max 11 years) (Table 2). In the maxilla 119 teeth out of 146 were rehabilitated with a prosthetic crown, representing 81.5%. As for lower teeth 71 were rehabilitated with a prosthetic crown out of 100, representing 71% (Table 3)
Success of therapy was evaluated both clinically and radiographically, with follow-up timings varying between 1 and 11 years. (Table 4); in the end 23.2% of patients were lost.
The statistical analysis shows a clinical success rate of 96.8%. Specifically, the success rate of the therapy on upper teeth is 77.4% with only 3 failures (2.1%), of which 2 due to marginal leakage and 1 due to fracture of the core. In the lower jaw, the success rate was 70% with only 3 failures (3%), all due to marginal leakage (Table 5).
The total cox regression model used in our clinical-statistical analysis showed how success, recorded over time, does not appear significantly influenced either by the length of the post, or by the presence of crowns (respectively p = 0.786 and p = 0.120) (Table 6).
Considering the arches individually, it should be noted that in the upper jaw the success rate is not significantly affected by the length of the post (p = 0.681) but is significantly influenced by the presence of crowns (p = 0.047) (Table 6).
For the lower arch, the success rate does not appear

	Direct Restoration	Prosthetic Restoration	Total
Incisors	6	17	23
Canines	6	9	15
Premolars	16	97	113
Molars	28	67	95
Total	56	190	246
Percentage	22.76%	77.24%	

TABLE 1 Teeth analyzed.

	Mean	Median	St. Dev.	Min	Max
Upper jaw					
Lenght	6.31	6.00	1.21	3.50	10.00
Follow-up	7.46	8.00	1.72	1.00	10.00
Lover jaw					
Lenght	5.91	6.00	1.16	2.50	9.50
Follow-up	7.72	8.00	1.96	1.00	11.00

TABLE 2 Needle-post length and follow-up mean time.

	Frequency	Percentage
Upper jaw		
Incisors	17	14.3%
Canines	7	5.9%
Premolars	68	57.1%
Molars	27	22.7%
Total	119	81.5%
Lover jaw		
Incisors	0	0%
Canines	2	2.8%
Premolars	29	40.8%
Molars	40	56.3%
Total	71	71%

TABLE 3 Frequency of teeth with prosthetic rehabilitation.

Follow-up (Years)	Upper teeth	Lower teeth	Total	Failures
1	2	3	5	2
2	1	2	3	0
3	3	2	5	0
4	2	2	4	1
5	15	0	15	0
6	11	6	17	0
7	17	10	27	0
8	24	15	39	1
9	38	26	64	2
10	3	6	9	0
11	0	1	1	0

TABLE 4 Therapy success at different follow-up timings.

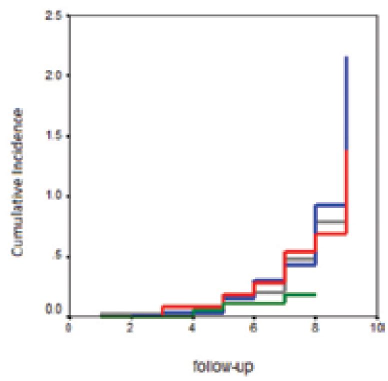
Failure type	Frequency	Percentage
Marginal leakage	5	2.03%
Core fracture	1	0.40%

TABLE 5 Frequency of failure types.

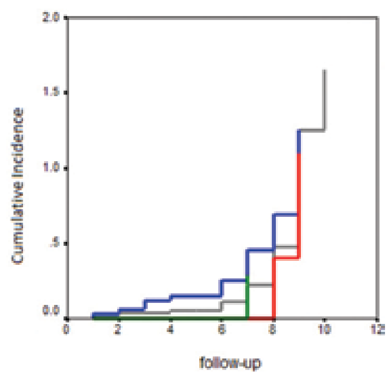
	Mean	Median	St. Dev.	Min	Max	St. Dev.	Min	Max
Upper jaw								
Lenght	.034	.082	.169	1	.681	.967	.823	1.136
Crown	.561	.287	3.807	1	.047	1.752	.997	3.078
Lover jaw								
Lenght	.046	.099	.216	1	.642	.955	.787	1.159
Crown	.046	.277	.028	1	.867	.955	.555	1.643
Total								
Lenght	.017	.062	.074	1	.786	.983	.870	1.111
Crown	.304	.195	2.240	1	.120	1.355	.924	1.988

TABLE 6 Cox Regression.

Upper jaw		
Log rank	Statistic	Significance
	2.71	0.438



Upper jaw		
Log rank	Statistic	Significance
	1.90	0.592



Upper jaw		
Log rank	Statistic	Significance
	5.45	0.141

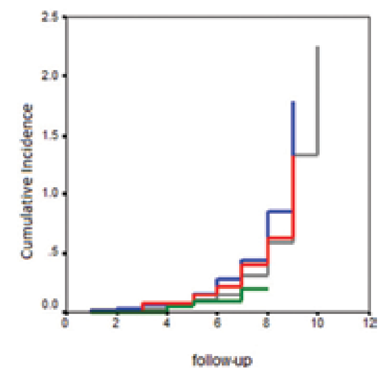


TABLE 7 Hazard Ratio and Log Rank. Test Statistics for Equality of Survival Distributions for groups and total.
LEGEND Groups: Molars, molars-censored; Premolars, premolars-censored; Canines, canines-censored; Incisors, incisors-censored.

significantly influenced either by the length of the post or the presence of crowns (respectively p = 0.642 and p = 0.867) (Table 6).
The risk probability of the 4 groups of teeth are presented in the Hazard Ratio curve.
Risk curves (both for each single arch and in total) tend to overlap as the 4 groups of teeth show a very similar trend. The Log Rank Test, therefore, does not show any significance between groups according to their probability of treatment success (Table 7).

