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ORIGINAL RESEARCH

Resistance to fracture of teeth with weakened roots using posts with and without root filling. A systematic review

Resistencia a la fractura de dientes con raíces debilitadas usando postes con y sin relleno radicular. Revisión sistemática

Katerine Carvajal Cabrales,* Meisser Vidal Madera Anaya,§ Gelen Patricia Bernett Zurita||

ABSTRACT

Teeth with thin root walls exhibit high fracture rate; it is therefore a challenge to find the ideal method to provide them with resistance. To this end, posts, either unfilled or filled with intra-root filling have been used, nevertheless, to this date, no certainty has been established on the differences among these therapeutic options. The main purpose of the present review was to compare evidence results on resistance to fracture of teeth with weakened roots which had been reinforced with either filled or unfilled posts, after being subjected to compressive forces. An electronic search was conducted in different databases (Medline, Embase, PubMed and Ovid). The search was unrestricted with respect to year or language. Aforementioned search produced 148 articles. Each author independently conducted data extraction and quality assessment of each article, following parameters established in calibration (gauging). Finally, seven articles meeting with inclusion criteria were selected. After information collection and analysis, it was concluded that resistance increase in root-weakened teeth was effected when intra-root posts were used, irrespectively of whether these posts had or did not have dentin root reinforcement material.

RESUMEN

Los dientes con paredes radiculares delgadas poseen un alto índice de fractura, por lo que es un reto encontrar el método ideal para proveerles resistencia. Para tal fin se utilizan postes con y sin relleno intrarradicular; pero aún no existe claridad acerca de la diferencia entre estas opciones terapéuticas. El objetivo de esta revisión fue comparar resultados de la evidencia sobre la resistencia a la fractura en dientes con raíces debilitadas reforzadas con postes con y sin relleno, luego de ser sometidos a fuerzas compresivas. Una búsqueda electrónica se realizó en las bases de datos (Medline, Embase, PubMed y Ovid), sin restricción por año o idioma, arrojando 148 artículos. La extracción de datos y la evaluación de calidad de cada artículo se realizaron de forma independiente por cada autor siguiendo los parámetros establecidos en la calibración. Finalmente se seleccionaron siete artículos que cumplieron con los criterios de inclusión. Luego de la recolección de información y análisis, se concluyó que el incremento de la resistencia en dientes con raíces debilitadas se produce con el uso de postes intrarradiculares, aunque indistintamente si están o no acompañados de refuerzo radicular dentinal.

Key words: Resistance to fracture, tooth fracture, tooth's root, non vital teeth.
Palabras clave: Resistencia a la fractura, fractura dental, raíz dental, dientes no vitales.

INTRODUCTION

Dental trauma can cause tooth damage or loss in children and adolescents. Upper anterior zones are the most affected.[1,2] These injuries can cause pulp necrosis in young permanent teeth, and interrupt their root development, since the root reaches final length and configuration four years after tooth eruption, therefore, apexes remain open, and root walls are thin and divergent, forming thus immature, fracture-prone teeth.[3,4]

Several materials and procedures are presently used to reinforce root walls which have become weakened after endodontic therapy. Among these we can count ionomers, resins, posts polyethylene fibers and Resilon®.[5-9] Nevertheless, there is controversy on the subject of ideal treatment selection: clinical data to lead to an optimal treatment is scarce, this would then require a study of different materials used to this end.

Posts are used to to restore teeth with great loss at crown level. Due to their bio-mechanical properties,

* DDS Oral Rehabilitation Specialist, Teacher at the Prosthodontics Department, School of Dentistry, University of Cartagena, Colombia.
§ DDS, Master's Degree in Clinical Epidemiology, Master's Degree in Biochemistry, Researcher at GISPOUC group, School of Dentistry, University of Cartagena, Colombia.
|| DDS, Master's Degree in Dental Sciences (C), School of Dentistry, National University of Colombia, Colombia.

they are recommended as root reinforcement, since their properties allow for the distribution of forces in apical direction as well as increase of tooth resistance.[10-12] Materials such as trans-illumination posts which conduct light to the interior of the root ensure full polymerization and suitable bonding between root dentin and polymeric components of resin materials, achieving thus favorable clinical results in weakened teeth and providing resistance.[13-15]

In order to contribute to the clarification of indicated therapy in these dental circumstances, the present systematic review targeted the comparison of evidence results with respect to fracture resistance in teeth with weakened root walls, reinforced with filled and unfilled posts after having been subjected to compression forces.

