REVIEW ARTICLE

Mechanical Properties and Clinical Success of Intracanal Posts in Primary Maxillary Anterior Teeth: A Systematic Review and Meta-analysis

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Abstract

Background: Intracanal posts are commonly used to restore lost permanent/primary tooth structure and the smile of the patient.

Aim: This systematic review aims to evaluate the clinical success of intracanal posts used in primary maxillary anterior teeth and compare their mechanical properties.

Methods: An extensive literature search was performed using Medline *via* PubMed, Embase *via* embase.com, LILACS, CINAHL *via* EBSCO, Cochrane Oral Health Group Specialized Register, Scopus, and Web of Science until December 2021 and was updated till December 2022. *In vivo* and *in vitro* studies in the English language that assessed clinical success and mechanical properties were included. Distiller SR software was used for everything from title screening to data extraction.

Results: A total of 30 studies were analyzed, including 11 *in vivo* and 19 *in vitro* studies. Four studies were included in a meta-analysis, and all 30 studies qualified for qualitative analysis. The meta-analysis showed that fiber posts are clinically superior to composite resin posts (CRPs) ($p = 0.02$). No significant difference was observed between the fracture resistance of CRPs and no posts ($p = 0.73$). Most of the included studies showed a high risk of bias.

Conclusion: Conclusive evidence about the effectiveness of various intracanal posts cannot be established. This is due to the limited number of clinical trials and included studies of low to moderate quality with a high risk of bias. To validate the use of posts in primary maxillary anterior teeth, further research, including randomized controlled trials (RCTs) of higher quality, is required.

Clinical significance: The use of intracanal posts in primary teeth is a commonly used treatment modality among pediatric dentists. However, the quality of the evidence to support its use is low. This systematic review provides a comprehensive summary of the current literature and highlights the need for further research. Results were interpreted with caution, as the evidence supporting the use of intracanal posts in primary teeth is limited.

Keywords: Post and core technique, Primary teeth, Survival rate.

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Introduction

Early childhood caries (ECC), previously known as nursing bottle caries and baby bottle tooth decay, continue to remain an important threat to public health.[1] Primary anterior teeth are the most frequently affected teeth as a result of ECC.[2] When ECC is not managed over an extended period, it may lead to severe tooth structure loss.[2,3] According to the American Academy of Pediatric Dentistry guidelines, due to the distinctive and rampant nature of ECC, immediate treatment is needed to prevent further destruction and resulting health problems.[3] Another prevalent cause of tooth structure loss in primary maxillary anterior teeth is crown fractures due to dental trauma.[4,5] Additional implications include interfering with the pattern of speech development, reduced masticatory efficacy, development of anomalous tongue habits, and malocclusion.[4]

Intracanal post and core systems are preferred to restore the lost permanent/primary tooth structure and smile esthetics of the patient.[6] Different types of posts have been applied for intracanal retention in primary teeth. These include resin composite posts (CPs),[6] orthodontic wires,[7] prefabricated metal posts,[8,9] nickel-chromium cast posts[9] with macroretentive features, biologic posts,[10] and fiber-reinforced posts.[10] Fiber posts were introduced

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in the 1960s.[7] The use of CP restorations began in 1986.[7] The use of Ω-shaped orthodontic wires is an efficient and simple procedure that adapts well to the canal walls of primary teeth. However, early detachment and fractures of the fragile root canal walls were anticipated.[8] Polyethylene fibers (Ribbond), a recently evolved material implemented in 1992, revealed a clinical advantage over conventional intracanal postmaterials.[9] Viera et al. utilized polyethylene ribbon fibers as root posts for reconstructing severely damaged primary maxillary anterior teeth because they are malleable and have superior fracture resistance without causing stresses.[10] In place of metallic prefabricated posts, a number of nonmetallic posts have been proposed, such as fiber-based posts with exceptional properties, such as biocompatibility with different core materials, fatigue and corrosion resistance, and improved tensile strength.[11] Glass fiber posts (GFPs) have excellent characteristics such as biocompatibility, fatigue endurance, and corrosion resistance as well as mechanical capabilities similar to dentin.[12]

Preserving primary teeth until exfoliation is important to retain a child's structural balance, functional integrity, and esthetic harmony, which has been successfully attempted and tested.[13] Studies using different posts for the rehabilitation of primary teeth have been extensively conducted for the reconstruction of grossly destructed primary anterior teeth. The question of whether or not posts should be used in primary anterior teeth remains unanswered as of yet. This review's primary objective is to provide an answer to the question that had been raised before. Thus, the systematic review aims to evaluate the clinical success of intracanal posts and compare the mechanical properties, namely, bond strength, compressive strength, retentive strength, and fracture resistance of various intracanal posts in primary maxillary anterior teeth. The null hypothesis stated that the clinical success of various intracanal posts used in primary maxillary anterior teeth was not different.

Methods

This systematic review was conducted and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-analysis 2020 (PRISMA) guidelines.[14] This proposal was submitted to the PROSPERO International Prospective Register of Systematic Reviews (CRD42021268823).

Focused Research Questions

- Primary research question: Among the intracanal posts used in children, which post used in primary maxillary anterior teeth showed better clinical success?
- Secondary research question: Which intracanal post used in primary maxillary anterior teeth showed superior mechanical properties?

PICOS Format

The following defines the focused PICO question: participants/patients (P)—children with endodontically treated primary maxillary anterior teeth; intervention (I)—endodontically treated primary maxillary anterior teeth were restored using different types of posts; and comparison (C)—different types of posts used in primary maxillary anterior teeth; outcomes (O)—primary outcome—clinical success rate (i.e., number of follow-ups) of intracanal posts in primary maxillary anterior teeth; secondary outcome—mechanical properties, namely, bond strength, compressive strength, retentive strength, and fracture resistance of various intracanal posts in primary maxillary anterior teeth; and study designs (S)—criteria for inclusion of studies in the review were *in vitro*, *in vivo* studies, and RCTs

Source of support: Nil
Conflict of interest: None

Objectives

The objective is to evaluate and compare the clinical success rate and mechanical properties of different types of intracanal posts used in pediatric dentistry.

