

Comparative Evaluation Of Fracture Resistance Of Three Different Ceramic Posts In Endodontically Treated Teeth: A Systematic Review

Prajakta Gir^{1*}, Vikas Punia², Meenakshi Khandelwal³, Anand Porwal⁴ and Abhijit Sethia⁵

¹MDS 3rd Year Post Graduate Student, Department of Prosthodontics, Darshan Dental College and Hospital, Udaipur, Rajasthan, India.
<https://orcid.org/0009-0006-5643-1805>

²M.D.S. & Ph.D. Professor in Department of Prosthodontics, Darshan Dental College and Hospital, Udaipur, Rajasthan, India.
<https://orcid.org/0000-0003-3106-9740>

³M.D.S, Head of Department, Department of Prosthodontics, Darshan Dental College and Hospital, Udaipur, Rajasthan, India.
<https://orcid.org/0009-0001-8170-2404>

⁴M.D.S. Reader in Department of Prosthodontics, Darshan Dental College and Hospital, Udaipur, Rajasthan, India.
<https://orcid.org/0000-0002-9928-3156>

⁵M.D.S. Senior Lecturer in Department of Prosthodontics, Darshan Dental College and Hospital, Udaipur, Rajasthan, India.

*Corresponding Author: Dr. Vikas Punia

*Professor, Department of Prosthodontics, Darshan Dental College and Hospital, Udaipur, Rajasthan.

Phone numbers: 9694355041, E-mail address: drvikas81@gmail.com

DOI: 10.47750/pnr.2022.13.S06.582

Abstract

Metal posts used to restore endodontically treated teeth may shine through all-ceramic crowns and thin gingival tissue. When nonprecious alloys are used, corrosion products may lead to discoloration. All ceramic posts and cores can be used in combination with all-ceramic crowns to prevent these problems. All-ceramic posts and cores are highly biocompatible and will almost always increase the translucency of an all-ceramic restoration. Hence a prefabricated zirconia ceramic post system has been introduced to satisfy aesthetic needs presented by endodontically treated anterior teeth. The translucency of all ceramic crowns can be successfully maintained with the use of ceramic post and core materials. In the existing published reports, most studies indicate the superiority of ceramic posts in terms of their fracture resistance but very few show the exact comparison and compilation between the fracture resistance of different ceramic posts with one another. The present systematic review aims at synthesizing all the available data. The purpose of this study was to systematically review the existing reports to compare and evaluate the fracture resistance of 3 types of ceramic posts by combining the available evidence in a systematic review. A search strategy was adopted using PubMed, ScienceDirect, and Google Scholar in May 2022 to screen research studies. These studies were screened against predetermined criteria for eligibility for systematic review. The values of fracture resistance to load applied on copy milled, pressable and pre-fabricated zirconia posts showed that the Prefabricated zirconia posts were more resistant to fracture when loads were applied.

Key words: Ceramic posts, Zirconia posts, Milled posts, Fracture resistance, Prefabricated posts.

INTRODUCTION:

Endodontically treated teeth present a high-risk of biomechanical failure due to the loss of tooth substance resulting from pre-existing decay and endodontic therapy itself. In treating these teeth, intra radicular posts are recommended to aid in the retention of artificial crowns and support the teeth by distributing intraoral forces along the roots.¹ For many years metals, whether cast or prefabricated, have been exclusively used to construct posts as foundations for indirect restorations. Furthermore, especially when nonprecious alloys are used for post-and-core fabrication, corrosion products may deposit in the gingival tissues or cause root discoloration².

Developments in composite and ceramic materials have resulted in the introduction of metal-free post systems as alternatives.³ Modern ceramic restorative systems offer the possibility to closely match the natural optical characteristics of lost tooth structure. Posts, cores, and copings fabricated in ceramic materials represent a promising alternative to metals in the restoration of severely compromised anterior teeth.⁴ In the recent times, there has been a tremendous increase in the use of all ceramic crowns, particularly for anterior teeth because of their superior natural appearance compared to metal ceramic restorations. Both the declining acceptance of cast post and core restorations as well as patients' interest in dental aesthetics has resulted in the development of esthetic posts, especially Glass Fiber and Zirconia Ceramics.⁵