MATERIAL AND METHODS

Search strategies

An electronic search of literature in databases such as Medline, PubMed, Embase and Ovid was conducted for the development of the present study. No restrictions with respect to year or language were observed. The following terms were used: «fracture resistance» and «fracture strength» combined with «tooth fracture» «tooth root», «root canal» «immature teeth» «flared walls» «weakened root» and «non-vital tooth».

Selection criteria

In vitro studies were included. These studies assessed resistance to (filled or unfilled) post fractures. Moreover, human permanent upper incisor teeth with thin root dentin walls were used, with laboratory-conducted assessment of forces.

Selected items were individually reviewed, searching for direct relationship with objectives of the present work. Methodological quality was assessed, bearing in mind criteria of scientific evidence weight based on internal validity.

Analysis and data collection

Findings were stored and organized in a digital database, to be later statistically analyzed and processed. Results of selected studies were expressed in different force units such as pounds, kilograms, kilonewtons. For analysis and later comparison all values were converted to Newton units.

The primary measurement to assess materials effect was standard difference of resistance to fracture mean among teeth subjected to compressions. Moreover, standard deviation measurements were used. For difference among means the Wilcoxon non-parametric test was used, assuming confidence intervals of 95% and limit probability values for decision under 0.05. Studies were combined using, for the hypothesis test, the primary estimators heterogeneity test (statistic Q test). All calculations were executed with Stata Corp, version 10.1 software.

RESULTS

148 articles were identified out of which seven met with inclusion criteria requirements. The rest were discarded for reasons shown in *figure 1*. In six of the selected articles, root walls had become weakened by the use of intra-canal rotating burrs, leaving 1 mm thickness.[16-21] One study did not report wall thickness, but root canal diameter was considered *(Table I)*.[22]

Table II shows assessment of methodological quality and research consistency.

A total of 24 groups in seven articles were assessed. In 15 groups, filled posts were examined and in 9 groups unfilled posts were apprised. The average sample size of groups was respectively 9.9 and 9.3 teeth.

With respect to comparability of teeth groups, they exhibited common characteristics with respect to variables such a load speed, wall thickness, type of filling material and post used in both groups.

According to load application speed, in the groups with filled posts, 66.7% force was 1 mm/min, and in 26.7% it was 2 mm/min. In the group with unfilled posts, force was 1 mm/min in 66.7% and 2 mm/min in 33.3%. With respect to wall thickness, walls of groups with filled posts were 1 mm in 33%, 1.5 mm in 13.3% and 2 mm in 13.3%. Distribution was similar in the unfilled post group: 44.4% was 1 mm, 11.1% was 1.5 mm and 22.2% was 2 mm.

With respect to post materials, in the unfilled group, 55.6% were nickel and chromium (NiCr), 33.3% were gold (Au) and 11.1% copper aluminum (CuAl). In the unfilled posts group, 40% used fiber glass, 20% NiCr, 26.7% titanium (Ti) and 6.7% gold (Au). In this group, filling material was resin in 93.3% of cases, and glass ionomer in 6.7%.

According to obtained findings, a fracture resistance mean was found in the group of teeth with unfilled intra-root posts, this mean was 795.8 N (SD = 642.3). In the group of teeth with filled intra-root posts mean was 666.9 N (SD = 332.7). Nevertheless, no statistical significant difference could be established (diff = 128.9; CI = -281.7-539.4 p value: 0.65) *(Table III)*.