Eligibility Criteria

Inclusion Criteria

- Studies that assessed posts in primary maxillary anterior teeth.
- All *in vitro*, *in vivo* studies and randomized controlled trials that assessed the different types of intracanal posts in primary maxillary anterior teeth will be included.
- Studies only in the English Language will be considered.

Exclusion Criteria

- Studies conducted on animal tooth specimens.
- Studies assessing primary posterior teeth.
- Studies reported in languages other than English.

Search Strategy

A systematic literature search was completed on seven electronic databases using broad MeSH terms and keywords until December 2021 and was updated again in December 2022 by two investigators. The seven databases searched were Medline *via* PubMed, Embase *via* embase.com, LILACS, CINAHL *via* EBSCO, Cochrane Oral Health Group's Specialized Register, Scopus, and Web of Science. The MeSH terms used were posts, intracanal posts, severely mutilated, primary anterior teeth, endodontically treated teeth, and pulpectomy. The following search strategy was used in MEDLINE and later adapted for other databases: (posts) OR (intracanal posts) OR (CPs) OR (mushroom-shaped posts) OR (onion-shaped) OR (metallic) OR (fiber) OR (nonmetal) OR (α-post) OR (γ-post) OR (Ω-post) OR (serrated post) OR (tapered post) AND (primary anterior) OR (primary maxillary anterior) OR (primary maxillary incisors) AND (endodontically treated) OR (pulpectomy). In addition, the referencing list of all the included articles and manual searching of some key journals such as the Journal of Endodontics, Journal of Clinical Pediatric Dentistry, International Journal of Paediatric Dentistry, Pediatric Dentistry, European Archives of Paediatric Dentistry, European Journal of Paediatric Dentistry, and Pediatric Dental Journal were performed. A gray literature search was conducted by screening the national database for dissertation abstracts (i.e., SHODHGANGA). Additional related studies were found after a manual search of the retrieved article's references. All references to the included articles from all the databases were uploaded into the Distiller SR software (Systematic Review and Literature Review Software by Evidence Partners), and duplicates were removed.

Selection of Studies

An initial screening of titles, abstracts, and keywords of the included studies was performed independently by two reviewers (YS and AR) using Distiller SR software (2022).

According to the fixed eligibility criteria, the studies were categorized into one of the following groups: included, excluded, and uncertain. Duplicates were removed automatically by Distiller SR software at the title screening level. The "uncertain" group included articles that required full-text screening because the abstract and title did not provide enough information to make a selection. As a result, the software was used to upload and screen the articles' full text for studies involving uncertain and included groups. After exclusion at various levels, the total number of included studies was determined, and The justifications for the exclusion were recorded. Any disagreements were settled at this point by a third expert reviewer (MSM).

Data Extraction

A prepiloted form, which is standardized, was used by two reviewers (YS and AR) to enter the extracted data from the included studies. Data extraction was performed separately for both the *in vitro* and *in vivo* studies. For the *in vivo* studies, the subsequent data was systematically obtained from the included studies: publication details (author name, author's country/continent, and year of publication), methodology (sample size, ethnicity, mean age), type of teeth assessed, number of operators, posts assessed, results (mean duration of the study, follow-up, randomization, and blinding), outcomes (based on clinical and radiographic success), and limitations. For the *in vitro* studies, the subsequent data was systematically obtained from the included studies: publication details (author name, author's country/continent, and year of publication), sample size, type of teeth assessed (storage medium, root length, reasons for extraction), number of operators, type of posts used, tests used, unit of expression, result, outcome (based on mechanical property/properties assessed), and limitations.

The "characteristics of included studies" were documented in a table. In cases of missing or unclear data, the corresponding author was approached directly by mail to retrieve the information. A third reviewer was consulted to sort out any disputes/disagreements between the first and second reviewers (MSM).

Risk of Bias and Quality Assessment

Two authors (YS and AR) independently assessed the risk of bias in the included studies. Disagreements were resolved by consensus with a third reviewer (MSM). The methodological quality of all included randomized controlled trials and *in vivo* studies was assessed using the Cochrane risk of bias tool 2.0 (RoB2).[15] For each item, the articles were classified as low risk (green circles), high risk (red circles), or some concern risk of bias (yellow circles) if sufficient information was not provided to allow adequate classification.

The methodological quality of all selected *in vitro* studies was assessed using the Risk of Bias tool given by Sarkis-Onofre et al.[16] The following parameters were assessed: randomization of teeth, use of teeth free of caries or restoration, materials used according to the manufacturer's instructions, use of teeth with similar dimensions, endodontic treatment performed by the same operator, description of the sample size calculation, and blinding of the operator of the testing machine. If the authors reported the parameter, the article had a "Y" (yes) on that specific parameter; if it is not possible to find the information, the article had an "*N*" (no) of articles that reported one to three parameters were classified as having a high risk of bias, four or five parameters as medium risk of bias, and six or seven parameters as low risk of bias.

Statistical Analysis

The collected data were summarized as the mechanical properties and clinical success of intracanal posts in the primary maxillary anterior teeth. The data were used to analyze the different posts used in the primary anterior teeth. Clinical heterogeneity was examined quantitatively in the decision to pool data from individual studies. Statistics were used to evaluate a meta-analysis of the included articles and data software (STATA) and was carried out after pooling qualitative data (percentage) for clinical success outcomes and obtaining summary quantitative values (mean and standard deviation) for mechanical properties. For quantitative and qualitative data, respectively, the pooled effect sizes of the mean difference and odds ratio were computed in the forest plots. The χ^2-test (χ^2) and *I*-square index (I^2) were used to assess heterogeneity at a significance level of $p = 0.05$. An I^2-value of >50% was considered indicative of substantial heterogeneity. The inverse variance random-effect approach was used for quantitative synthesis if more than four studies could be pooled or if high heterogeneity was found; otherwise, a fixed approach (inverse variance for continuous variables and Mantel–Haenszel method for binary variables) was planned if fewer than four studies existed.