Use of zirconia as a post and core material began in 1993 when introduced by Mayenberg et al. Prefabricated zirconia post present positive qualities, such as high strength to bending forces and appropriate optical properties.⁶ These increase the transmission of light within gingival tissues and underlying root, enhancing the aesthetics. Being metal free materials, they also annihilate the potential hazards of corrosion and allergic hypersensitivity. A prefabricated zirconia ceramic post system has been introduced to satisfy esthetic needs presented by endodontically treated anterior teeth. The translucency of all ceramic crowns can be successfully maintained with the use of ceramic post and core materials. Also, amelioration in adhesive porcelain bonding systems have accelerated the trend toward the use of ceramic core materials.

Many dentists prefer to use prefabricated post systems because they are more practical, less expensive and in some situations less invasive than customized post and core systems. They also save time and can provide satisfactory results.⁵ Nowadays, zirconia is widely used in dentistry, due to its chemical stability, high mechanical strength, a Young's Modulus similar to stainless-steel alloys, and above all, the similarity of its color to that of teeth. Streacker and Awad developed the process of milling one-piece zirconia post and core out of yttrium tetragonal zirconium polycrystals using CAD-CAM machines.

On the one hand, application of these systems has always been a matter of debate, as the high elastic modulus of zirconia is responsible for catastrophic fractures of roots in teeth restored with these systems. On the other hand, there are some articles suggesting that zirconia could even reinforce the tooth structure due to its mechanical characteristics and offer better stress distribution along the roots.⁷ Although most of the available literatures confirmed the high fracture resistance of ceramic posts, there are many studies contradicting the same. Hence, an evidence-based study is required to know the fracture resistance of ceramic posts.

There is enormous literature on various post materials and their effect on fracture resistance of the endodontically treated teeth, but according to the authors' knowledge, there is no single documentation on the compilation of the various ceramic post materials and their effect on the fracture resistance in the endodontically treated teeth. The objectives of this systematic review were to critically examine and compile the studies involving various ceramic post materials and determine the effect of these materials fracture resistance in the endodontically treated teeth.

Hence, the present systematic review was conducted to summarize various ceramic post materials and determine the effect of these materials on the fracture resistance in the endodontically treated teeth.

MATERIALS AND METHOD:

This review was based on the Preferred Reporting Items for Systematic Reviews (PRISMA) guidelines.

All literatures that investigated the effect of various ceramic post materials and determine the effect of these materials on the fracture resistance in the endodontically treated teeth were searched using the PRISMA statement guidelines with a predetermined search strategy. The search strategy was based on a population (ceramic posts), intervention (different available ceramic post materials), comparison (copy milled ceramic posts, prefabricated zirconia posts and pressable ceramic posts), outcome (fracture resistance), and study design (systematic review), i.e., PICOS framework. The search was done to include studies comparing the fracture resistance of various ceramic posts in endodontically treated teeth.

Search terminologies included ceramic posts, cast metal posts, prefabricated zirconia, fibre-reinforced, copy milled zirconia, titanium posts, quartz fibre, stainless steel posts, carbon fibre, pressable ceramics, zirconium dioxide, glass fibre and fracture resistance. An electronic search of studies published in PubMed (www.ncbi.nlm.nih.gov/entrez/query.fcgi), ScienceDirect (www.sciencedirect.com) and Google Scholar (<http://scholar.google.com> till April 2023 was included. Search terms were a combination of the appropriate Medical Subject Headings terms and free-text words in simple or multiple conjunctions and were grouped into PICOS. Through these descriptors, a search with a specific algorithm was carried out in each database.

INCLUSION AND EXCLUSION CRITERIA:

Two reviewers read the titles and abstracts of the studies independently to decide whether the studies met the inclusion criteria. Full articles were examined if necessary. Any disagreement between the first two reviewers was resolved by third and fourth reviewers.

INCLUSION CRITERIA

- It should be an original study (in vitro/in vivo)
- It should be a complete study (full-text article)
- Study should be on various types of ceramic posts
- SI unit of fracture resistance must be N and/ or convertible to the same
- Test methodology for Fracture resistance should be Universal Testing Machine
- The load applied should be between the range of 130 – 135 degrees
- Test methodology for Fracture Resistance should be One Way ANOVA and Tukey HSD Tests, though it was not an exclusion criterion.

