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Review Article

Cement selection criteria for different types of intracanal posts

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ABSTRACT

Background: To consciously select an appropriate dental cement for each type of intracanal post.
Materials and Methods: An electronic search was carried out (1970 to 2020) through Medline, PubMed, Scopus, and Google Scholar. The following keywords were searched in title, abstract, or keywords with different combinations: endodontically treated tooth, root canal therapy, dental posts, post and core, prefabricated posts, custom posts, dental cement, resin cements, cement selection, cement, and adhesive resin cement.
Results: Evaluating full texts, 146 articles were selected to review the types of posts and cements, selection criteria of appropriate cement for each type of post, and compare the results obtained by different cements.
Conclusion: Dental cements affect the survival rate, durability, and success rate of postbased treatments. Considering special characteristics and application of each type of intracanal post, conscious selection of cement is an important determining factor in long-lasting success. Choosing an appropriate cement has a key role in success and durability of dowel posts-based fixed restorations.

Key Words: Dental cement, glass ionomer cements, post-core technics, zinc phosphate cement, resin cement

INTRODUCTION

One of the most prevalent methods for restoring an endodontically treated tooth (ETT) with inadequate remaining structure is to use dowel post and core complex. The concept of using a root canal to provide retention for core material was the first expressed in 1700_s by Pierre Fauchard,[1,2] who suggested to use metallic "tenons" posts screwed into root canal.[3] In 1800_s, several researches focused on increasing crown retention by posts application.[1] Posts, generally, could be classified to prefabricated or custom-made, and metallic or nonmetallic with their related subcategories. Prefabricated metallic posts, the oldest version of intracanal posts, had some limitation in esthetic zone,[4] as well as the risk of toxicity, the possibility of corrosion, and allergic reactions;[5,6] nonmetallic posts were introduced to overcome these deficiencies.[7] However, several failures in the treatment of endodontically treated teeth in the current century[1] put a significant question mark in front of the applications of dowel post. Some studies claimed posts could concentrate stress, and lead to root fracture.[8-11] Other reported gingivitis,[12,13] periodontal disease,[14] fracture of core,[12] fracture of

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post,[12] loss of retention,[14,15] and caries[14,16] as the complications of post-based treatment, and introduced gingivitis,[12] and root fracture[15] as the most prevalent complications.

Although some treatment alternative namely "Richmond crown"[1,17] and "Endocrown" were introduced in 19th and 20th centuries, post-based restorative options are still among the most prevalent treatment options used in every day dentistry. The improvement in scientific criteria resulted in an ever-increasing introduction of different materials and methods for post fabrication to maximize the profits, and minimize the potential risks. However, long-term successful results, and predictable retention without stress concentration inside the remaining root structure mainly return to appropriate cement selection. Considering the varieties of available cements with special characteristics [Table 1], the present review focuses on comparing different types of dental cement, according to their selection and application criteria for different types of posts.

MATERIALS AND METHODS

An electronic search was carried out (1970 to 2020) through Medline, PubMed, Scopus, and Google Scholar. The following keywords were searched in title, abstract, or keywords with different combinations: ETT, root canal therapy, dental post, post and core, prefabricated post, custom post, dental cement, resin cement, cement selection, cement*, adhesive resin cement. Using reference management software (Endnote X8, Thomson Reuters), duplicated studies were eliminated, and the most relevant articles were chosen based on inclusion criteria: English articles focusing on different types of posts and dental cements, and selecting appropriate cement for each type of post. The studies addressed extra canal posts, or other characteristics of intracanal posts were excluded, as well as studies on other direct or indirect restorations.

RESULTS

The numbers of search results for the selected keywords were 1580 (PubMed), 18,000 (Google scholar) and 3105 (Scopus). After duplicate removal and title/abstract analysis, 317 studies were selected for full-text review. Finally, 146 studies met the requirement of inclusion/exclusion criteria and were included to be discussed.