Results

Study Selection

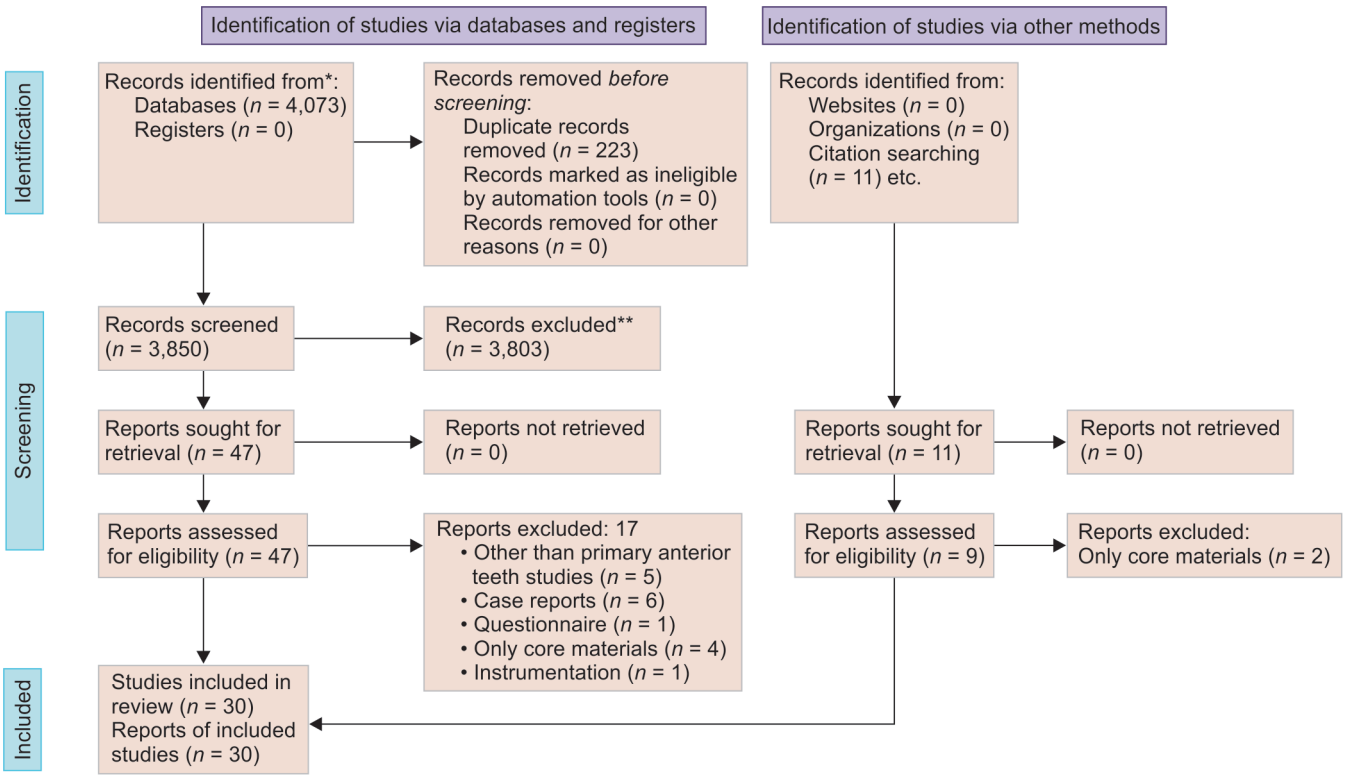
The study selection process is given in the PRISMA 2020 flowchart in Figure 1. The search yielded 4,073 articles, of which 4,052 studies were found through an electronic database search and 21 studies were found through other sources (hand searching, gray literature, and cross-referencing). After removing duplicates, 3,850 reports were reviewed for their titles and abstracts. Of these, 3,803 studies were excluded, resulting in a total of 47 full-text screening studies. Following full-text screening for eligibility, 17 articles were excluded for various reasons (e.g., permanent teeth, case reports, only core materials, instrumentations, and questionnaire types). Finally, 30 relevant studies were identified for inclusion in the review, of which 19 were *in vitro,* and 11 were *in vivo* studies (including clinical studies and randomized controlled trials). The characteristics of the included studies are presented in Tables 1 and 2, respectively. Qualitative synthesis included 30 studies, whereas quantitative synthesis included four studies (two *in vitro* and two *in vivo*).

Study Characteristics

A total of 30 included studies were conducted in Iran, the United States of America (USA), Brazil, India, Japan, Turkey, Boston, Syria, China, Australia, Egypt, and Saudi Arabia. The included studies provided data on 1,632 primary maxillary anterior teeth from 303 individuals. The language of publication of all the studies was English. All included articles were published between 2002 and 2021.

In Vivo Studies

Among the 30 included studies, 11 were *in vivo* studies that assessed the clinical and radiographic success of various posts in the primary maxillary anterior teeth. The overall sample size ranged from 28 to 144 patients, involving only the primary maxillary anterior teeth. Follow-ups ranged from 3 to 30 months. The posts evaluated were CPs (two studies evaluated),[17,18] GFPs (six studies evaluated),[9,17–21] polyethylene fiber posts (PFPs) (two studies evaluated),[18,22] orthodontic wires (three studies evaluated),[6,23,24] and metallic posts (two studies evaluated).[9,25] Only two of the 11 studies reported



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers)
**if automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

Fig. 1: Preferred Reporting Items for Systematic Reviews and Meta-analysis 2020 (PRISMA) flow diagram of the study selection process

the longest follow-up period of 30 months, which was observed in fiber core posts and PFPs.[7,21] Five comparative and six clinical studies were conducted.

In Vitro Studies

Among the 30 included studies, 19 were *in vitro* studies that assessed the mechanical properties of various posts in primary maxillary anterior teeth. The most commonly measured mechanical properties were fracture resistance, bond strength, compressive strength, and retentive strength. Concerning the measurement of mechanical properties, 10 studies measured fracture resistance, four studies measured various bond strengths, and the remaining four studies measured other properties, such as compressive strength, retentive strength, bending strength, and tensile strength. Only one study evaluated posts based on microleakage. The overall sample size of the teeth included in the *in vitro* studies ranged from 20 to 120, involving only the primary maxillary anterior teeth.