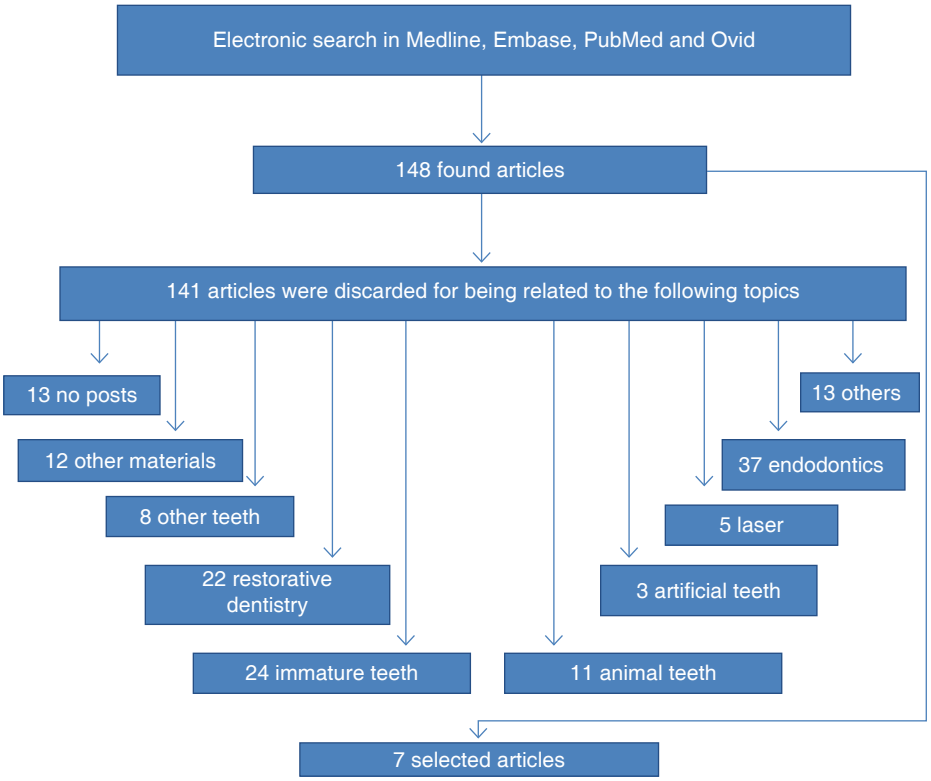

Figure 1.

Search and selection of studies.

Table I. Methodological characteristics of studies.

Author	Teeth	State of crown	Wall thickness	Sample distribution	PL simulation	Dinamometer
Tjan e*t al.*[16]	UC	S-EDL	1 mm 2 mm	**G1:** metallic post Au type IV (1 mm) **G2:** metallic post Au type IV (2 mm)	Yes	0.05 inch x min 30º
Saupe *et al.*[17]	UC	S-EDL	0.5 mm 0.75 mm	**GA:** metallic post Au type III (no splint) **GB:** metallic post Au type III + resin (no splint)	Yes	2 mm x min
Katebzadeh e*t al.*[18]	UC	S-EDL	ND	**G5:** resin + metallic post	ND	2 inch x min
Goncalves e*t al.*[22]	UI	S-EDL	ND Diámeter of root canal 3.2 mm	**CP:** metallic post control copper aluminum **LT:** resin filling + titanium post (TiP) **LF:** transillumination post (TRP)+ filled with resin **LZ:** TRP+ filled with resin + TiP **LR:** TRP+ filled with resin + TiP	No	1 mm x min 135º
Liang e*t al.*[19]	UC	S-EDL	1 mm	**G1:** metallic post NiCr **G2:** metallic post NiCr+ resin	No	2 mm x min 135º
Wu e*t al.*[20]	UI	S-EDL	1 mm	**G0:** metallic post NiCr **G2:** cement resin + post NiCr **G3:** ionomer + post NiCr	Yes	2 mm x min 135º
Kivanç e*t al.*[21]	UI	S-EDL	**1:** 1 mm **2:** 1.5 mm **3:** 2 mm	**L:** resin + fiber glass post **E:** fiber glass post **M:** metallic post NiCr	No	1 mm x min 45º

PL: periodontal ligament; UI: upper incisors; UC: upper centrals; S-EDL: sectioned at enamel-cement limit; ND: no declaration.

DISCUSSION

The main limitations in the present review project were scarcity of articles meeting with inclusion criteria and lack of specific data for some confusing variables. Nevertheless, with methodological analysis of articles, seven articles with similar characteristics were selected. This allowed collection of reliable findings with respect to indicated treatment used to reinforce weakened teeth.

In the present review, no statistically significant differences were found when comparing resistance to fracture of weakened teeth, when using filled or unfilled posts. Carvalho *et al*.,[14] compared walls reinforced with zirconium posts and composite resin. They proved that teeth with weakened walls experienced an increase in fracture resistance when filled or unfilled posts were used. This is a reasonable assumption, since metallic posts confer high resistance to fracture, due to their metallic composition, additionally composite resins

Table II. Assessment of study quality.

Author	Year	Type of study	Sample size	Randomization	Comparable groups	Masked measurement
Tjan et al.[16]	1985	*In vitro*	40	ND	Yes	No
Saupe et al.[17]	1996	*In vitro*	40	Yes	Yes	No
Katebzadeh et al.[18]	1998	*In vitro*	100	Yes	Yes	No
Goncalves et al.[22]	2006	*In vitro*	48	ND	Yes	No
Liang et al.[19]	2007	*In vitro*	12	Yes	Yes	No
Wu et al.[20]	2007	*In vitro*	21	Yes	Yes	No
Kivanç et al.[21]	2009	*In vitro*	165	Yes	Yes	No

ND: not declared.

Table III. Fracture resistance of teeth with weakened walls.

