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ADAPTATION OF PREFABRICATED/CAD-CAM INTERRADICULAR POSTS: A integrative review

María Jesús Gutierrez Gonzalez

Dissertação conducente ao Grau de Mestre em Medicina Dentária (Ciclo Integrado)

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Clique ou toque aqui para introduzir texto.

Trabalho realizado sob a Orientação de Dr. Valter Raúl Da Cunha Fernandes

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Ao meu pequeno grande homem, Imanol, desculpa por te fazer sofrer a minha ausência e perdoa-me sem pedir nada em troca, obrigado por o compreenderes.

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Ao meu fiel e incondicional parceiro de vida, Blas, por estar sempre presente sem dizer nada e dizer tudo.

Ao meu mentor Dr. Valter Da Cunha Fernandes, pela sua ajuda.

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RESUMO

A adaptação dos sistemas de retenção intrarradicular é um grande desafio devido à variedade anatómica e à normalização dos sistemas de retenção.

Esta revisão integrativa visa analisar a adaptação dos sistemas de retenção intrarradicular pré-fabricados versus sistemas de retenção intrarradicular personalizados, tendo em conta parâmetros que influenciam a adaptação da retenção intrarradicular. A hipótese nula é que os espigões pré-fabricados terão uma adaptação semelhante aos espigões personalizados.

Método: Foi efetuada uma pesquisa bibliográfica na base de dados PubMed, Scielo e Web of Science utilizando uma combinação de palavras-chave. Foi aplicado um filtro temporal e linguístico, apenas foram pesquisados artigos entre 2011 e 2022 em inglês e espanhol. Esta revisão sistemática integrativa foi conduzida de acordo com a metodologia PRISMA.

Resultados: A pesquisa inicial obteve resultados e artigos foram considerados relevante para o estudo. Estudos selecionados forneceram dados sobre variabilidade anatómica radicular, desobturação e preparação mecânica e química do canal radicular; tipos de materiais e formas na retenção intrarradicular, outros avaliaram a adaptação com diferentes tipos de cimentos, analisando a localização e os resultados da espessura onde foram detetados defeitos nos poros e microfissuras na microestrutura do cimento resinoso e onde estão representadas áreas de concentração de tensão e fratura.

Artigos recentes sobre retentores intrarradiculares personalizados e novos fluxos de trabalho digitais, discutem a adaptação, com novos materiais e técnicas de impressão adaptadas às novas tecnologias.

Conclusão: Foi possível concluir que o sucesso da reconstrução depende mais da estrutura dentária remanescente e da sua implementação do procedimento dentário do que da escolha do sistema de retenção intrarradicular. O cumprimento cuidadoso das especificações de cada procedimento dentário é preciso e imperativo.

PALAVRAS-CHAVE: *"adaptation", "endodontic post", "CAD/CAM", "custom-made post", "oval and flared canals", "workflow"* and *"cement thickness"*

ABSTRACT

The adaptation of intraradicular retention systems is a major challenge due to the anatomical variety and standardization of retention systems.

This integrative review aims to analyze the adaptation of prefabricated versus customized intraradicular retention systems, considering parameters that influence the adaptation of intraradicular retention. The null hypothesis is that prefabricated posts will have similar adaptation to custom posts.

Method: A literature search was performed in PubMed, Scielo and Web of Science databases using a combination of keywords. A temporal and language filter were applied, only articles between 2011 and 2022 in English and Spanish were searched. This systematic review was conducted according to the PRISMA methodology.

Results: The initial search yielded results and articles were considered relevant to the study. Selected studies provided data on, root anatomical variability, mechanical and chemical root canal clearance, and preparation; types of materials and shapes in intraradicular retention, others evaluated the adaptation with different types of cements, analyzing the location and thickness results where pore defects and micro cracks were detected in the microstructure of the resin cement and where areas of stress concentration and fracture are represented.

Recent articles on customized intraradicular retainers and new digital workflows discuss fitting, with new materials and impression techniques adapted to new technologies.

Conclusion: We can conclude, with this integrative systematic review that the success of reconstruction depends more on the remaining tooth structure and its implementation of the dental procedure than on the choice of intraradicular retention system. Careful compliance with the specifications of each dental procedure is precise and imperative.

KEYWORDS: *"adaptation", "endodontic post", "CAD/CAM", "custom-made post", "oval and flared canals", "workflow"* and *"cement thickness"*

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ABREVIATIONS

N/A: No analyzed

(FRC): Customized glass reinforced composite / fiber-reinforced composite

(EPFV): Endo preformed fiberglass posts

CAD/CAM Computer Aided Design/Computer Aided Manufacturing

(AET): Anatomic Endodontic Technology

(SS): stainless-steel

Ni-Ti: Niquel –titanio

(SAF): The Self Adjusting File

(PUI): passive ultrasonic irrigation

CP: CAD/CAM FRC posts

(CEJ): Cement enamel junction

(CCd): prefabricated glass fiber post

1. INTRODUCTION

The restoration of teeth that receive endodontic treatment is positioned as a factor that directly influences the success of endodontic treatment and guarantees, to a certain extent, the permanence of the dental element in function in the oral cavity. The loss of dental tissue causes morphological, functional, and esthetic alterations. Currently, the objective is to restore the lost dental structure, preserving as much as possible the integrity of the tissues, using minimally invasive techniques.(1)

It is important to promote a adequate post-endodontic rehabilitation as soon as possible. Also, the restorative maneuvers should consider this microbial contamination in the prognosis of long-term success of the dental treatment. The professional should make the patient aware of the need to perform the definitive restoration as soon as possible, since it is part of the treatment and not only the disappearance of the painful symptoms.(2)

The preparation of the post space in an endodontically treated tooth with oval shaped canal(s) could present possible complications (3) since the root anatomy before biomechanical instrumentation is determinant in the cleaning of the root canals. The oval or irregular shape of the root canal will result in the instruments not being able to reach all the canal walls (4) Selecting an appropriate post and core system from the wide variety available can be a clinical dilemma. This selection must satisfy many interrelated biological, mechanical, and esthetic factors to optimally restore the endodontically treated tooth to proper form and function (5) by achieving a good fit in the intraradicular canal. An ideal post system should have the following features: (a)physical properties similar to dentin, (b) maximum retention with little removal of dentin, (c) distribution of functional stresses evenly along the root surface, (d) esthetic compatibility with the definitive restoration and surrounding tissue, (e) minimal stress during placement and cementation, (f) resistance to displacement, (g) good core retention, (h) easy retrievability, (i) material compatibility with core, (j) ease of use, safety and reliability, and (k) reasonable cost. Therefore, the clinician should be knowledgeable in selecting the right type of post and core systems to meet the biological, mechanical, and esthetic needs for each individual tooth. (5)

On round-shaped canals with sufficient volume of the dentin walls, a prefabricated post can have an intimate fit to the prepared canal along its entire length. However, in oval, non-circular and wide canals, the usual cylindrical prefabricated post systems may not achieve an intimate fit of the root canal (6), possibly compromising the retention of the post. Currently, new software techniques, CAD/CAM, have been developed for the fabrication of customized posts to achieve better canal adaptation. (7)

In this integrative systematic review different factors affecting the adaptation of a post system to the root canal will be studied according to different criteria.