Various posts used are:

- Glass fiber posts (GFPs) (five studies evaluated).[1,11,28,32,33]
- Composite posts (CP) (six studies evaluated).[26–31]
- Customized posts: Orthodontic wire–Ω-shaped, α-shaped, γ-shaped (four studies evaluated).[4,8,32,36]

Other prefabricated posts

- Polyethylene fiber posts (PFPs) (two studies evaluated).[34,35]
- Customized quartz glass fiber (three studies evaluated).[8,11,37]
- Short fiber reinforced polyglycolic acid (PGA) and polylactic acid (PLLA) screw posts (one study evaluated).[41]

As fracture resistance is the most commonly measured mechanical property, a meta-analysis was performed on studies measuring the same. Due to a lack of evidence from other properties, the efficacy of posts could not be determined, and meta-analysis was not performed. Fiber posts seemed to be the most efficient despite the various properties measured and showed greater values.

Risk of Bias

In Vivo Studies

The methodological quality of all included randomized controlled trials and *in vivo* studies was assessed using the Cochrane Collaboration risk assessment tool as shown in Tables 3.[15] All 11 included *in vivo* studies showed a high risk of bias. All included randomized controlled trials were followed according to Consolidated Standards of Reporting Trials guidelines. All studies had at least one domain with unclear or high risk of bias. Randomization was mentioned in all studies, but not allocation concealment.

In Vitro Studies

All of the included *in vitro* studies had their methodological quality assessed using the Risk of Bias tool given by Sarkis-Onofre et al.,[16] as shown in Table 4. While three[7,30,35] of the 19 *in vitro* studies showed a medium risk of bias, and there was a substantial risk of bias in the remaining studies. No study specified whether each procedure was performed by a single operator or if the test machine operator was blind to experimental groups.

Table 1: Characteristics of the included *in vivo* studies

S. no.	*Author details, year, country, study design*	*Sample size*	*Comparison groups*	*Follow-up*	*Results*	*Study conclusion*	*Limitation*
1.	Ibrahim et al.,[17] 2020, Syria; randomized controlled trial	36 maxillary primary incisors	GFPs and CRP	3, 6, 9, 12 months	12 months posttreatment, the success rates were 88.2% in GFP and 70.6% in CRP group	Both are effective	
2.	Mehra et al.,[18] 2016, India; randomized controlled trial	45 primary anterior teeth	Polyethylene post, glass post, and CP	3, 6, 9, and 12 months	12 months follow-up: 86.67% with PP and 93.3% with GP, whereas only 60% with CP	Both GP and PP proved to be effective;GP showed the maximum retention and marginal adaptation, followed by PP	Superficial staining
3.	Vafei et al.,[9] 2016, Iran; randomized controlled trial	Primary maxillary canines	GFP and reverse oriented metallic post (RoMP)	6, 12, and 18 months	At 18 months: 81.1% for RoMP and 67.6% for GFP	RoMP has higher clinical survival compared with GFP	
4.	Memarpour et al.,[22] 2013, Iran; nonrandomized controlled trial	Primary maxillary incisors: 55	Tapered-shaped posts and PFPs (ribbon triaxial)	2.5 years (6 months for 30 months)	In 30-month follow-up: 48 teeth evaluated—surface texture: 97.9% (sound), no marginal discoloration: 79.2%, no evidence of periapical radiograph, no gingival inflammation	PFP shows excellent clinical performance with good retention for 2.5 years	Higher cost and more root fracture in case of MP
5.	Sawant et al.,[19] 2017, India; nonrandomized controlled trial	Primary maxillary incisors: 60	EverStick glass fiber-reinforced CP and ParaPost Taper Lux post	3, 6, 9, and 12 months	The dislodgment of posts was not statistically significant as a mode of failure; however, both study groups experienced clinical failures	Due to the monoblock effect with the luting agent, post system, and bonding to dentin, FP was found to be effective	Removal of additional radicular dentin
6.	Mortada A et al.,[23] 2004, China; nonrandomized controlled trial	96 primary maxillary anterior teeth	Ω-shaped posts (Ω-posts) with compomer	3–18 months	After 18 months, 81.2% of the 96 restorations, which were available for evaluation, 60 (79.9%) were intact	Ω-posts: simple, effective, and quick	
7.	Aminabadi et al.,[24] 2009, Australia; nonrandomized controlled trial	144 primary anterior teeth	Modified Ω-posts (SS wire) with compomer	6, 12, and 24 months	5.9% of the teeth had partial loss of the restoration at 6 months; after 12 and 24 months, the failure rates were 10.8 and 18.5%, respectively	Modified Ω posts: simple, effective, and quick	
8.	Shahawy et al., 2016,[20] Egypt; nonrandomized controlled trial	86	Glass ionomer post with zirconia crown	3, 6, 12, 18, and 24 months	After 12 months, the restoration's overall survival rate was 95.3%, and after 24 months, it was 80.2%	Effective and esthetic: new technique	

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S. no.	Author details, year, country, study design	Sample size	Comparison groups	Follow-up	Results	Study conclusion	Limitation
9.	Dogan et al., 2020,[25] Turkey; nonrandomized controlled trial	60 maxillary anterior teeth	Mushroom-shaped restorations: short post technique	6,12, and 18 months	Success rates at 6, 12, and 18 months were 86, 80, and 71%	A clinically acceptable alternative treatment approach is the short post (mushroom restorations) technique	
10.	Sharaf et al., 2002,[21] Saudi Arabia; nonrandomized controlled trial	30 primary maxillary anterior teeth	FP system (Jeneric/Pentron, USA)	3, 6, and 12 months	12 months: 28 out of 30 restored teeth performed well	FP: effective, failure also due to failure in pulp therapy	Technique-sensitive and requires patient cooperation
11.	Subramaniam et al., 2008,[6] India; randomized controlled trial	28: maxillary primary anterior teeth	GFRCRP and Ω-posts	1, 6, and 12 months	Retention: GFRCR—(10, 79, 79), Ω-posts (100, 72, 54); marginal adaptation: GFRCR: (10, 79, 79), Ω-shaped (100, 71, 15)	Retention and marginal adaptation–GFRCRP was found to be effective	

GFRCR, glass fiber reinforced composite resin; GFRCRP, glass fiber reinforced composite resin post

Meta-analysis

In Vivo Studies

Among the 30 included studies, a meta-analysis was conducted with only two randomized controlled studies.[17,18] Due to the availability of limited data regarding the control group, the meta-analyses were subjected to two included studies.