Table 1: Properties of different types of cement

Cements	Chemical content	Compressive strength	Tensile strength	Solubility (weight% at 24 h)	Setting time (min)	Modulus of elasticity (GPa)	Bond to tooth	Mikroleakage	Retention	Film thickness
Zinc phosphate	Phosphoric acid liquid + zinc oxide and magnesium oxide powder[18]	62-101 MPa[18]	5-7 MPa[18]	0.2[19]	5-9[19]	13[19]	No[18,19]	High[7,18]	Moderate[7,18]	<25[7,18]
Zinc polycarboxylate	Polyacrylic acid + zinc oxide and magnesium oxide powder[18]	67-91 MPa[18]	8-12 MPa[18]	0.06[19]	7-9[19]	5-6[19]	Moderate chemical[19,22]	High to very high[7,18]	Low to moderate[7,18]	<25[7,18]
GI	Aluminosilicates in the powder + polyacrylic acid and tartaric acid[18]	85-126 MPa[18]	6-7 MPa[18]	1[19]	6-8[19]	7-8[19]	Chemical[19]	Low to very high[7,18]	Moderate to high[22]	<25[7,18]
Resin-modified GI	Resin and GI[18]	93-226 MPa[18]	13-24 MPa[18]	0.7-0.4[19]	5.5-6[19]	2.5-7.8[19]	Chemical[19]	Very low[7,18]	Medium[22,23]	>25[7,18]
RC	Diluted composite resin + additive adhesive monomers	179-250 (high[24])	High[24]	0.05[19]	4+[19]	4-6[19]	Micro-mechanical[19]	Very low[7,18]	High[22]	<25[25]

GI: Glassionomer; RC: Resin cement

Dental cements provide retention for indirect restorations by chemical or mechanical bonding, or simply, filling the space between the restoration and tooth structure, physically.[26] Intra canal posts provide retention for core materials; however, its own retentiveness should be passively provided by dental cements. Different dental cements are available with varieties of properties to be used:

Zinc phosphate cement (ZP), introduced in 1800s, is the oldest luting cement.[19,27] Low tensile strength,[18,19] high degree of solubility (0.36%),[19] high compressive strength, and elastic modulus,[18] low cost, and early strength are among the properties. After 1 h, ZP has the lowest PH (about 1.2),[18,19] that increases to 5.5 after 24 h.[18] In patients with acid reflux problems, and in vital teeth with low residual dentin thickness, this cement should be used carefully.

Zinc polycarboxylate cement (ZPC), introduced in 1968,[28] was the first cement that exhibited chemical bond to tooth structure, and according to increasing pH after mixing, it was very biocompatible.[22] However, weak bond to enamel and dentin,[18] and low compressive and tensile strength,[18,20] make it inappropriate for single-unit restorations or long-span fixed partial dentures.[18]

Glass ionomer cement (GI) was introduced in 1969 under the name of aluminosilicate polyacrylic acid.[19] Enamel and dentin adhesion, fluoride release, low bonding strength, moderate compressive strength, low tensile strength, and high solubility are among the properties.[18,19] GI could be indicated in varieties of restoration namely all-metal/PFM crowns, short span fixed partial denture, alumina/zirconium-based all-ceramic restorations, and Metal post and core.

Resin-modified GI (RMGI) was introduced to overcome GI sensitivity to early moisture contamination and high solubility rate. In this combination of resin and conventional GI,[21] adhesion to tooth structure was improved as well as compressive/tensile strength, solubility, and post-cementation sensitivity.[29] RMGI has a wide range of applications; however, in traditional feldspathic or pressable ceramic restorations should be used with caution.[18]

Resin cement (RC) was introduced in mid-1970s as an acid-base reaction cement.[30] High compressive, tensile, and bonding strength, esthetics, and low solubility, candidate this cement for esthetic or compromised situations.[31] RCs could be classified to conventional, self-etch, and self-adhesive types [Figure 1].[7,32] In conventional (total etch or etch-and-rinse) RC, etching process happens as a separate stage, and after rinsing, adhesive, or primer-adhesive is applied on tooth structure before cement application. Self-etch primer, used in self-etch RC, is a combination of acidic monomers, phosphate esters, and primer. These cements might be used in 2 or 3 steps. Self-adhesive (all-in-one) RC combined all the steps in one tube to reduce the technical sensitivity, and facilitate the process. However, the research reported lower bond strength for this type.[33-36]