DISCUSSION

Our prospective clinical study has shown a high success rate for the "Unicore" system (96.8%).
The literature about the posts, shows a variable success rate. Cagidiaco et al. (3) reported that the fiber post survival rate was 76.7% while, Zicari et al. (31) reported a higher success rate (97.1%). A prospective study of Ferrari et Aal. (32) reported a failure rate of 8% for carbon fiber posts, while the prospective clinical study by Naumann (33) found failures of 12% for fiber glass posts.
Analyzing studies reporting comparisons of posts, Schmitter et al. (34) showed that the survival rate of fiber posts was 71.8%, while that of metal posts was significantly lower (about 50%, p = 0.26). On the contrary, Sterzenbach et al. (35) in a long-term evaluation between fiber glass posts (low modulus of elasticity) and titanium posts (high modulus of elasticity), found that the survival rate was similar (90.2% for fiber posts vs. 93.5% for those in titanium).
The use of a relatively rigid carrier could be detrimental because of the significant difference between the modulus of elasticity of the filling material retention system and the dentin. Considering the Unicore system success rate, it is reasonable to assume that the carrier

fully incorporated within the resin matrix does not cause excessive loads on root dentin.
Sterzenbach (35) reports case studies in which the reasons for failure are related to: root fracture (3.3%), fracture of the core (1.1%), endodontic failure (3.33%). Zicari (31) identified the following types of failure: root fractures (0.98%), endodontic failure (0.49%), decementation (1.46%) and post fracture (0.49%). In our research, among these failures, 5 cases were due to marginal leakage (2.65%) and 1 case was due to fractured core (0.53%) (Table 5).
The factors that play a decisive role in the survival of an endodontically treated tooth are the type of tooth and its position in the dental arch in relation to the occlusal loads (33, 36), the presence of interproximal contacts (37), the type of final restoration (38), length of and material constituting the post (9).
Our data show that the failures primarily affect molars (5 cases) and incisors (1 case). Although the Log Rank Test logs no statistically significant differences between groups of teeth as regards their probability of success, in assessing the Hazard Ratio curves, premolars and molars have a higher risk of failure than groups of incisors and canines (demonstrated graphically by the thickening of the curves with similar trends).
Then the type of tooth, depending on the magnitude and direction of functional loads, should be considered when evaluating the survival of teeth restored using this method. Horizontal loads cause a higher stress concentration within the dentin than loads parallel to the long axis of the tooth (39-45). Inserting a post improves the stress distribution on dentin (45).
In our prospective evaluation, 77.2% of teeth were rehabilitated with a prosthetic crown, with a higher incidence of premolars (51%). The Cox regression highlights the non-significance of the two independent variables (post length and presence/absence of the prosthetic crown) for the success of our technique. However, considering the dental arches separately, the presence of a prosthetic crown in the upper jaw significantly influences the success of treatment ($p = 0.47$).
According to this hypothesis, the use of a prosthetic restoration results in an increase of fracture resistance of endodontically treated teeth (38, 46-48), while some studies show no improvement in survival (41, 49).
Indeed, the presence of a crown would seem to improve the success rate of teeth with post-endodontic restoration. Vire (48) demonstrated that a prosthetic rehabilitation showed a significant increase in tooth longevity. Aquilino (38) also concluded that the survival of endodontically treated teeth was strongly associated with the presence of a crown and that the failure rate of unrestored teeth was 6 times higher. However, Goracci et al. (50) reported that in groups of teeth with >50% of residual coronal tissues, the success rate for fiber posts was 90% and the survival rate was 100%, while in groups of teeth with a residual crown <50% the success rate was 63.3% and survival rate 86.6%.

CONCLUSIONS

Our follow-up data demonstrate a low incidence of failures of the technique.
The positive results are not influenced by the type of tooth nor by its position and there are no significant differences considering the length of the post. Molars and premolars are at greater risk of failure if not prosthetically restored. However, the presence of crowns significantly improves success only in the upper jaw. It is likely that the application of adhesive resin cement by pressure, using the needle-post, avoids filling defects, usually located at the entrance of the post-space and along the walls of the canal (51). Therefore, the use of dual composites injected into the canal could avoid the presence of air bubbles resulting from polymerization stress (22) or which remain into the resin cements during placement, due to their high viscosity and difficult insertion.
Incorporation of the rigid needle-post in the resin does not seem to be the cause of failures secondary to mechanical stress on the dentin surface, infact our follow-up recorded no root fractures.

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