2. OBJETIVE

The aim of this study is to evaluate the degree of adaptability between different retention systems to different anatomies and the effect of cement thicknesses on the bond strength between posts and root dentin.

3. METHODS

3.1 Information sources and search strategy

The literature review was conducted following the Preferred Re-porting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

At the end of this analysis, the pertinence of including 18 scientific articles in this systematic literature review was determined, of which the acronym PICO is presented (table 1), and who see content supports the discussion.

The research question that under pins the purpose e of this study, built in line with the PICO methodology, is the following: What parameters can influence the proper adaptation of interradicular posts to the root canal?

Table 1. PICO Question:	
P	Insufficient remaining tooth structure
I	Intraradicular retention systems
C	Adaptation conventional pins vs customized pins
O	Successful adaptation intra-radicular retention

Also, a hand-search was performed on the reference lists of all primary sources and eligible studies of this systematic review for additional relevant publications. Manual searches were performed in the following data bases of scientific publications: PubMed, SciELO and Web of Science.

3.2 Results of the research methodology

A literature search was carried out on PubMed (via National Library of Medicine), SciELO and Web of Science, considering such data base includes the major articles in the field of dentistry and biomaterials using the following combination of search terms were applied in this study: *"adaptation post"* OR *"endodontic"* OR *"CAD/CAM"* OR *"post and core"* OR *"custom made post"* OR *"oval shaped canals"* OR *"flared root canal"* OR *"tooth nonvital"* OR *"workflow"* OR *"cement thickness"*. The inclusion criteria involved articles published in any language, from 2011 to 2022, involving, *in vitro* analyses, meta-analyses, randomized controlled trials, and prospective cohort studies. The exclusion criteria were the following papers without abstract, systematic reviews, bibliography review, articles whose title and/or abstract do not fit the theme; all papers in a foreign language (not in the English language) where the full text was not available. Also, a hand-search was performed on the reference list of all primary sources and eligible studies of this systematic review for additional relevant publications. The total of articles was compiled for each combination of key terms and therefore the duplicates were removed using Mendeley citation manager.

4. RESULTS

A search was carried out in the PubMed, SciELO and Web of Science database obtaining a total of 313 articles. A selection of articles was made based on the type of study and eliminating those that were duplicated (n=10) being a total of 303 articles according to the type of studies. They were excluded by titles and abstracts giving a total of 65 articles that were selected for the complete reading of which a total of 18 articles were left for this integrative systematic review study. Finally, 9 articles were used for systematic review

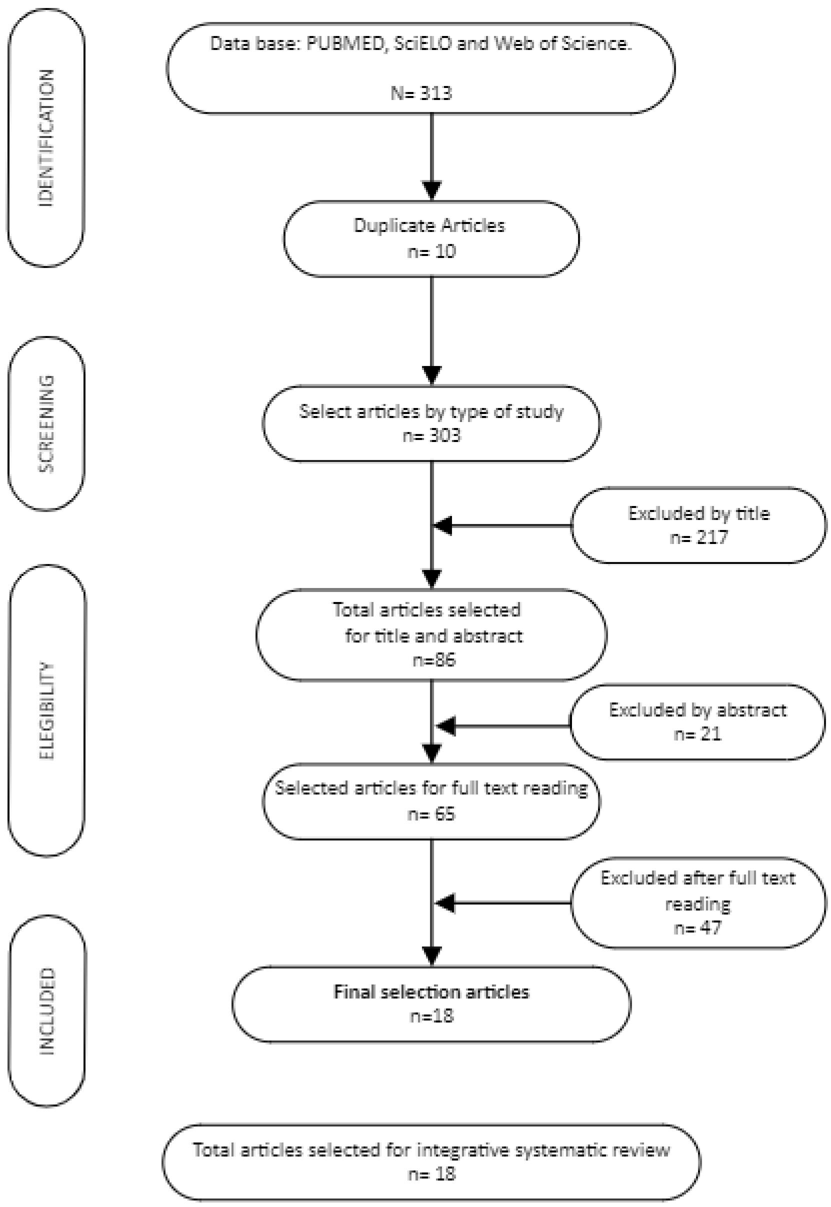

Figure 1 – Prisma flow diagram of the search strategy

Regarding the publication period, the years 2011, 2018, 2019 and 2021 registered 3 articles each on the subject in question (66.67%); 2014, 2016 and 2017 with 2 articles each (33.33%)

As for the type of studies of the articles evaluated, all studies are in vitro studies all studies except for one study which is ex vivo.