Appropriate cement selection calls for knowing the cements properties [Table 2], and posts requirements. For bonding a post to root canal using RC, the cement has to be bonded to dentin structure. Conventional RC reported to provide high, predictable, and durable bond strength to enamel,[55-57] while bonding to dentin represents a greater challenge.[58] Dentin is a wet organic tubular tissue that communicates with dental pulp. All RCs have been reported to cause marginal leakage when used on this dynamic structure.[58] Micromechanical retention of RC to dentin is provided by the formation of hybrid layer between demineralized collagen fibers and cement, and also resin tags. The quality (thickness and uniformity) of hybrid layer determines the bond strength. Unlike self-etch RC, conventional RC proved to provide a thick uniform hybrid layer.[59] On the other hand, self-etch RC penetrates deeper into the dentin compared to self-adhesive type.[60] Morphological imaging has demonstrated a thin hybrid layer formation in self-etch RC, but no hybrid layer or resin tag in self-adhesive type.[33,61-66]

However, there are controversial results on preferred RC for dentin bonding. Some studies indicated self-etch cement as the preferred RC for dentin bonding,[57,66,67] while others gave more priority to self-adhesive RC.[68-70] It has been reported that in the presence of smear layer, self-adhesive RC provides a weak bond with dentin,[68] and self-etch cement is preferred under such situation to provide an acceptable bond with smear layer, improve fluid content of dentinal tubules, and reduce the amount of dentin decalcification.[51] In spite of all of these controversies, all types of RC,

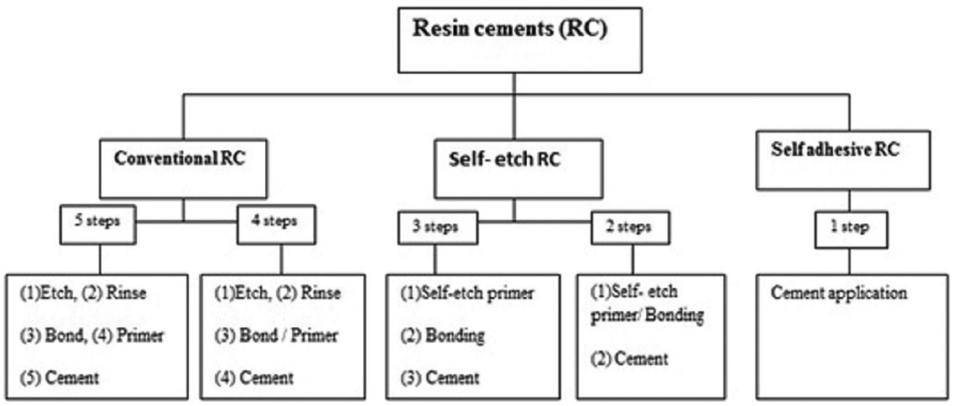

Figure 1: Resin cements classification.

Table 2: Advantages and disadvantages of available dental cements

Cement	Advantages	Disadvantages
ZP	Nonexpensive[37] Easy to manipulate[37] Quick to use[37] Relatively no technical sensitivity[37] Reliable retention[37] Weak enough to remove the post if necessary[37] Easy clean-up of excess cement[37]	Does not adhere to tooth or post[37] Brittle[37] Soluble in time[19,37] Vulnerable to microleakage[17,37-39] Does not release fluoride[37]
GI	Adhere to dentine[37] Release fluorid[19,37] Nonexpensive[37] Easy to manipulate[37] Low film thickness[17,37] Easily cleanable for excess cement[37] Proper choice for patients with gastric reflux problems or want their teeth to be bleached[40,41]	Vulnerable to dehydration and elution of calcium and aluminum ions in exposure to excess moisture[37,38] Brittle[37] Retention of post might be unreliable[37]
Resin-modified GI cements	Increased retention[18,14,37] Adherence to metallic posts and root dentin[37] Fluoride release[37] Easily cleanable for excess cement[37]	More expensive than ZP or GI cements[37] Calls for application of primer or adhesive[37] Difficult or impossible to remove post, if required[37]
Conventional RCs (etch and rinse)	Highest bond strengths to enamel[42] High bond strengths to dentin[43]	High technique sensitivity[42,43-46] Possibility of postoperative sensitivity of tooth[47,48]
Self-etch resin cements	Higher bond strengths to dentin[36] Easy to use and fewer steps requirement[49] Low technical sensitivity[50]	Lower bond strength to enamel compared to etch and rinse system[51]
Self-adhesive resin cements	Lower technique sensitivity[51,53] Fewer steps are required[50-53] No pre-treatment is required[54]	Lower bond strength[33-36] Low rigidity and visco-elasticity[20]

ZP: Zinc phosphate; GI: Glassionomer; RCs: Resin cements

including self-adhesive types, produce adequate bonds to dentin.[51] Bond strength of etch and rinse cements (20–35 Mpa), self-etch (10–35), and self-adhesive (20–30 Mpa) are all in acceptable clinical ranges.[59]

The type of restoration also plays an important role. Total-etch RC is often preferred in indirect restorations especially in the presence of large areas of enamel, while self-etch adhesives are recommended for direct restorations, and predominantly on dentinal bed.[58] According to these controversies, more clinical long-term evaluations are needed.