EXCLUSION CRITERIA

- Case reports
- Incomplete studies
- Studies between different manufacturers of Ceramic Post materials
- Studies which measured Fracture Resistance by incorporating other variables (such as Ferrule Effect, Post Diameter etc.)
- Studies without units and/or unconvertible units for Fracture Resistance (N)

QUALITY ASSESSMENT:

Quality assessment was performed independently by two investigators applying the Case RE port guidelines; any conflicts were discussed and resolved by another two authors. An estimated risk of bias (low, medium, or high) was assigned to

each of the included studies by the investigators. The disagreements were resolved by discussion between all the four authors.

DATA EXTRACTION AND STATISTICAL ANALYSIS:

Data were extracted by two reviewers independently using a designed form that included the following information: year of publication, type of Post material, type of study, conditioning of samples, test methodology, sample size, and Fracture Resistance (N) of various types ceramic post Materials available in literature. The studies in which the data were not clearly stated were excluded from the analysis. Flowchart for article selection process is mentioned in figure 1.

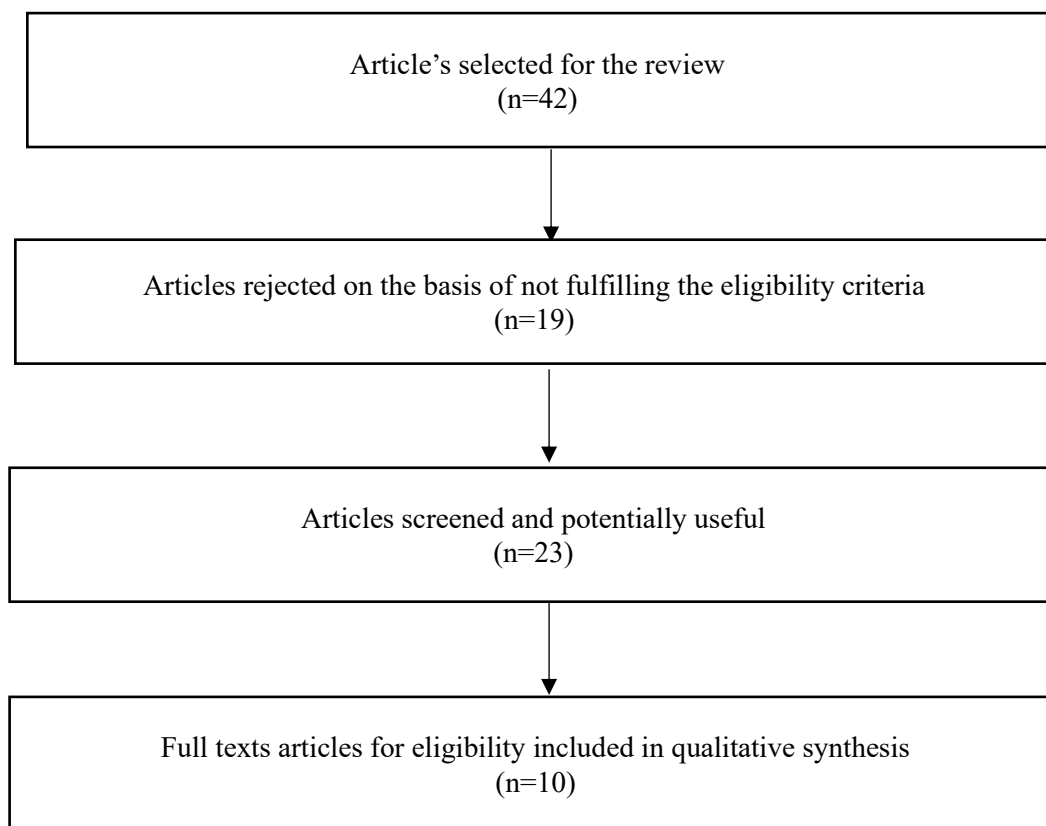


Figure 1: Flowchart for article selection process

DISCUSSION:

In 1989, Kwiatkowski and Gelier described the clinical application of glass-ceramic posts and cores (Dicor, Dentsply) and, in 1991, Kern and Knode introduced posts and cores made of glass-infiltrated aluminum oxide ceramic (In-Ceram, Vita Zahnfabrik). In 1995, Pissis proposed a "monobloc" technique for the fabrication of a post and core and a crown as a single component made out of glass-ceramic material (IPS-Empress, Ivodar). In 1994 and 1995, Sandhaus and Pasche and others introduced prefabricated zirconia ceramic endodontic posts to restorative dentistry. Sandhaus and Pasche also suggested the use of zirconia ceramic for the fabrication of a core build up and post in 1 piece. The major advantage of an all-ceramic post and core is its dentin like shade. The positive contribution of the dentin shade ceramic core is related to the deeper diffusion and absorption of the transmitted light in the ceramic core mass. An all-ceramic restoration transmits a certain percentage of the incident light to the ceramic core and post on which it has been placed. Thus, with all-ceramic posts and cores, the color of the final restoration will be derived from an internal shade similar to the optical behavior of the natural teeth. In addition, a ceramic post does not reflect intensively through thin gingival tissues, and it provides an essential depth of translucency in the cervical root areas. All-ceramic posts and cores, as metal-free constructions, provide an excellent biocompatibility, and do not exhibit galvanic corrosion.²

According to Duret and colleagues, an ideal post should have similar shape to the lost dentin volume (the prepared root canal) and mechanical properties identical to the dentin to provide long-lasting bonding. The post should not induce tension while being set, and minimal root canal preparation should be done to fit the post.⁸ Zirconia-rich ceramic materials (94.9% zirconia dioxide, 5.1% yttrium oxide), introduced in the early 1990s, proved to be adequate for the fabrication of prefabricated posts. Zirconia posts have been shown to have flexural strength similar to or even higher than that of metal posts and carbon-fiber posts. Having high elastic modulus, these ceramic posts are less subject to adhesive failure during mastication and permit a more conservative root canal preparation, decreasing the chances for root.⁴

To perform this systematic review a total of 42 published articles were screened and assessed for eligibility. Out of these 19 studies did not meet the eligibility criteria and hence were rejected. The full text of the remaining 23 studies was further reviewed. Later 10 relevant studies were chosen out of remaining 23 studies. These 10 studies were chosen based on the comparison to be done. 5 relevant studies for copy milled ceramic posts (diagram 1), 5 relevant studies for pressable

ceramic posts (diagram 2) and remaining 5 relevant studies for prefabricated zirconia posts (diagram 3) were compiled, compared and summarize.