	Filled posts		Unfilled posts	
Author	Sample	Resistance (N)	Sample	Resistance (N)
Wu e*t al.*[20]	7	640	7	370
	7	490		
Kivanç e*t al.*[21]	11	557.82		
	11	593.97	11	1,708.73
	11	838.45	11	1,659.36
	11	562.18	11	1,220.18
	11	708.93		
	11	938.36		
Goncalves e*t al.*[22]	8	520.9		
	8	479.9	8	212.8
	8	391.6		
	8	333.0		
Liang e*t al.*[19]	6	639.3	6	360.8
Katebzadeh e*t al.*[18]	20	578.27		
Saupe e*t al.*[17]	10	1,730.87	10	1,196.41
Tjan e*t al.*[16]			10	216.63
			10	210.85
Mean (SD)	666.9 (332.7)		795.8 (642.3)	
IC = 95%	482.7-851.1		302.1-1,289.5	

N: Newton; *Dif. Means = 128.9; CI = 95%: -281.7-539.4; value p = 0.65.

used with posts increase thickness of dentinal root walls, and thus strengthen them. It might be worth mentioning that force application speed in the groups was minimal, this might explain the fact that there were no significant differences in results, since in laboratory assessments, when variations are minimal they still influence results.

Even though no difference was found between both treatments it might be mentioned that the group restored with only-metallic posts exhibited greater resistance to fracture. This would agree with reports of Kivanç *et al*.;[21] and Maccari *et al*.[23] It could be due to the fact that when the walls are thinner, greater will be the post's diameter and the amount of metal that withstands a fracture force, in comparison with narrow walls. Additionally, this type of reconstruction can better withstand transverse static forces when compared to adhesive posts, this is also due to the intrinsic adaptation of the casting with root anatomy.[24] Nevertheless, in the distribution of assessed groups, NiCr alloy was found in greater proportion in the unfilled posts group than in the filled post group. This latter group was mostly composed of fiberglass posts; this probably might have influenced results since metallic alloys are more resistant to compressive forces than fiberglass.[24,25]

Authors such as Saupe *et al*.,[17] Katebzadeh *et al*.,[18] Liang *et al*.,[19] Wu *et al*.,[20] and Fukui *et al*.,[26] concluded that the use of metallic posts with resin increased resistance to fracture, and that this difference was statistically significant when compared to unfilled posts. This could be explained by the fact that used filling material increased root wall thickness of the tooth, creating a more resistant surface which absorbs and distributes forces transmitted during chewing movements, more uniformly than that achieved by metallic materials, offering thus better prognosis in restoration function.[6,7]

In turn, Goncalves *et al*.,[22] found that the therapeutic option with greater resistance to fracture was filled titanium posts, when compared to teeth restored with copper-aluminum posts. This is probably due to the fact that, when allowing for suitable polymerization and adhesion of the filling, reinforcement of remaining tooth structure is achieved due to the integration of these components.[27] It might be worth mentioning that in the present study materials with different elasticity modules were confronted, since titanium posts exhibited lesser rigidity than copper-aluminum posts, and were closer to a natural tooth's characteristics, this could lead to an increase in tension in the post-dentin inter-phase in this latter group.[28] These tensions could be the reason why teeth with weakened roots and restored with only metallic posts would have the lowest resistance value of all other studied groups. This would then tend to prove tooth susceptibility to fracture in cases when no root filling material is used, or alternatively, techniques such as ferrule design which allow to use the vertical tooth remnant with a 2 mm bevel at the termination line, providing thus greater resistance to dental fracture.[29]

Resistance to fracture is evidently increased with the use of filled and unfilled posts, nevertheless, it cannot be established which option provides better results with respect to fracture resistance of weakened roots. This suggests the need to conduct studies to complement available evidence, on comparison of filled and unfilled posts, and furthermore establish possible difference between use of metallic and adhesive posts. These studies should control all possible confusing variables and standardize the method of force application to thus achieve more reliable results which might guide the clinician in his quest of an ideal therapeutic criterion.

CONCLUSION

Increase of fracture resistance of teeth with weakened walls can be achieved using posts placed within the canal as well as posts combined with root reinforcements. Both options provide greater resistance to the walls during compressive forces. Unfilled posts exhibit the advantages of fast and easy manufacture, long success history and excellent physical properties. Nevertheless, in cases when esthetics are essential and the clinician can avail himself to latest technology materials and systems, use of resin-reinforced posts represents a practical and innovative treatment option.

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Mailing address:
Meisser Vidal Madera Anaya
E-mail: meissermadera@gmail.com