The major findings from the selected articles are shown in Table 2 and briefly described as follow:

-Adhesion is an important factor for the adaptation of prefabricated or CAD/CAM posts to the root canal. 9 articles refer to this characteristic showing no significant differences in the type of material used.[8,9,10,11,12,13,14,15] Although, there were significant differences depending on the size of the post.[16] 4 articles mention the type of etching used to achieve better adhesion to the canal and thus improve adaptation.[17,18]

-Another parameter to be considered in the adaptation is the amount of cement used when adapting the post to the root canal. Several authors evaluate this parameter in terms of cement thickness and other authors evaluate the spaces and voids produced by this cement in the canal between the posts and the dentin.[8,10,16,17,19,20,21]

-Oval root canal configurations, which raises questions about the adaptation of conventional posts to oval root canals. The space for the post is usually prepared with burs, however, healthy tooth tissue must be sacrificed when performing circular post placement in oval-shaped root canals to adapt the canal shape to that of the circular post. This procedure also decreases root strength and may generate incomplete instrumentation of the canal wall. To improve adaptation, an experimental ultrasonic tip (Ellipson tip; Satelec, Acteon group, Merignac, France) with an oval shape will be evaluated for the preparation of posterior spaces in oval canals.[10]

-Other authors evaluated the adaptation according to the fabrication of the post type and the anatomy of the root canal, oval or circular. The results showed that in oval canals, the adaptation of the posts was more difficult than in circular canals when preformed posts were used and the CAD/CAM posts adapted better to the anatomy of the root canal.[8,16,22,23,24]

TITLE AUTHOR YEAR	TYPE OF STUDY	PURPOSE	POPULATION	INTERVETION	MAIN OUTCOME	FAILURE PATTERN	CONCLUSION
1 Influence of oval and circular post placement using different resin cements on push-out bond strength and void volume analyzed by micro-CT Uzun *et al.* Int Endod J. 2016	In vitro	Evaluate % voids within cement layers, to determine the push-out bond strength of circular and oval fiber posts luted with different commercial resin cements in oval cross-sectional root canals, and to correlate push-out bond strength values and volume of voids of circular and oval fiber posts.	72 mandibular premolars with oval-shaped root canals	Two groups: *Oval Post *Circular Post *Three Sub-groups (n = 24) Resin cement: *Maxcem Elite, *Rely-X Unicem*Duo-Link	Pressure resistance *Bond strength: * Root canal thirds *Post type – *Cement. ($P< 0.001$). (MPa) *Interactions: *Post type *Cement type ($P = 0.001$) *Compressive strength: *Oval posts: *Coronal-Apical > ($P = 0.001$) *Cement> ($P < 0.05$) *Compressive strength: *Rely-X and Duo-Link >Maxcem ($P < 0.05$). *Rely-X = Duo-Link Adhesion ($P < 0.05$). *The push-out bond strength: *Oval > Circular *Apical > Coronal ($P < 0.05$).	*Failure type: *Adhesive (all the groups.) *No correlation between the push-out bond strength and void	Void volume did not affect push-out bond strength of oval and circular posts luted in oval canals
2- Effects of Auxiliary Fiber Posts on Endodontically Treated Teeth with Flared Canal Li *et al*. Operative Dentistry 2011	In vitro	*The resistance and retention of endodontically treated roots with over-flared canals restored with different post systems, including one cast metal post and four fiber posts with/without auxiliary fiber posts.	One hundred incisor roots flared	*One hundred incisor: *Restored: *Five post systems: *(CM): Ni-Cr cast metal post * (D.T) Light glass fiber post *(ML) Macro-Lock glass fiber post *(2FC) ML+2 Fibercone auxiliary fiber posts *(5FC) ML+5 Fibercone auxiliary fiber posts	*Failure strengths (N) *Fracture failure strength: *Group DT lowest. *Fracture strength: *No difference *Groups CM, 2FC, and 5FC. *Root fracture: *Almost all *Invisible fracture: *Four specimens *Groups CM and 5FC *No post fractures. *Post fracture *% 50% =DT, ML,	Fracture failure strength and pull-out strength were measured and analyzed using one-way analysis of variance (ANOVA) followed by Tukey's post hoc test (a¼0.05). *Root fracture, *Post fracture, *Invisible fracture.	Within the limitations of this in vitro study, the following conclusions were drawn: 1. The Macro-Lock post showed superior retention and fracture resistance compared with the D.T. Light post. 2. The Macro-Lock post combined with the auxiliary fiber posts increased the fracture resistance of the over-flared root

					*30% =2FC, *Analysis of Pull-out Tests *Pull-out strengths (N) *Group CM: *Failure strength fiber post (p,0.05). *Pull-out strength: *No differences *Groups ML-2FC-5FC > (p.0.05). *Group DT < (p,0.05). *A rough surface: *Glass ionomer *Group CM. > *Post-cement layer *Group DT> *Residual cement layer: *Groups ML, 2FC, and 5FC.		
3-Oval Fiber Posts Do Not Improve Adaptation to Oval-shaped Canal Walls. Muñoz *et al*. American Asociación of Endodontists. 2011	In vitro.	Oval fiber posts attempt to provide better adaptation to root canals.	Twenty human premolars	*2 groups: * Group 1: *10 circulars canals by using the (Ellipson ultrasound tip (Satelec/Acteon) *70%–80% / P5. *Group 2: *10 ovals canals. (Rebilda posts) (Voco) *Cemented: *Composite cement: *Coronal. *Middle. *Apical *Silanized with Ceramic Bond (Voco) for 60 seconds	*Space post showed: *No significant differences (P >.05) *Ovals/ Circulars. *The cement layer: *Thicker Circular posts. *Oval posts *No differences (P > .05) *Adaptation 2 groups: * No differences *Posts Oval/Circular: *Surface. *Canal wall (Mesial, distal, lingual, and buccal points) (P > .05). *Along post: *Buccal and lingual > Greater *Circular posts occupied: *Higher apical/middle *Coronal third (P < .05) *Posts buccal/lingual aspects higher (P < .05) apical. *Circular posts: * Higher Coronal (P < .05)	N/A	Oval posts do not adapt better than circular posts to the morphology of oval canals.