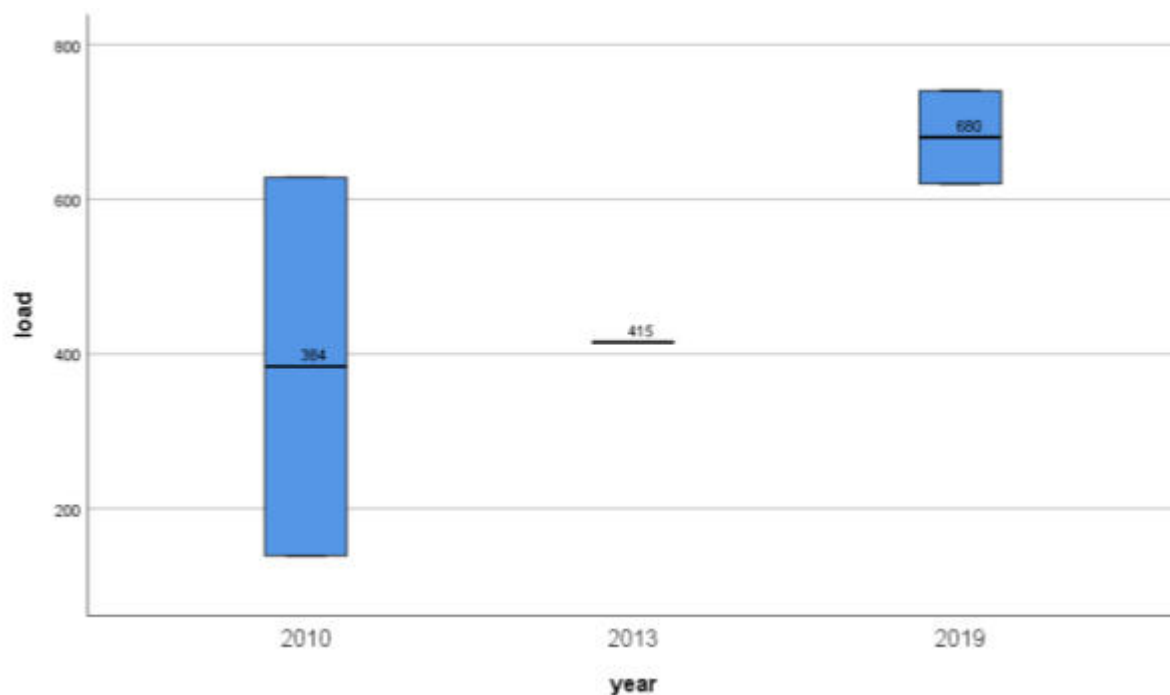


Diagram 1: Fracture Resistance of Copy milled ceramic posts in endodontically treated teeth.

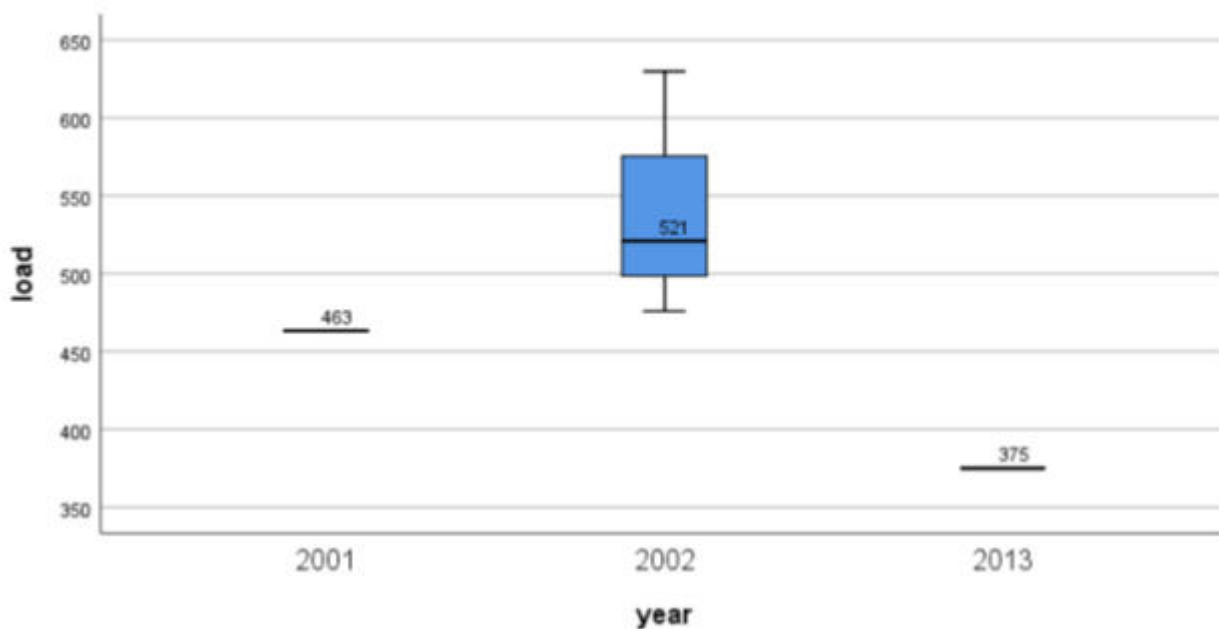


Diagram 2: Fracture Resistance of Pressable Ceramic posts in endodontically treated teeth.