DISCUSSION

Selecting a proper dowel post depends on various factors namely the amount of remaining tooth structure, tooth anatomy, position, functional requirements, root length, width, and configuration, potential torquing force, dowel post design and material, bonding capability, esthetics, and restoration type.[71,72]

Prefabricated posts and recommended cements

Prefabricated posts are indicated when sufficient width and length of root structure has been preserved, the

root has circular cross-section, and severe root canal undercuts prevent cast posts application.[73] Metallic prefabricated posts could be routinely cemented by conventional cements.[73-76] However, dual-cure RCs have been recommended for nonmetallic types,[67,77] or when higher retention is desired.

A. Metallic post has been using during the past 20 years, and divides into three subgroups based on material type: titanium, stainless steel, or brass. Conventional permanent cement (ZP and GI) could be used for these posts.[73] However, there are controversies in comparison between ZP and RC. Some studies reported better retention for RC,[78] while the others gave more priority to ZP in these posts;[74-76] there are other studies not recommend RC for clinical application in posts.[73]
   a. Stainless steel and brass posts are rigid and strong, and are not appropriate when minimal tooth structure remains.[7] They might form corrosion products, and lead to root discoloration[79]
   b. Titanium post, introduced to reduce the possibility of corrosion,[7] has low fracture strength (that make it contraindicated in thin root canal), and close radiodensity to gutta-percha.[7]

B. Nonmetallic posts are either made from ceramics (zirconia or alumina),[80] or a combination of resin matrix and reinforcing fibers (carbon, glass, or quartz).[81] They were introduced to provide more favorable esthetics,[82] or close elastic modulus to dentine compared to metallic dowel posts[81] to reduce the risk of root fracture and increase the survival rate.[83]
   a. Zirconia post, composed of zirconium oxide, is an all-ceramic post with high flexural strength, elastic modulus,[84] and toughness.[85-87] It could be indicated in esthetic area;[32,88] however, inherent brittleness, limitates its application.[89] There is inherent deficiency in retention of these posts considering the smooth surface,[78] and insufficient bonding to RCs.[90-94] However, RC provides higher bond strength compared to GI cement,[95] and the RC with phosphate monomer content, proved to be more reliable for bonding zirconia[96]
   b. Fiber reinforced posts show high success rate with reduced risk of root fracture by their close toughness to dentine.[97] Self-adhesive RC has been suggested as the cement of choice for fiber posts with high bond strength.[97] However, other researches proved better results using etch-and-rinse dual curing adhesive system, compared to self-adhesive or self-etch RC or GI cements.[98-102] A company have suggested dual-cure flowable hybrid composite for cementation of fiber posts.[103]
   i. Fiber reinforced resin-based composite (FRC) post reduces the risk of toxicity,[31,104] and by their close modulus of elasticity to dentine,[105-107] reduces the possibility of root fracture. Moreover, FRC posts can be removed easily for retreatment if necessary.[88-108] Bonding with tooth structure causes good distribution of occlusal forces.[109] However, FRC post has low physical strength. The most reliable cement for this group of posts is etch-and-rinse dual-cure RCs.[110]
   ii. Polyethylene fiber post (PFP), introduced as an alternative to stainless steel and zirconia posts with less micro-leakage,[111] is made from ultrahigh molecular weight polyethylene woven fiber ribbons.[112] Tooth structure protection, and reduced risk of root fracture have been mentioned as advantages.[106] Eskitaşcioğlu *et al*. reported minimum stress within PFP compared to cast post and core system; and suggested these posts for restoration of apically resected teeth[113]
   iii. Carbon fiber posts (CFP), introduced in 1998,[114] was the first nonmetallic postintroduced. CFP consists of bundle of stretched carbon fibers embedded into an epoxy matrix.[72,73,115]
   iv. Glass fiber (GF) post is made from silicate glass (electrical, or high-strength glass), or quartz fibers,[116,117] and different types of matrices (polymethylmethacrylate or epoxy resin).[118] Silicate glass ceramic post has better esthetic, that could even be enhanced by using epoxy resin as matrix.[88] Quartz (Glass) fiber post could be preferred over CFP for ease of application and removing, and clinicians preferred to use them because of their esthetic biocompatibility.[119] Self-adhesive RCs have been recommended by some companies[120] One study claim that RMGI could be indicated for GF posts.[37] Table 3 summarizes the recommendations of different companies for selecting proper type of cement for each type of posts.