4- Oval Versus Circular-Shaped Root Canals: Bond Strength Reached with Varying Post Techniques. Webber *et al* P, CP. Braz Dent J. 2018	In vitro	The aim of this study was to compare the bond strength (BS) of glass fiber posts (GFP) luted to oval and circular-shaped root canals rehabilitated using varying post techniques, at different intraradicular levels.	Ninety 16-mm-long roots of human mandibular premolars, classified either as having oval or circular-shaped canals	Ninety 16-mm- *Oval or circular: *Three post techniques: (n=15): 1) single GFP; 2) resin-relined GFP; 3) main GFP associated with accessory posts. *GFPs- dual polymerizing resin cement (RelyX ARC) *Treated: *3-step etch-and-rinse adhesive system (Adper Scothbond. *Multipurpose).	*GFPs luted to oval and circular-shaped *Post techniques: *Different levels. (p=0.560). The double interactions: *Root canal x Post technique (p = 0.717) *Root canal x Root third (p=0.572) *Post technique x Root third (p=0.074) *Not significant. *Post technique/root third: *Bond strength: *GFPs (p) lower oval *(8.00 MPa /3.79 MPa) in comparison with the *Circular: (10.51 MPa/4.70 MPa). *Post technique: *Bond strength: *GFPs (p=0.018), *Group showing *Highest oval/circular	The failure: *Adhesive cement/ dentin; *Post/cement; *Post/composite resin *Mixed: *Cohesive: resin /cement. *Cohesive: resin /Dentin.	The samples were sectioned into three 1-mm-thick sections, which were differentiated by the root level (cervical, middle and apical) and tested for push-out BS. Assessment of failure mode was made under a stereomicroscope. Data were analyzed using repeated measures three-way ANOVA and Tukey's test. The root canal cross-section had a significant influence on BS (p<0.001), with the lowest values being observed in oval-shaped canals. The post technique also significantly affected the BS (p=0.018), with the resin-relined GFPs providing the highest BS values in both oval and circular-shaped canals. Irrespective of the cross-section of the root canal and post technique, there was no significant difference in BS in the cervical, middle, and apical third of the root canal (p=0.084). In oval-shaped canals, the BS to interradicular dentin at cervical, middle, or apical level could be increased when the GFPs posts were relined
5 The fit of two fiber posts into the root canal space enlarged with rotary Niti	In vitro	*Test the fitting at different radicular levels of two posts (DT) #0.5 and #1 in root	*40 Human lower single root canal premolars. (21-23mm).	*Two groups: 20 teeth DT #1-#0.5 *Diameter Post Space: *Translucent glass DT *Fiber posts: #0.5 or #1.	*Discrepancy: *27% (SD 15.4) - DT #0.5 *32.5% (SD 18.8)- DT #1 * T-Student test: *Roots filled:	*Discrepancy formula: *(Root canal /section area) *(Fiber post /area) *(root canal /section area)	Discrepancy increases at coronal level and decreases towards the apical sections of each post. Statistical analysis does not show significant

files at four different levels. Porciani, *et al*. International dentistry SA		canals enlarged with a rotary NiTi files system.		*#0.5 /0.8mm-.02/.04 *#1 / 0.9mm-.02/.06 *(6 - 8mm) * (DT Light Post) *Decalcified: * Phosphoric: 32%-30¨ *Immersion: Sodium hypochlorite: (2%-120¨)	*Cervical media: *#1 = #0.5 (p <0.05)		differences among discrepancies reported with #0.5 DT and #1 DT at the same level. Therefore, clinical use of a smaller post (#0.5 DT) can be supported.
6-Fibre post adaptation and bond strength in oval canals Scotti *et al* Endod J. 2014	Ex vivo	To evaluate ex vivo the bond strength and adaptation of fiber posts with oval and circular cross sections luted in oval canals with post spaces prepared using dedicated drills or ultrasonic tips.	*40 premolars oval canals.	*Two groups (n = 20 each): *Space preparation: *Group A: *Drill (3M ESPE) * Group B: *Diamond coated ultrasonic tip: Fine-grit (46-lm) & val cross section *Post space Prepared: *A- 8-mm- 5 mm *Two subgroups (n = 10 each) *Luted fibre post. *Subgroup 1 *Round glass–fibre posts (RelyXFibre Post, 3M ESPE) *Sub-group 2 *Oval glass–fibre posts (Ellipson post; RTD/Satelec) *Before cementing: *Posts Cleaned: *70% alcohol * Silane agent *Self-adhesive *Luting agent *Photoactivation *After polymerization:	*Adapted: *Oval, >Apical *Post space (P = 0.001). *Bond strength: *Oval canals: * >Coronal. *Postspace prepared Dedicated drill. *Oval post luted (P < 0.0001). Fibre post adaptation: (P < 0.05). Both and oval (P = 0.001). * A1-Apical: 54.81 +/-18.33 *A2-Apical: 47.97 +/-10.21 Bond strength Corona (dedicated drill) *17.776 +/- 5.337	*Failure mode: *Adhesive failure: * Dentine and cement (AD) *Cement and the post (AP) *Cohesive failure cement (CC) *Cohesive failure the post (CP) *Mixed failure (M)	Circular and oval posts achieved similar adaptation to oval canals, but the use of ultrasonic tips and round posts resulted in reduced bond strength values

				*Stored: Distilled water/37 °C/24 h. *Cemented			
7- Comparison of push-out bond strength of fiber-reinforced composite resin posts according to cement thickness Park *et al* The journal of prosthetic dentristry 2017	In vitro	The purpose of this in vitro study was to evaluate the push-out bond strength of fiber-reinforced composite resin posts to root dentin with cement layers of varying thickness.	Thirty human premolars were endodontically treated and restored with fiber-reinforced composite resin posts.	*Post space prepared: *Length of 8 mm *(green-colored LuxaPost) *Drill - 1.5 mm. *37% phosphoric acid * Dentin adhesion *LuxaBond Total Etch (DMG). *The post was dried: * LuxaPost of 1.25-mm in diameter (black) *Medium (M) group: *Post spaces prepared: *greenLuxaPost. * S group LuxaPost of 1.375 mm *Large (L) group: *Post spaces prepared: *greenLuxaPost *ALuxaPost of 1.5 mm *Cement of 3 groups: *LuxaCore Z Dual (DMG) injected into post space,	No significant differences were found in the debonding force and push-out bond strength among fiber-reinforced composite posts of different sizes (P>.05)	*The failure modes: * Adhesive failure: Between (Luting material and fiber reinforced) * Mixed failure: *Post or the luting material and dentin occurred *Cohesive failure: *Fiber-reinforced composite post or the luting material. * Failure modes: No difference *Coronal group = Apical group	The widening of post spaces and, consequently, the increased cement thickness do not significantly affect the bond strength of fiber-reinforced composite resin posts to root dentin.
8-Influence of the resin cement thickness on bond strength and gap formation of fiber posts bonded to root dentin. Gomes *et al*. J Adhes Dent. 2014	In vitro	To evaluate the effect of the resin cement thickness (RCT) on bond strength (BS) and gap formation (GF) of fiber posts bonded to root dentin.	24 human mandibular premolars.	*Post spaces *Prepared: *Drills different diameters. *Groups (n = 8): *Well adapted (WA), *Moderately well adapted (MA) *Poorly adapted (PA). *Fiber glass posts ^Cemented (Excite DSC and Variolink II)	*The lowest RCT (μm) * *Group WA > PA. *Push-out BS *Group MA>showed an intermediate > WA compared other groups. *Groups MA = PA (similar) *Highest gap length (%) width (μm): for PA. *Groups MA=WA (similar).	1.Adhesive/ dentin/ luting cement 2.Adhesive/luting cement/post 3.Cohesive/luting cement 4.Cohesive/post; 5. Cohesive /dentin 6.Mixed failure.	Lower resin cement thickness resulted in better fiber post adhesion, that is, in higher bond strength and less gap formation.