Figure 2 compares the survival of the two types of posts and shows that fiber posts are superior to composite resin posts (CRPs). The survival odds ratio (OR) of 4.98 (95% confidence interval 1.24–19.90) indicates that the GFPs are nearly five times more successful than CRPs after 12 months of treatment. The difference between the two groups was statistically significant ($p = 0.02$). No heterogeneity ($I^2 = 0\%$) was recorded; hence, a fixed-effects model was employed for the meta-analysis.

In Vitro Studies

Among the 30 included studies, a meta-analysis was conducted with only two *in vitro* studies.[4,27] Since the test and control groups in these two studies were comparable with similar mechanical properties, namely fracture resistance, they were assessed, and Forest plots were designed.

Figure 3 compares the fracture resistance between CRP and no post. Considering the very high heterogeneity ($I^2 = 92\%$), a random-effect model was employed. A mean difference of 44.60 was observed between the two groups. However, the difference observed between the two groups was statistically nonsignificant ($p = 0.73$).

Discussion

The studies evaluating the clinical success of intracanal posts in primary maxillary anterior teeth were analyzed in this systematic review and meta-analysis. In addition, it assessed the mechanical properties, namely, bond strength, fracture resistance, compressive strength, and retentive strength in primary maxillary anterior teeth with intracanal posts. Since the mechanical properties of intracanal posts can influence clinical success, both were studied in this systematic review. The clinical success was evaluated by assessing the included RCTs. Mechanical properties were evaluated by assessing *in vitro* studies.

The retention and stability of definitive restorations are improved by intracanal posts in teeth that have undergone endodontic treatment[39] and offering actions for both esthetic and functional treatment of severely decayed primary anterior teeth.[23] This form of reconstruction should provide adequate retention and withstand masticatory forces in function.[10]

Mechanical Properties

Various mechanical properties have been used to measure the efficacy of posts *in vitro* studies. The most crucial element for creating a sustainable restoration is fracture resistance, which is one of the fundamental properties of restorative materials, particularly during mastication.[32]

Glass Fiber Posts

Glass fiber posts (GFP) were found to have the highest fracture resistance and retentive strength compared to other posts in most of the studies included in the systematic review.[9,17–21]

Glass fiber posts and Ribbonds were found to be more expensive than posts made of stainless steel wire. This implies that economic considerations need to be taken into account when selecting posts for clinical use.[7]

Bonding Materials and Tensile Bond Strength

According to Pinthan et al. and Alves et al., the type of post and bonding material does not affect tensile bond strength. This implies that the efficacy of posts is not significantly influenced by the bonding material used.[8,26]

Composite Resin Posts and Success Rates

Various types of CRPs, such as flowable, bulk-fill, nanohybrid, and fiber-impregnated, were inferior to GFPs in terms of success rate. This suggests that GFPs are more reliable in clinical practice.[6,17]