Table 3: Manufacturers' recommendations for proper type of cement in each type of post

Classification of posts	Manufacture of posts	Recommended type of cement
Metallic prefabricated		
Titanium	A-UCR-330-EX (Sweden and martina implantology)[121] ParaPost X Posts (Coltene/Whaledent)[122] Dentatus Classic Surtex® Posts (Dentatus)[123]	Self- etch RC[122] Self-adhesive RC[124,125] Self-curing GI cement[126]
Stainless steel	Parapost (Coltene/Whaledent)[122]	
Brass	Dentatus Classic Surtex® Posts (Dentatus)[123]	
Nonmetallic prefabricated		
Fiber reinforced posts	TENAX® Fiber Trans (Coltene/Whaledent)[127] Para post Fiber Lux (Coltene/Whaledent)[127] Para post Taper Lux (Coltene/Whaledent)[127] RelyX™ Fiber Post (3M ESPE)[128] EZ-Fit Translucent (Essential dental system)[129] DT Posts (VDw Dental)[130]	Self-adhesive RC[103,124,127,132] self-etching RCs[103] Dual- and self-cure RCs[127] Light-curing RC[127]
Zirconia	Cosmopost (Vivadent)[131] Snow post (Snow post)[7,133]	
FRC	Marco- lock (RTD dental)[103]	
Glass- fiber	FibreKor Posts (Pentron)[133] Lucent anchor (Dentatus)[122]	
Quartz fiber	Aesthetic-Plus (RTD/Bisco)[7,133] D.T. Light-Post (RTD/Bisco)[7,133]	
Carbon fiber	C-Post (RTD/Bisco)[7,133]	

GI: Glassionomer; RCs: Resin cements

Custom posts

Custom posts are indicated when moderate-to-severe coronal structure has been lost, root canal has noncircular cross section,[72] the core has different angle to the post, core retention on post is compromised duo to tooth size, and when multiple post and core are to be made in the same patient.[72] A company recommended self-adhesive RC for metallic customize posts;[134] however, considering the adaptation of these types of posts to the root canal, all types of cements could be used for custom posts.[22,135] One study found ZP and GI to be more retentive than ZPC or even RC.[75] Another study claimed that GI is inappropriate for casted intracanal posts considering the insufficient strength.[136]

A. Metallic custom post is a very strong and retentive choice especially for small tooth, as the core is an inherent part of the component. Poor esthetics, risk of corrosion and fabrication inaccuracy, and difficult retrieval could be mentioned as disadvantages.[73]
   a. Precious alloy post contains silver, palladium, and gold,[137] is corrosion resistant, highly biocompatible, and suitable for hypersensitive patients.[138]
   b. Nonprecious alloy posts include the posts fabricated from nickel–chrome, chrome-cobalt, and nonprecious gold color alloy (NPG). Nickel–chrome alloy might be electrolytically etched to enhance micro-mechanical bonding for RCs.[139] NPG alloy with its golden color has been introduced as an alternative for precious alloys with lower cost.[26] It has been claimed to have acceptable durability and thermal resistance, excellent fit, good biocompatibility, and easy adjustability, soldering, and finishing capacity.[26] However, it shows high corrosion susceptibility,[25] that might lead to significant discoloration, and potential cell toxicity.[80]

B. Nonmetallic all-ceramic custom post, made from high-toughness ceramic materials such as alumina or zirconia, is very biocompatible, does not exhibit galvanic corrosion, and provides significantly enhanced esthetic; but it has low fracture strength and toughness.[80] Dual-cure adhesive RCs have been recommended for this type of posts.[131] Self-curing RC and conventional cements (ZP, GI, RMGI) could also be used for ceramic custom posts.[131] Self-adhesive RC has been suggested for these posts; with higher bond strength compared to conventional cements.[126,134,140] Table 4 summarizes the characteristics of different types of post.