10-Micro-computed tomography analysis of gap and void formation in different prefabricated fiber post cementation materials and techniques. A. ArRejaie *et al.* Production and hosting by Elsevier B.V. on behalf of King Saud University. 2019	In vitro	The study was built around the objective of determining the variances in the gap and void formation around cemented prefabricated fiber posts with two different cementation materials and techniques with micro-computed tomography (lCT)	Standardized acrylic resin roots (N = 40) with prefabricated fiber posts (RelyXTM Fiber Post 3D) were split into four sets (n = 10)	FRI group: resin cement (by injecting the material inside the canal by using a root canal tip, followed by cementation of the post. FRB group: resin cement by injecting the material inside the canal by using a root canal tip and a microbrush to distribute the cement inside the canal, followed by cementation of the post. FMI group: dual curing resin cement by injecting the material inside the canal by using a root canal tip, followed by cementation of the post. FMB group: dual curing resin cement by injecting the material inside the canal by using a root canal tip and microbrush to distribute the cement inside the canal, followed by cementation of the post	There was no significant effect on the void and gap parameters ($p > 0.05$) in any of the groups	N/A	There was a certain amount of void and gap formation inside all of the tested specimens. However, no significant variances were found.
11-Bond strength values of fiberglass post to flared root canals reinforced with different materials Bakaus *et.al* Oral Res. 2018	In vitro	The aim of this study was to compare in vitro the bond strength (BS) between fiberglass posts and flared root canals reinforced with different materials	The roots of 48 premolars were endodontically treated	The roots of 48: *Cemented *(PCG) control group *(PFP) *Prefabricated fiber post compatible with the root canal size. *Simulating: *Ideal adaptation. The other samples (n=8/group). *Alternative techniques: *Negative control group (NCG [PFP *Smaller	*Highest BS value was observed for PCG. *NCG and the GIG groups lowest BS values. *Reinforcement/conventional /bulk-fill composite resins highest BS values. *Bulk-fill resin/only/ high BS all regions. *Self-adhesive cement: CRG = GIG.	Results not shown	In teeth that need cementation of a fiberglass post, clinicians should attempt to maintain as much root dentin as possible, since a closely fit post exhibited the highest bond strength results. However, if this is not possible, root reinforcement with a bulk-fill composite resin is an effective technique for restoring flared root canals.

				diameter *Composite resin group - CRG, *Bulkfill group - * BFG, self-adhesive *Cement group – SAG *Glass ionomer group – GIG.			
12-Effect of Glass Fiber Post Adaptation on Push-Out Bond Strength to Root Dentin Freitas *et al*. Brazilian Dental Journal (2019)	In vitro	The aim of this study was to evaluate the effect of different glass fiber posts (GFPs) diameters on the push-out bond strength to dentin.	Forty unirradicular human teeth.	*Cementation of GFPs (White Post DC, FGM) with: Different diameters (n=10): *P1 - ø 1.6 mm coronal x 0.85 mm apical: *P2 - ø 1.8 mm coronal x 1.05 mm apical; *P5 - ø 1.4 mm coronal x 0.65 mm apical. *PC - customized post number 0.5 with composite resin (Tetric Ceram A2, Ivoclair Vivadent). *All GFPs cemented *Dual-curing luting (Variolink II, Ivoclar Vivadent).	*The highest bond strength: *P2 and PC groups. (There was no statistically significant difference between the GFP thirds in each group.) *P2, P5, and PC showed predominantly adhesive failure. * P1, the most prevalent type of failure was adhesive between resin cement and post.	*Adhesive failure *Resin cement /post; adhesive. *Dentin / resin cement. *Cohesive: *Resin cement/ post/ dentin. *Mixed failure.	It may be concluded that a glass fiber post that is well adapted to the root canal presents higher bond strength values, regardless of GFP third.
13-Effect of Anatomical Customization of the Fiber Post on the Bond Strength of a Self-Adhesive Resin Cement Rocha *et al*.	In vitro	The aim of the study was to evaluate, by means of the push-out test, the effect of the anatomical customization of the fiber post on the bond strength of a self-adhesive resin cement	Twelve endodontically treated, human, upper central incisors.	* Two group: (n = 6): *Control group (glass fiber posts cemented with Relyx® U200) *Customized (glass fiber posts anatomically customized with translucent composite resin cemented with Relyx U200). *The roots were sectioned into three slices:	Different root thirds in relation to the area occupied: * By air bubbles: ($p < 0.05$). *Bond strength, when all the thirds are considered: * the control group 8.77 ± 4.89 MPa. * Customized group 16.96 ± 4.85 MPa for the.	The images were analyzed by software, for evaluation of the cement line. The slices were subsequently submitted to the push-out test until the post had completely extruded, and the fracture mode was analyzed with a stereomicroscopic loupe.	The customized group showed greater bond resistance than the control group and a more uniform cement layer.