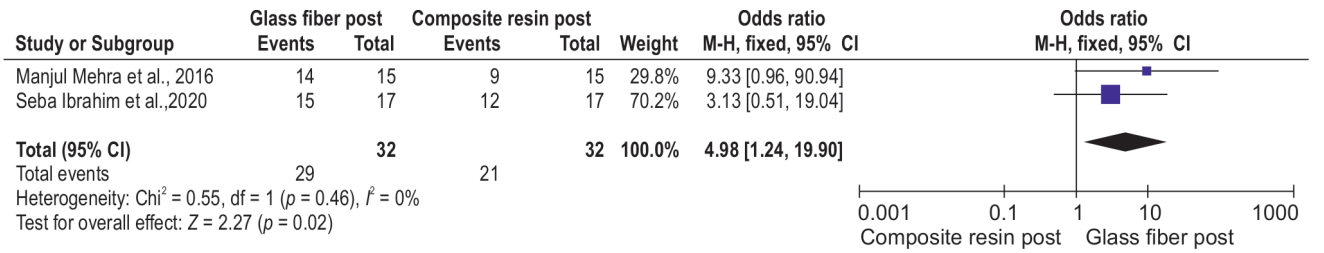

Fig. 2: Forest plot comparing the fracture resistance between CRP and no post

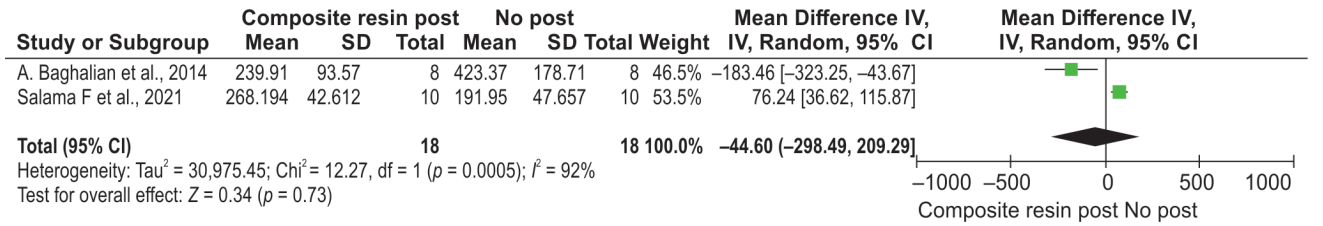

Fig. 3: Forest plot showing the survival of GFP and CRP at 12 months

Table 2: Characteristics of the included *in vitro* studies

S. no.	*Author details year and country*	*Sample size and tooth assessed*	*Comparison groups*	*Mechanical property measured*	*Results*	*Study conclusion*	*Limitation*
1.	Memarpour et al., 2013,[7] Iran	120 extracted primary maxillary canines	Group I: short CRP group (SCRP) (control); group II: SCRP with undercut (mushroom-shaped); group III: GFP + resin cement group; group IV: GFP + flowable CRP group; group V: PEFP + resin cement group; group VI: PEFP + flowable CP	Retentive strength and fracture resistance	SCRP: 127.96 ± 46.98, undercut SCRP 175.70 ± 53.24, GFP 175.70 ± 53.24, GFP + flowable resin 132.71 ± 63.59, PEFP + Resin cement 121.31 ± 44.65, PEFP + flowable resin 149.95 ± 40.07	Greatest resistance: undercut SCRP; fiber posts cemented with flowable composite: more retention and fracture resistance	Groups that used CRP: no gain in reinforcement with core
2.	Baghalian al., 2014,[4] USA	50 extracted primary maxillary incisor	Group I: CRP; group II: γ-wire posts; group III: intact GFP; group IV: split-ended GFP; group V: no post as control group	Fracture resistance	γ wire post: 219.661; intact GFP: 203.937; split-ended GFP: 363.201; CRP: 268.194; control with no post: 191.95	Greater mean fracture resistance: split-ended GFP	
3.	Pinheiro et al., 2006,[36] Brazil	30 primary anterior teeth	10 CRP, 10 α-shaped orthodontic wires (α-posts), and 10 dentin posts.	Bond strength	CRP: 13.51, dentin posts: 13.95, α posts: 12.92	There is no statistically significant difference; the dentin posts approach may be used instead of rehabilitation in pediatric dentistry	
4.	Alves et al., 2004,[26] Brazil	40 primary anterior teeth with two-thirds root	Four groups: SCRP with ZOE, Sealapex, UFSC paste, and Vitapex	Tensile strength	SCRP with ZOE-3.56, Sealapex- 2.69, UFSC paste: 2.66 and Vitapex: 2.72 MPa	Bonding material does not interfere with tensile strength	

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S. no.	Author details year and country	Sample size and tooth assessed	Comparison groups	Mechanical property measured	Results	Study conclusion	Limitation
5.	Salama et al., 2021,[27] Saudi Arabia	40 extracted primary maxillary incisor with two-thirds root	Group I was filled with bulk-fill resin composite (Tetric® N-Ceram Bulk Fill – Ivoclar), group II was filled with flowable resin composite (AeliteFlo), group III was filled with nanohybrid universal resin composite (Filtek Z250 XT), and group IV was filled with resin-modified glass ionomer (GC Fuji II), group V with Vitapex as control	Fracture resistance	Tetric® N-Ceram Bulk Fill 239.91 ± 93.57 (161.68, 118.14), AeliteFlo 375.74 ±19.73 (359.25, 392.23), Filtek Z250 XT 318.78 ±12.84 (308.04, 329.51), GC Fuji II LC® capsule 439.82 ± 25.16 (418.79, 460.85) and control 423.37 ± 178.71 (258.09, 588.65)	Higher fracture resistance: resin-modified glass ionomer cement (GIC) (GC Fuji II LC® capsule): lower fracture resistance: Bulk fill resin composite (Tetric® N-Ceram Bulk Fill)	(1) Sample size; (2) During *in vitro* research, it is challenging to reproduce intraoral circumstances; (3) root movement may result from enclosing roots with silicon or wax before embedding them in acrylic resin; (4) no attempt was made to identify the failure mode
6.	Gab et al., 2020,[1] India	45 primary anterior teeth with two-thirds root	Ω-shaped post (group I), reinforced glass-fiber-post (group II), and core buildup (group III)	Compressive strength and fracture resistance	Groups I, II, and III were found to be 828.35, 846.62, and 778.25 N; group I: favorable fractures amounting to 73%, followed by group II, 67%, and group III, 53%	Glass finer post: high compressive strength; high fracture: Ω-shaped posts	The torsional, oblique, and lateral shearing forces produced during mastication were not taken into consideration since compressive strength was examined on a universal testing machine
7.	Kadkhodaei et al., 2020,[28] Iran	90 primary maxillary anterior teeth with intact root	Six groups: conventional CRP, X-tra fill CRP, Tetric N Ceram CRP, prefabricated GFP with conventional composite buildup, prefabricated GFP with X-tra fill composite buildup, and prefabricated GFP with Tetric N Ceram composite buildup	Fracture resistance	418.64 N in prefabricated GFP with conventional composite build-up	Prefabricated GFP with conventional composite buildup group showed high fracture resistance	
8.	Ravikumar et al.,[8] India	20 primary maxillary anterior teeth	Group I: control group; group II: chemical surface treatment of the root with 2% chlorhexidine; group III: mechanical surface treatment with a mushroom-shaped undercut; group IV: combination of mechanical and chemical surface treatments	Shear bond strength	Combination of mechanical and chemical surface treatments: (8.41 MPa), mechanical surface treatment (4.68 Mpa), chemical surface treatment (3.92 Mpa), and control group (2.76 Mpa)	High shear bond strength: mechanical and chemical followed by mechanical, chemical, and control	Only *in vitro* studies carried out
9.	Nilavarasan et al., 2016,[32] India	60 primary anterior teeth with two-thirds root	Group I (Ribbond), group II (Ω), and group III (GFP)	Fracture resistance	Groups I, II, and III as 83.25, 61.60, and 75.55 N	Group I shows the highest fracture resistance, followed by groups III and II	Variations in sample sizes
10.	Seraj et al., 2015,[11] Iran	60 primary maxillary incisors	Group I: customized QFP, group II: CRP, and group III: prefabricated GFP	Fracture resistance	Three groups were 343.28, 278.70, and 284.76N	Customized QFP: greatest fracture resistance	