Cement selection criteria

Dental cement in indirect restorations could be considered as an important determining factor affects retention, stability, survival, esthetic, and also patient satisfaction. The selection of appropriate cement could even be more important in intracanal posts; as in post-based restorations, not only the durability of

Table 4: Characteristics of different type of intracanal posts

Type	Subcategory	Advantages/indications	Disadvantages/contraindications
Prefabricated posts	Metallic		
	Titanium	Preservation of tooth structure[141]	Possibility of corrosive or allergic reactions[5,6]
	Stainless steel		Same radiodensity as Gutta-Percha[7]
	Brass		Low fracture strength (titanium)[4,7,104,142]
	Nonmetallic		Contraindicated in thin canal[7]
	Esthetic		
	Ceramic posts		
	Zirconia	Esthetic[32,88,143] High fracture toughness[76] Excellent resistance to corrosion[76] High flexural strength[76,88] High elastic modulus[84] and toughness[85-87] Good chemical stability Good biocompatibility	Weaker than metallic posts[7] Less conservative of tooth structure[7] Endanger the core retention[30,144] Poor resin-bonding capability[93,145]
	Fiber reinforced posts		
	Polyethylene	Decrease possibility of root fracture[146,147] Less microleakage than zirconia and stainless-steel posts[112] Indicated in teeth with apical resection[146,147] High elastic coefficient[146,147] High resistance to stretch and distortion[147]	Very expensive[112]
	FRC	Reduced risk of toxicity[31,104] Close modulus of elasticity to dentine[105-107] Can be used in esthetic zone[104] Easy to remove and retreat[88,108] Good bonding with tooth structure[109]	Low physical strength[104]
	Glass-fiber		
	Silicate	Better esthetic than quartz fiber posts[88] Biocompatibility[88] Dentin bonding[88]	Esthetically weaker than FRC posts[88] Low strength[88] Debonding[88] Uncertain clinical performance[88]
	Quartz	Easy to use and manipulation[88] Easy to remove for retreatment[88]	Debonding[88] Moderate strength[88]
	Nonesthetic		
	Carbon fiber	Close modulus of elasticity to dentine[7,88,148] Reduce the possibility of root fractures[7,82,148] Easy to remove[149] Reduce the risk of toxicity[31] High tensile strength[88]	Should not be used in esthetic zone[7,88,148]
Customize posts	Metallic		
	Nonprecious alloy		
	Nickel-cobalt	High success rate[150,151] Good choice for misaligned, or small teeth[7] Easy to remove[7]	Contraindicated in high esthetic zone[4,7] More time and cost[7] Possibility of allergic reactions[5,6]
	Chrome-cobalt		
	NPG color alloy	Cost effect[26,152] High durability[26,152] High thermal strength[26,152] Excellent fit[26,152] Easy soldering[26,152] Biocompatibility[26,152]	High corrosion reaction[26] Uncertain and insufficient documented evidence
	Precious alloy		
	Platin-palladium	Highly biocompatible[138] Suitable for hypersensitive patients[138] Repair option[138]	Expensive
	Palladium-silver		
	Gold		
	Nonmetallic		
	All ceramic	Excellent aesthetics[73] Excellent biocompatibility[73,80] Low fracture strength and toughness[80] No galvanic corrosion[80] Good radioopacity[73]	Brittle[73] Not appropriate for bruxism patients[73] Very rigid[73] High possibility of root fracture[73]

NPG: Nonprecious gold; FRC: Fiber reinforced resin-based composite

intracanal posts but also the survival and durability of restorative treatments depend on post retention. There are a wide range of prefabricated or custom posts types/materials introduced in an ever-increasing manner in the last decade. The same varieties exist in available cements, especially when it comes to resin luting cements.

Conventional or resin cements?

In general, when an intracanal post has high degrees of adaptation in the root prepared canal (custom post), or the strength of post is not affected by bonding to tooth structure (e.g., metallic post), or esthetic is not a determining factor, conventional cements namely GI and ZP might provide acceptable retention.[8,19,29] RMGI could provide higher retention,[8,15,37] and ZPC cement could be indicated for situations where retrievability is predicted in dowel post-based treatments.[7,18] These conventional well-known cements with a long history of application, are easily accessible, less expensive, and less technique sensitive that candidate them for routine dental applications.[37] However, there are situations where higher retention, strength, or esthetic call for the application of RCs. Considering the variety of types and characteristics of these cements, conscious selection is important to guarantee the long-lasting success.