International Journal of Dentistry 2017				*Cervical. *Middle. *Apical,.			
14- Clinical Evaluation of Cement Thickness Around PreFabricated vs. Costume-Fabricated Posts. Zsuzsanna *et al* European Scientific Journal September 2016	In vitro	The purpose of this study was to evaluate the variation of cement thickness in different regions of the root in case of prefabricated and custom-fabricated posts.	Totally twelve extracted human incisors and premolars with single tooth canals were distributed among 3 experimental groups of 4 specimens each.	They were treated endodontically and *Restored: *Prefabricated fibre post *Custom-fabricated metallic posts. *Cemented: *Adhesive cements. Each	*The costume-fabricated post groups (group 2,3) obtained statistically significant lower cement thicknesses,in particular in the apical third. *The prefabricated post grou: *(group 1) showed the highest cement thickness. Cement thickness was less for the specimens prepared using direct impression technique.	The cement thickness is correlated to the post fitting into post space: the more the post is adapted to the canal walls, the less is the cement thickness	Within the limitations of this in vitro study, it may be concluded that a better post fitting can be obtained using direct impression technique and custom-fabricated posts.
15-Mechanical Properties of CAD/CAM Manufactured and Prefabricated Endodontic Posts Sinmazisik *et al* Key Engineering Materials 2018	In vitro	Evaluate the stiffness, elastic limit and strength of CAD/CAM manufactured metal and zirconia posts in comparison to prefabricated zirconia and glass-fiber posts.	Four types of posts were investigated	Four types of posts: (n=40). *Prefabricated posts made of zirconia (Cosmopost) *Glass-fiber reinforced composite (FRC Postec Plus) *Cr-Co (Magnum Lucens) *Zirconia (Zirkonzahn) posts manufactured CAD/CAM Cemented with a self-etch/self-adhesive dual cure resin cement (Totalcem).	The difference: *Strength, elastic limit/ stiffness > highly significant ($p<0.01$). *CAD/CAM Cr-Co posts showed > strength / elastic limit/ stiffness *CAD/CAM zirconia posts < lowest Strength. *FRC < lowest elastic limit / stiffness. *Cosmopost >higher elastic limit stiffness compared CAD/CAM zirconia posts.	N/A	If an endodontic post restoration is required, functional load and aesthetics should be considered in addition to mechanical properties of the material selected.

16-Influence of Adaptation and Adhesion on the Retention of Computer-aided Design/Computer-aided Manufacturing Glass Fiber Posts to Root Canal Eid *et al* The Journal of Contemporary Dental Practice 2019	In vitro	The study aimed to assess the effect of friction and adhesion on the pushout bond strength of CAD/CAM fiber-reinforced composite (FRC) post and cores in comparison to prefabricated fiber posts	Thirty extracted single-rooted premolars	Thirty extracted *Three groups (N = 10): CP: CAD/CAM FRC posts (Trilor, Bioloren) *Cemented with self-adhesive resin cement (Rely X U200, 3M). *Control group. CPL: CAD/CAM FRC composite posts cemented: self-adhesive resin cement after lubricating (Vaseline). *RXP: *Prefabricated posts cemented self-adhesive resin cement.	*Push-out/bond strength: * RXP< group (8.54 ± 3.35 MPa) comparison CP (12.10 ± 1.38 MPa). were concluded between the other groups.	Failure was mostly adhesive for CPL and RXP and adhesive and mixed for CP.	Custom made CAD/CAM posts have a positive effect on the retention of FRC posts to root canal walls while adhesion between self-adhesive cement and root dentin did not influence significantly the pushout bond strength of CAD/CAM posts to root canal. Clinical significance: The friction of well-adapted CAD/CAM fiber post and cores plays a predominant role in the success of post restorations of
17-Does Multi-Fiber-Reinforced Composite-Post Influence the Filling Ability and the Bond Strength in Root Canal? Kharouf *et al* 2021	In vitro	to investigate the bond strength of root canal dentin and the filling ability of a new multi-fiber-reinforced composite post (mFRC) compared to a conventional single fiber-reinforced-composite post (sFRC).	Twenty-eight freshly maxillary first permanent single-rooted premolars were instrumented.	Twenty-eight (n = 14). *Group 1: single-fiber-reinforced composite (sFRC). *Group 2: multi-fiber-reinforced composite (mFRC).	*Obtained : *in the sFRC group (44.7 ± 13.1 MPa) compared to the mFRC group (37.2 ± 9.2 MPa). *No significant difference middle third: * (sFRC group "33.7 ± 12.5 MPa" *(mFRC group "32.6 ± 12.4 MPa") ($p > 0.05$).	Voids lower mFRC /sFRC group ($p < 0.05$) at the coronal third. *Whereas no difference found at the middle third ($p > 0.05$) between the tested groups.	Filling ability was overall improved when employing mFRC, although such technique might have characteristic limitations concerning the bond strength to dentin.

18-Effect of half-digital workflows on the adaptation of custom CAD-CAM composite post-and-cores Perucelli *et al* Prosthet Dent. 2021	In vitro	Analyze the adaptation of CAD-CAM composite resin post-and-cores fabricated through a part-digital fabrication workflow and to compare it with that of metal cast post-and-cores fabricated through conventional methods.	Eight extracted human premolars were endodontically treated and prepared for custom post-and-cores.	Metal cast post-and-cores were fabricated with: * Ni-Cr alloy (Fit Cast-Sb Plus; Talmax) and conventional resin pattern modeling methods directly in the root canal (conventional direct modeling) or indirectly in a stone cast (conventional indirect modeling). Composite resin post-and-cores were milled from nanohybrid glass-ceramic composite resin CAD-CAM blocks (Brava Block; FGM) by using the part-digital workflow. A laboratory scanner was used to digitalize polyvinyl siloxane impressions (part-digital scanned impression direct CAD-CAM [PSC]) of the root canals and resin patterns fabricated directly (part-digital direct CAD-CAM [PDC]) or indirectly (part-digital indirect CAD-CAM [PIC])	*The conventional direct modeling group had lower mean volume of the cementation space than all CAD-CAM composite resin post-and-cores ($P<.041$). *The conventional indirect modeling group had a lower volume of the cementation space mean than PDC ($P<.024$) but *was not significantly different from PIC ($P=.577$) or PSC ($P=.221$). *Regardless of the fabrication workflow, no differences were observed among the CAD-CAM composite resin post-and-cores ($P>.05$). At the apical root third, conventional direct modeling and conventional indirect modeling had lower film thickness means than PSC or PDC ($P<.05$). In the middle third, conventional direct modeling and conventional indirect modeling had lower film thickness means than PDC ($P\leq.001$). At the cervical third, no differences in film thickness means were observed among the groups ($P>.05$). PDC had a lower apical gap mean than PSC ($P=.013$), while no significant differences were found for other pair comparisons ($P>.05$).	N/A	Metal post-and-cores had slightly better adaptation than the CAD-CAM composite resin post-and-cores; however, the part-digital fabrication workflow of CAD-CAM composite resin post-and-cores provided adaptation parameters within a clinically acceptable range and is less time consuming.