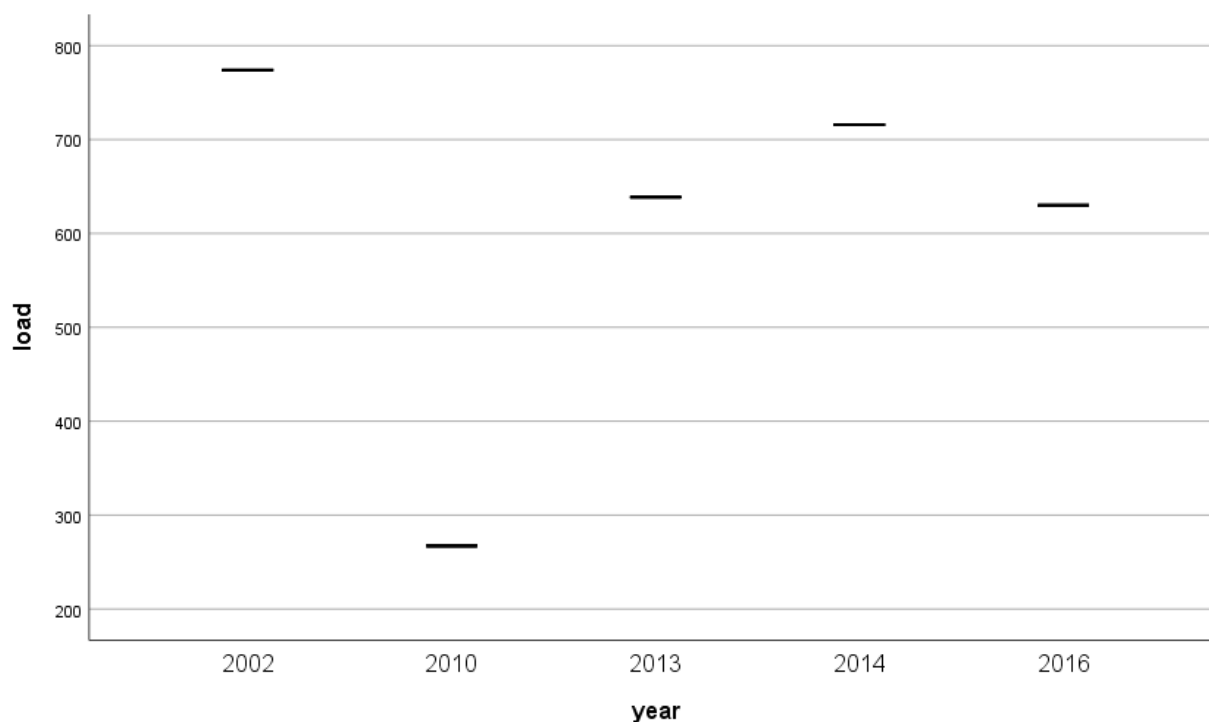


Diagram 3: Fracture Resistance of Prefabricated Zirconia posts in endodontically treated teeth.

Rita Eid, Jelena Juloski, Hani Ounsi, Munir Silwaidi, Marco Ferrari and Ziad Salameh used fiber posts, one-piece milled post and core from fiber reinforced composite blocks and one-piece milled post and core from hybrid ceramic disks. The study results stated that one-piece milled post and core from hybrid ceramic disks had the highest mean load to fracture (620.02 N) in comparison to the other groups ($p = 0.000$).⁹

Dr. S.I. Joephin Soundar conducted a study on three all ceramic post and core and one cast post system. Comparison was done between Cast metal post, Pressable ceramic post, Prefabricated Zirconia – Cosmo post and Milled Zirconia post. Maximum fracture load recorded for milled zirconia posts was 415 N and stated that Milled zirconia is a good option as post and core along with cosmo post in prosthodontics.⁶

Nina Beck et. al in his study concluded that the copy milled zirconia post showed 139.30 N maximum fracture load.¹⁰ Malathi Dayalan, Abhishek Jairaj, K. R. Nagaraj and Ravindra C. Savadi in their study showed that maximum fracture load of copy milled zirconia posts was 627.97 N.¹¹ Thilak Shetty et. al concluded that maximum fracture load of copy milled zirconia posts was 740 N.¹²

Dr. S.I. Joephin Soundarin his study showed that maximum fracture load of Pressable Ceramic Posts was 375.00 N.⁶ the values for Strub et al. was 463.3 N,¹⁰ for Massimiliano Guazzato, Mohammad Albakrya, Simon P. Ringerb and Michael V. Swaina was 476 N and 630 N¹² and for Guido Heydecke et. al the values recorded was 521 N.¹³

The values recorded for Prefabricated Zirconia by Begum Akkayan and Turgut Gulmez was 773.94 N,¹⁴ for Dr. S.I. Joephin Soundar the value recorded was 638.67 N,⁶ for Rajini Jununthula and Sunanda Gaddalay was 630.03 N,⁵ for Begum Akkayan was 715.885¹⁵ and for Nina Beck et. al the value recorded for maximum fracture resistance was 267.10 N.¹⁰

The values seen in the above studies summarized that the fracture resistance to load applied on copy milled, pressable and pre-fabricated zirconia posts showed that the Prefabricated zirconia posts were more resistant to fracture when loads were applied to them.