Which type of resin cements?

Some RC proved to provide higher and more durable retention (total etch cements),[51] while the others could facilitate the cement application in cementing a dowel post intra root canal (self-adhesive cements),[153] or control the acid penetration or dentin desiccation during cementing process (self-etch cements).[51] Some RC provide immediate and predictable complete polymerization (light-cure RC), while the others could be used when full light penetration is not assured (dual- or self-cure RC).[51] The selection between these cement types call for knowing the characteristic of different dowel posts, and clinical requirements.

The present review tried to provide a document-based information to select an appropriate cement based on dowel post material/type classifications. Long-term studies focused on the changes that occur in cement characteristics over the time, and the behavior of different cements under challenging conditions (e.g., short roots, abnormal dentin structure, excessive applied forces, or potential material deteriorations) are suggested to provide sound and reliable choice of cements for different types of dowel posts. Table 5 summarizes outcomes of studies on different cements.

Table 5: Outcome of some studies on different cements retention for post and cores

Author	Type of post	Compared cements	Conclusion
Habib *et al.*, 2005[154]	Custom cast posts	ZP and self-etch dual RC	ZP had higher retentive values compared to RC
Duncan and Pameijer, 1998[155]	Parallel titanium posts	RC, ZP, GI, and RMGI	RC provided higher retention than others
Chan *et al.*, 1993[156]	Stainless steel para-posts	ZP, ZPC, GI, RC	Stainless steel posts cemented with RC exhibited higher resistance to dislodgement by vertical tensile forces
Cohen *et al.*, 1999[157]	Stainless steel posts	RC and ZP	Stainless steel dowels have been shown to be more retentive than carbon fiber posts when cemented with either RC or ZP cement
Lencioni *et al.*, 2010[158]	Pure titanium posts	Self-etch RC, self- adhesive RC, ZP	Posts fixed with self-adhesive RC presented superior bond strength compared to ZP and self-etch cements
Ubaldini *et al.*, 2018[159]	Fiber posts	Etch and rinse RC and self-etch adhesive RC	Etch and rinse RC provided higher retention for fiber posts
Radke RA, 1988[74]	Cast gold posts	ZP, GI, ZPC	ZP and GI cements were found to be more retentive than ZPC
Sahmali *et al.*, 2004[160]	Ceramic posts and carbon fiber posts	Self-etch RC, RMGI, GI	Self-etch RC had significantly higher bond strength than two other cements
Hagge *et al.*, 2002[161]	Prefabricated post (paraposts)	Self-etch RC, ZP	Self-etch RC demonstrated higher retention than ZP
Bonfante *et al.*, 2007[37]	Glass fiber posts	RMGI, dual-cure RC	RC provided higher tensile bond strength for glass fiber posts
Menani *et al.*, 2008[162]	Cast posts (gold alloy-pure titanium)	ZP, RC	Both cements provided similar mean tensile retention
Cohen *et al.*, 1998[163]	Flexi-post, access post, titanium post	Composite cement, ZP, advance, duet, and GI	Composite cement provided higher retention for all types of posts
Sen *et al.*, 2004[164]	Prefabricated posts (ParaPost, Flexi-Post)	Etch and rinse RC, ParaPost Cement, Flexi-Flow Natural, and ZP	Flexi-post showed significantly higher retentive strengths compared to non-threaded posts RC significantly increased the dowel retention compared to ZP
Ertugrul and Ismail, 2005[76]	Cast metal posts	RC, ZP	ZP cement provided greater tensile bond strength than RC with and without silane coating agent

ZP: Zinc phosphate; GI: Glassionomer; RC: Resin cement; RMGI: Resin-modified glass ionomer

CONCLUSION

Considering the limitation of this review, the following conclusions could be derived:

1. Conventional cements could be used safely for metallic prefabricated posts; in nonmetallic posts, or in situations with extensive coronal destruction, or higher retentive demands, dual-cure RCs have been recommended as appropriate alternative
2. Etch-and-rinse RC provides higher retention with predictable durability, but the retention provided by self-etch or self-adhesive RCs could still be acceptable in normal clinical situations
3. RCs containing functional phosphate monomer are the most appropriate adhesive cement for zirconia prefabricated or custom posts
4. Considering the perfect adaptation, all types of cements could be used for custom posts; however, conventional cements are preferred for metallic, and adhesive resin for ceramic posts.

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Conflicts of interest

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