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S. no.	Author details year and country	Sample size and tooth assessed	Comparison groups	Mechanical property measured	Results	Study conclusion	Limitation
11.	Seraj et al., 2014,[29] Iran	60 primary maxillary incisors	Group I: composite filling; group II: composite filling with CRP; group III: composite filling extended 0.5 mm to cementum; group IV: composite filling extended 0.5 mm to cementum with CRP	Fracture resistance	Group I: 410.57 ± 139.44 N, group II: 564.44 ± 92.63 N, group III: 507.5 ± 76.37 N, and group IV: 601.08 ± 96.04 N	Higher fracture resistance: groups IV and II	
12.	Ghajari et al., 2019,[33] Iran	40 maxillary primary canine with two-thirds root	(I) Grandio Flow composite core and GFP; (II) Grandio Flow composite core and Grandio Flow CRP; (III) Grandio composite core and GFP; and (IV) Grandio composite core and Grandio CRP	Fracture resistance	Grandio Flow composite core and Grandio Flow CRP showed the highest fracture resistance		
13.	Estaki et al., 2018,[30] Iran	32 primary anterior teeth with half root	Horizontal layering technique (HLT); funnel-shaped layering technique (FSLT)	Push-out bond strength	8.46 ± 3.45 MPa and 7.7 ± 2.24 MPa for the HLT and FSLT	No significant difference	
14.	Pasdar et al., 2017,[34] Iran	60 primary maxillary incisors with two-thirds root	Group I: ZOE and group II:canals obturated with Metapex; (1) short CP (SCP); (2) GFPs cemented withflowable composite; and (3) GFP with GIC (GFP + GIC)	Push-out bond strength	ZOE: group I: 12.26 ± 4.47,group II: 11.87 ± 6.48, group III: 8.31 ± 1.64; metapex; group 1: 14.74 ± 6.04, group 2: 14.28 ± 5.07, and group 3: 11.11 ± 4.03	Bond strength: less in ZOE; push-out bond strength: high in SCP and GFP	
15.	Pinthan et al., 2002,[8] Brazil	45 primary anterior teeth with two-thirds root	Group I: CRP, group II: 0.6 mm γ, group III: fiberglass pin	Tensile strength	Tensile bond strength: means were very similar, mode of fracture; highest: 93% for group II	The tensile bond strength was not influenced by the type of posts utilized	Eugenol is used in the paste used to fill root canals
16.	Mizutani et al., 2012,[41] Japan	Not mentioned	PGA and PLLA	Bending strength and hydrolysis ability	Bending test: 168 ± 13.2MPa for PGA and 126.7 ± 5.8 MPa for PLLA	Both PGA and PLLA have better bending strength and hydrolysis ability; they are suitable as better biodegradable screw posts for primary teeth	
17.	Ferreira et al., 2007,[31] Brazil	20 primary maxillary canines with two-thirds root	1: Single Bond and 2: Adper Prompt LPop	Microleakage		Microleakage occurred in both systems	
18.	Kara et al., 2017,[35] Turkey	120 primary maxillary incisors	Group I: control group—nanohybrid CRP, group II: resin with preimpregnated GFP + flowable composite resin, group III: unsaturated GFP + flowable composite resin,group IV: PEFP + flowable composite resin, group V: SFCRP	Bond strength	Highest in group V (20.6 9.0 MPa) and group I (19.8 4.1 MPa), whereas the lowest was in group III (15.2 9.7 MPa)	Bond strength: highest in short-fiber reinforced CRP and nanohybrid composite, whereas the lowest was in unsaturated GFP + flowable composite resin	
19.	Island et al., 2005,[37] Boston	60 maxillary primary anterior teeth	Group I used nonpreimpregnated resin fibers (GlasSpan), and group II used preimpregnated resin fibers (Splint-it)	Fracture resistance	Group I was 71.346, and for group II 97.952	Preimpregnated resin fibers (Splint-it): high fracture resistance	

Table 3: Quality assessment of the *in vivo* studies included based on the Cochrane RoB2[15]

Studies	*Randomization process*	*Deviations from intended interventions*	*Missing outcome data*	*Measurement of the outcome*	*Selection of the reported result*	*Overall*
Ibrahim et al., 2020[17]	High	High	High	High	Some concern	High
Mehra et al., 2016[18]	High	Low	Low	Some concern	Some concern	High
Vafei et al., 2016[9]	High	Some concern	Low	High	Some concern	High
Memarpour et al., 2013[22]	High	High	Low	Low	High	High
Sawant et al., 2017[19]	High	High	Low	High	Some concern	High
Mortada et al., 2004[23]	High	Low	Low	High	High	High
Aminabadi et al., 2009[24]	High	Low	High	High	Some concern	High
Shahawy et al., 2016[20]	High	High	High	High	Low	High
Dogan et al., 2020[25]	High	High	High	Some concern	High	High
Sharaf et al., 2002[21]	High	High	High	High	Some concern	High
Subramaniam et al., 2008[6]	High	High	High	High	Some concern	High

Table 4: Quality assessment of the *in vitro* studies included[16]

Studies	*Teeth randomization*	*Teeth free of caries or restoration*	*Materials used according to the manufacturer's instructions*	*Teeth with similar dimensions*	*Endodontic treatment performed by a single operator*	*Sample size calculation*	*Blinding of the operator of the testing machine*	*Risk of bias*
Memarpour et al., 2013[7]	Y	Y	Y	N	Y	N	N	Medium risk
Baghalian al., 2014[4]	N	N	N	N	N	N	N	High risk
Pinheiro et al., 2006[36]	N	N	N	N	N	N	N	High risk
Alves et al., 2004[26]	N	Y	N	N	N	N	N	High risk
Salama et al., 2021[27]	Y	N	Y	N	Y	N	N	High risk
Gab et al., 2020[1]	Y	N	N	N	N	N	N	High risk
Kadkhodaei et al., 2020[28]	Y	N	N	N	N	Y	N	High risk
Ravikumar et al., 2017[38]	Y	N	N	N	N	N	N	High risk
Nilavarasan et al., 2016[32]	N	N	Y	N	Y	N	N	High risk
Seraj et al., 2015[11]	Y	N	Y	N	N	N	N	High risk
Seraj et al., 2014[29]	N	N	N	Y	Y	N	N	High risk
Ghajari et al., 2019[33]	Y	N	N	N	N	N	N	High risk
Estaki et al., 2018[30]	Y	N	Y	N	Y	Y	N	Medium risk
Pasdar et al., 2017[34]	N	N	Y	N	N	N	N	High risk
Pinthan et al., 2002[8]	Y	Y	N	N	N	N	N	High risk
Mizutani et al., 2012[41]	N	N	Y	Y	N	N	N	High risk
Ferreira et al., 2007[31]	Y	Y	Y	N	N	N	N	High risk
Kara et al., 2017[35]	Y	Y	Y	N	N	Y	N	Medium risk
Island et al., 2005[37]	N	N	Y	N	N	N	N	High risk

Bond Strength with Root Canal Filling Materials

Zinc oxide eugenol (ZOE) showed poor bond strength with intracanal posts compared to metapex, which indicates that the choice of root canal filling material can affect the bond strength of posts.[23]

Biodegradable Screw Posts and Bending Strength

Mizutani et al. subjected newer biodegradable screw posts to bending tests and reported better bending strength. The biodegradable screw post materials used were PGA and PLLA.[40,41]

Other Prefabricated and Customized Posts

Ribbond (PFP) and CRPs were also found to have relatively high fracture resistance.[22] Ω-shaped stainless steel wire posts showed high fracture resistance, while GFPs exhibited higher compressive strength.[1]

When compared to restorations prepared with a fiber postattached with resin cement, the mushroom-shaped undercut approach was found to considerably increase retentive strength, as reported by Memarpour et al.