19-Adaptability of glass fiber posts fabricated by chair side versus in lab CAD/CAM technology. In vitro Mostafa *et al* Journal of Dental American Science 2021		*In-vitro study will be directed to compare the adaptation of glass fiber posts fabricated by chair side versus in lab CAD/CAM technology.	A human maxillary central incisor.	*Thirty prepared resin root models. *Three groups: * (n=10 per group) *Impression technique as follows: *Group I - Acrylic pattern lab scanning. *Group (ALS) (n=10). Group II -Vinyl polysiloxane lab scanning *group (VLS) (n=10). *Group III -Chair-side scanning group (CS) (n=10).	The adaptability of CAD/CAM glass fiber posts *Affected: *Fabrication technique: (P<0.05) *The highest: *Gap -ALS group (58.623 ± 16.797 µm) *CS group (53.483 ± 14.111 µm) *VLS group overall gap (33.890 ± 4.936 µm).	N/A	Based on the recorded results and within the limitation of this in- vitro study, the following conclusions may be drawn: •The gap values observed in the different studied groups were all within the clinically acceptable range. •The fabrication technique greatly influenced the adaptability of CAD/CAM glass fiber posts. •The vinyl polysiloxane lab scanning fabrication technique had the highest adaptability, and its overall gap width was significantly lower than other studied techniques. •There was no significant difference in the overall gab width between chair-side scanning and acrylic pattern lab scanning fabrication techniques.

Table 2: Relevant data and variables retrieved from the selected studies

5. DISCUSSION

In this integrative systematic review, we will study adaptation according to different factors, which, associated with each other or separately, can influence it. In all the studies selected and studied, we have found different parameters that lead us to associate a close relationship with the adaptation factor, which we will briefly discuss.

Among these factors, derived from the studies consulted, are the following:

5.1 Types of endodontic posts

The available post designs can be classified according to their shapes and surface characteristics. They may be parallel, tapered, or parallel-and-tapered combination. The active post mechanically engages the dentin with threads, whereas the passive post depends on the cement and its close adaptation to the canal wall for its retention. There is a need for long term clinical evaluation of both metallic and nonmetallic post systems to allow a definitive recommendation of either of them. Until such time, metallic posts continue to be the standard for most situations because they have stood the test of time. (5)

The factors that influence the selection of the post-and-core system and offers the following clinical recommendations: (1) conserve as much remaining tooth structure as possible during the post space preparation, (2) custom-cast post and cores are recommended for noncircular root canals and when coronal tooth structure loss is moderate to severe, (3) parallel-sided, passive, serrated, self-venting prefabricated posts are recommended for small circular canals, (4) posts with an anti-rotational feature should be used in situations with circular canals, (5) adequate apical seal must be maintained without compromising the length of the post, (6) more than one post may be used for multirooted short teeth, (7) passive parallel posts are advocated for adequate retention but when the apical thickness of dentin is minimal, a parallel-tapered combination post design may be preferred, (8) retentive qualities of the post head may facilitate firm retention of core material, (9) the post should ensure material compatibility, bonding ability, adequate rigidity, and esthetic compatibility with permanent restoration, (10) retrievability in the event of failure should be considered, and (11) the system should be easy to use and cost effective.(5)

Park *et al*, in their study, found no significant differences in posts with different fiber sizes. (8)

Kharouf *et al*. studied the bond strength of multi-fiber posts compared to single fibers and found that multi-fiber posts offered lower bond strength than single fiber posts in the coronal third. (15)

Porciani *et al* analyzed the adaptation with posts of different diameters DT#0.5 and DT#1 at different root levels and observed that there were no significant differences with respect to post adaptation at any root level, although a greater discrepancy was obtained at the coronal level and less at the apical level. (16)

Lopes de Freitas *et al*, evaluated the effect of different diameters of glass fiber posts (GFP) on the strength of the push-to-dentine bond. There were no significant differences between GFP thirds; however, the highest values for bond strength were for posts sized 1.8 mm coronal and 1.05 mm apical and for custom posts sized 0.5 mm. (22)

Adrycila Texeira Rocha *et al*, evaluated the effect of anatomical customization of the fiberglass post on the bond strength of a self-adhesive resin cement whose results showed significant differences between groups in the different root thirds in relation to the area occupied by air bubbles being larger in the customized group than in the control group, thus showing higher bond strength and a more uniform cement layer. [23]

Mostafa *et al*, compared the adaptability of prefabricated fiberglass posts with laboratory CAD/CAM posts and found that CAD/CAM posts had better adaptability than prefabricated posts. [24]

There are 3 types of failures that can compromise the success of the rehabilitation of an endodontically treated tooth. These include Adhesive (cementum-post), adhesion (cementum-dentine) and cohesive (within the cementum, post, or dentine) failures. [22]

Different authors report this type of failure in their studies, the most frequent being adhesive failure. [9,10,11,22]

Of all the articles selected for this dissertation only one author evaluates the stiffness, yield strength and strength of CAD/CAM fabricated zirconia and metal posts compared to prefabricated zirconia and glass fiber posts. The results obtained by Sinmazisik *et al*. are that the highest values for stiffness, yield strength and strength were for CAD/CAM Cr-Co posts and CAD/CAM zirconia posts show the lowest values; glass fiber posts show lower values for yield strength and stiffness; zirconia prefabricated posts offer higher values for yield strength and stiffness compared to CAD/CAM zirconia posts. [25]

5.2 Anatomical structure of the root canal

Oval-shaped canals should have a different approach to management compared to normal root canal configurations to apply a different approach to cleaning, shaping and obturation of the canal.[3]

One of the main goals of endodontic treatment is the thorough preparation of the root canal system and proper obturation to obtain a three-dimensional seal. To achieve this goal, clinicians must have a thorough knowledge of the normal anatomy of the root canal system in question and its common variations. Root canal configurations in cross-section have been classified as round, oval, long oval, flattened or irregular.[26]

This complex anatomy can be considered as one of the main challenges in attempting to achieve adequate debridement by root canal instrumentation. Oval and long oval canals are approximately 25% prevalent in the apical part. However, in the distal roots of mandibular molars, the prevalence is 25-30%. In other tooth groups, such as mandibular incisors and maxillary second premolars, the prevalence is higher than 50%.[3,27]

For root canal preparation, the use of instruments favors the adaptation of posts in oval canals:

Scotti *et al*, demonstrated that a #4 Gates-Glidden bur caused perforations in the distal canal of mandibular molars, so the authors recommended that Gates-Glidden drills larger than a #3 should not be used in these roots.[9]