REFERENCES:

1. Chauhan S, Singh T. Assessment of fracture resistance of stainless steel post, Carbon fiber post and ceramic post in endodontically treated teeth: A comparative study. *restoration*. 2020;1:3.
2. Koutayas SO, Kern M. All-ceramic posts and cores: the state of the art. *Quintessence international*. 1999 Jun 1;30(6).
3. Stewardson DA. Non-metal post systems. *Dental update*. 2001 Sep 2;28(7):326-36.
4. Lopes GC, Baratieri LN, de Andrada MA, Maia HP. All-ceramic post, core, and crown: technique and case report. *Journal of Esthetic and Restorative Dentistry*. 2001;13(5):285.
5. Rajini Jununthula and Sunanda Gaddalay. Comparison of Fracture Resistance of Three Recent Esthetic Post and Core Systems with Cast Metal Post and Core to Compressive Loading - An in vitro Study. *International Journal of Science and Research*. Volume 7 Issue 2, February 2018
6. Habibzadeh S, Rajati HR, Hajmiragha H, Esmailzadeh S, Kharazifard M. Fracture resistances of zirconia, cast Ni-Cr, and fiber-glass composite posts under all-ceramic crowns in endodontically treated premolars. *The journal of advanced prosthodontics*. 2017 Jun 1;9(3):170-5.
7. Soundar SJ, Suneetha TJ, Angelo MC, Kovoor LC. Analysis of fracture resistance of endodontically treated teeth restored with different post and core system of variable diameters: an in vitro study. *The Journal of Indian Prosthodontic Society*. 2014 Jun;14(2):144-50.
8. Maccari PC, Conceicao EN, Nunes MF. Fracture resistance of endodontically treated teeth restored with three different prefabricated esthetic posts. *Journal of Esthetic and Restorative Dentistry*. 2003 Jan;15(1):25-31.
9. Eid R, Juloski J, Ounsi H, Silwaidi M, Ferrari M, Salameh Z. Fracture resistance and failure pattern of endodontically treated teeth restored with computer-aided design/computer-aided manufacturing post and cores: a pilot study. *Journal of Contemporary Dental Practice*. 2019;20(1):56-63.

10. Beck N, Graef F, Wichmann M, Karl M. In vitro fracture resistance of copy-milled zirconia ceramic posts. *The Journal of prosthetic dentistry*. 2010 Jan 1;103(1):40-4.
11. Dayalan M, Jairaj A, Nagaraj KR, Savadi RC. An evaluation of fracture strength of zirconium oxide posts fabricated using CAD-CAM technology compared with prefabricated glass fibre posts. *The Journal of Indian Prosthodontic Society*. 2010 Dec;10(4):213-8.
12. Guazzato M, Albakry M, Ringer SP, Swain MV. Strength, fracture toughness and microstructure of a selection of all-ceramic materials. Part II. Zirconia-based dental ceramics. *Dental materials*. 2004 Jun 1;20(5):449-56.
13. Heydecke G, Butz F, Hussein A, Strub JR. Fracture strength after dynamic loading of endodontically treated teeth restored with different post-and-core systems. *The Journal of prosthetic dentistry*. 2002 Apr 1;87(4):438-45.
14. Akkayan B, Gülmez T. Resistance to fracture of endodontically treated teeth restored with different post systems. *The Journal of prosthetic dentistry*. 2002 Apr 1;87(4):431-7.
15. Akkayan B. An in vitro study evaluating the effect of ferrule length on fracture resistance of endodontically treated teeth restored with fiber-reinforced and zirconia dowel systems. *J Prosthet Dent*. 2004 Aug;92(2):155-62. doi: 10.1016/j.prosdent.2004.04.027. PMID: 15295325.