Clinical Success Rate

Glass Fiber Posts

Several studies have compared the success rates of different types of posts in terms of their fracture resistance and retention strength. Ibrahim et al. found that the success rates of GFPs after 12 months were higher than those of CRPs, although the difference was not

statistically significant.[17] Vafaei et al. reported a 74.4% success rate in a GFP group 12 months posttreatment,[9] while Mehra et al. reported a higher success rate of 93.33% in the GFP group after the same time period.[39]

Composite Resin Posts

The CP exhibited the lowest retention and marginal adaptation. This can be explained by resin polymerization contraction, which enhances microleakage and leads to possible fracture. Some iatrogenic factors, such as trauma and dietary habits, are responsible for the low retention rate.[39]

Customized Posts

Orthodontic wires associated with direct resin composite can be an alternative treatment option to posts.[39] Rifkin described the placement of simple wire posts in primary teeth in 1983,[40] and the modified Ω-loop design attempts to diminish some inherent problems associated with the original design.[10,21] The reversed metal post technique can also be used, where the metallic post's quadrangular core is cemented to the most coronal 3 mm of the canal, where it does not obstruct the physiological resorption of the primary tooth root. However, the use of metallic posts in pediatric dentistry is limited due to their potential drawbacks.[10,21]

Other Prefabricated Posts

Polyethylene fiber posts (PFPs) have shown excellent clinical performance, according to Memarpour et al.,[22] with the longest follow-up of 30 months. Aminabadi et al. found the use of modified Ω-shaped posts in primary anteriors to be simple and effective, with a follow-up of 24 months.[24] The studies included typically evaluated the success rates of different types of posts for an average follow-up of 3 to 12 months,[6,12,21,39] with few studies extending the follow-up period to 18 months.[10,23,36]

Evaluation of Posts

The failure of posts was the main reason for the loss of follow-ups. Clinical evaluation of posts was performed using the specified criteria known as the Ryge criteria, also known as the US Public Health Service criteria. The following characteristics were clinically evaluated: anatomical form, marginal integrity, marginal discoloration, recurrent caries, color stability, and surface texture.[42] In addition, the radiographic evaluation showed failure due to the failure of pulp therapy, which presented as a periapical abscess.[2,19,24,25] However, this could not be the only criterion to use when evaluating the posts clinically. Therefore, clinical assessment must be done using standards that only evaluate the posts, even though overall radiographic evaluation provided valuable evidence.

Limitations and Future Implications

This systematic review has some limitations that should be acknowledged. The limited availability of clinical data and its inconsistency in publishing makes it impossible to consider substantial evidence as to which posts serve better. The number of *in vitro* studies was significantly higher than that of clinical studies. Secondary caries and fractures are the primary causes of post failures; therefore, greater mechanical properties are essential for predicting the post material's clinical performance, especially over the long term. Therefore, even before clinical studies, conducting *in vitro* studies is indispensable. Fiber posts exhibited superior mechanical properties and a greater clinical success rate; however, because only two clinical trials with important limitations could be incorporated into the meta-analysis, this outcome should be considered with caution. More randomized clinical trials should ideally be conducted to corroborate our findings.

The included studies overall quality of assessment revealed a high risk of bias, preventing us from arriving at a clear decision about the use of posts in primary anterior teeth. Future research should take into account the absence or partial explanation of the factors, namely in the case of *in vitro* studies, such as the determination of the sample size, the randomization of the specimen preparation, and the blinding of the operator conducting the mechanical test. However, heterogeneity was not found in all meta-analyses. This result is unusual because, generally, meta-analyses of laboratory studies demonstrate considerable heterogeneity,[43–45] mostly due to methodological differences and the uncommon use of predetermined criteria for conducting and reporting *in vitro* studies. Future research should include the domains' incomplete or lack of description in order to get a compelling conclusion. Nonheterogeneity may be related to some circumstances, such as the standard testing device utilized in all studies (universal testing machine). Another limitation of the present study was that only articles published in English were retrieved. However, no language limitations would be great for a substantial literature search. Additionally, non-English papers often make up a small percentage of the articles included and have a minimal influence on a systematic review's outcomes and conclusions.

Overall, the studies reviewed suggest that GFPs have a high fracture resistance and retentive strength compared to other posts, followed by Ribbonds and CRPs. The success rates of GFPs after 12 months ranged from 74.4 to 93.33%,[17,39] while PFPs showed excellent clinical performance with the longest follow-up of 30 months. Other alternative treatment options include the use of orthodontic wires and modified Ω-shaped posts in primary anteriors. The type of post and bonding material does not impede tensile bond strength. However, economically, GFPs and Ribbonds are more expensive than posts made of stainless steel wire.

To the author's knowledge, this is the first systematic review and meta-analysis that evaluates posts in the primary anterior teeth. Further research should be conducted to make the use of posts in primary teeth clinically comprehensive and effective.

Clinical Significance

Of the studies included, only two RCTs suggest that fiber posts in primary maxillary anterior teeth had a significant clinical success rate. This systematic review provides a comprehensive summary of the current literature and highlights the need for further research. Results were interpreted with caution, as the evidence supporting the use of intracanal posts in primary teeth is limited.

Conclusion

The following conclusions can be drawn from this systematic review and meta-analysis's results: Due to a distinct lack of higher quality studies, which serves as a major drawback, conclusive evidence cannot be obtained.

To validate the use of posts in pediatric dentistry, high-quality randomized controlled studies are needed.

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