Anatomic Endodontic Technology (AET) AET (Ultra Dent Products Inc., South Jordan, UT, USA) has been designed to maintain the original canal shape during instrumentation to minimize the number of instruments required for canal preparation. Canals formed with AET had lower scores of debris and smear layers compared to canals prepared with the ProFile system (Dentsply, PA, USA) or manual preparation techniques; however, complete cleaning could not be achieved with any of the techniques investigated and is intended to demonstrate the importance of regularizing the root canal to achieve a good fit of the interradicular post to the canal.(9,10)

Authors, such as Uzum *et al* and Porciani *et al*, describe different instrumentation techniques for the preparation of oval canals using Ni-Ti files whose results did not favor the total debridement of the canals, and could cause steps and perforations that would be inconvenient for the adaptation of the post in the root canal.(10,16) Uzum *et al* described that bond strength was affected depending on root region, post type and type of cement used. This author noted that ideal adaptation is difficult to obtain in a canal with an irregular anatomical configuration. For preparation of the post space in oval canals, burs are often used, but this procedure alters the canal anatomy and sacrifices dentin. The main objective is to achieve the best possible adaptation of the fiber post to the canal walls, thus minimizing the thickness of the cement layer. (10)

On the other hand, the ultrasonic tips (Ellipson tip; Satelec, Acteon group, Merignac, France), with oval shape, do not alternate the canal conformation and help the adhesion force to be greater at apical level, but produce a greater volume of voids at coronal level that can misalign the oval posts at this level besides not performing an effective debridement between the post and the tooth, although they are more conservative with the dental tissue. (9,10,28)

In terms of adhesion, Scotti *et al*, evaluated adaptation of circular and oval posts and their results were that both adapted better to the apical region of the post space and in oval canals had significantly higher bond strength in the coronal zone.(9) Eid *et al*, evaluated the effect of friction and adhesion on the thrust bond strength of CAD/CAM fiber-reinforced composite posts and cores and compared them with prefabricated fiber posts resulting in better adhesive strength for the fiber-reinforced ones, the prefabricated ones showed higher strength.(11) Perucelli *et al*, analyzed the fit through fabrication workflow (partial digital fabrication and metal casting through conventional methods) in which there are no significant differences between the posts and their fit to the root canal. However, partial digital CAD/CAM fabrication provided a fit within acceptable parameters with a shorter working time.(12) Webber *et al*, was another author to compare the bond strength of glass posts to rehabilitated circular and oval root canals using different post techniques and different interradicular levels with the result that the use of glass fiber posts (GFP) overlapping influences the bond strength showing higher values in both circular and oval root canals, and in the latter, it can improve their adhesion in either third.(13) Li *et al*, investigated the fracture resistance and retention of endodontically treated roots with widened canals restored with different post systems and showed that cast metal posts showed higher pull-out resistance but no significant differences in adhesion.(14) Porciani *et al*, observed significant differences in adaptation of fiber post diameters DT-#0 and DT-#1 at either level but no discrepancies at the same level of adaptation.(16)

5.3 Cement thickness variation

Another parameter to consider in the adaptation is the amount of cement between the spaces and voids that may exist between the post and the root dentin. Thus, several authors evaluate these parameters:

Park *et al* found that it does not significantly affect the bond between post and dentine. (8) Also, he evaluated the void volume of the cement to determine whether it affected bond strength, with a positive result that it was affected by root canal region, post type and cement, although there is no significant correlation between bond strength and void volume. (10)

Thus, Porciani *et al* found significant differences between cement thickness at different depths.(16) Bakaus *et al*, compared the bond strength between glass fiber posts and flared root canals reinforced with different materials. The materials used were composite resin (CRG), Bulk Fill (BFG), bonding cement (SAG) and glass ionomer (GIG). The highest bond strength value was for the positive control group (PCG) and the lowest value was for the negative control group (NCG) and GIG. Higher bond strength values were obtained when root reinforcement was performed with conventional composite resins and block filler. The block-filled resin was the only treatment able to maintain high bond strength values in all regions of the root canal and root reinforcement with this type of resin is most effective for root canals widened prior to cementation. Among the other groups CRG had the highest bond strength value followed by SAG and GIG. (17)

Gomes *et al* observed in their study that lower cement thickness gave better adhesion and fewer voids in well adapted posts and therefore better adaptation.(19). Zsuzsanna *et al*, evaluated the variation of cement thickness in different regions of the root. In the case of prefabricated and custom-made posts the result was (20)

ArRejaie *et al*, in their study, determined the variations in void and gap formation around prefabricated fiber posts cemented with two different materials and using different techniques in which they found no significant differences within the experimental groups.(21)

6. LIMITS

This integrative systematic review has some limitations.

The search methodology may have excluded relevant articles, due to the use of a single database (PUBMED), this problem was minimized by searching the bibliographic references of the selected studies and using other alternative databases.

The studies included in this integrative systematic review are based on in vitro studies, there is only one ex vivo study, which can demonstrate more accurate data.

In the absence of previous studies relating these two variables, void volume, and push-out bond strength, it is not possible to compare the finding with previous studies. In the micro-CT studies, only a small number of samples are used due to the cost of micro-CT analysis; future studies should be conducted with larger study groups.(10)

Generate a standardized method for storing teeth for use in studies investigating their physical or chemical properties has not yet been established. However, despite these considerations, the major limitation of laboratory studies is that they do not fully replicate the variables encountered in a clinical setting.(8) The manufacturer's recommendations and the properties of the materials are limitations for conducting the studies due to humidity conditions and chewing forces that do not reproduce oral conditions. (11,14)

Most studies use two-dimensional methods to measure root canal diameters, which makes visualization of the canal anatomy relatively difficult. The use of CBCT or Micro-CT ensures more accurate classification and visualization of canal. (13) Clinical conditions and crown morphology of the teeth under study may alter the results of the studies. (19)

Only 1 composite resin CAD-CAM block and 1 type of milling bur were used. Therefore, the findings must be interpreted with caution. (16)

7. CONCLUSION

The null hypothesis that there is difference in the fit of prefabricated posts and CAD/CAM posts

Oval canals show greater difficulty for post adaptation than circular canals. Adhesion strength showed higher adaptation values at the apical level than at the coronal level in oval canals with oval posts.

Instrumentation systems, files and ultrasonic tips do not improve the adaptation of the post in the root canal.

In the preformed post systems, there were significant differences in the diameter of the posts. CAD/CAM manufactured posts show better fitting results than prefabricated posts and show higher values for stiffness, yield strength and strength.

There is no significant correlation between bond strength and volume of spaces, nor between the use of cement with any intraradicular post system. Less thickness in the cement layer improves the adaptation of the post to the root canal.

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