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Marginal Adaptability of Custom Made Cast Post Made by Different Techniques - A Literature Review

Research Article

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Abstract

Introduction: A post and core is a type of dental restoration required where there is an inadequate amount of sound tooth tissue remaining to retain a conventional crown.Marginal and internal adaptation of indirect restorations are both very important parameters that may affect the periodontal status and longevity of the restorations. .In this review we report all the factors responsible for affecting the marginal adaptability of post and core systems used in restoration of endodontically treated teeth.
Purpose: To find out all those factors which can be used to increase marginal adaptability which ultimately enhance the clinical success rate. Since Increased marginal discrepancies of post endodontic restorations are related to increased exposure of the luting material to the oral environment, leading to chemo-mechanical degradation of the cement and the adhesive interface between the tooth structure, luting agent, and esthetic indirect restoration.
Conclusion: The performance of a CAD-CAM system relative to marginal adaptation is influenced by the restorative material. Digital workflow has several advantages over conventional casting, such as eliminating the need for impression material and transportation, reducing the time-consuming laboratory procedures, increasing patient comfort and the marginal adaptability and internal fit.

Keywords: CAD-CAM; Cast Metal; Custom Post; Microleakage; Zirconia.

1. Introduction

After root canal treatment, dentists are subjected with the task of restoring the tooth to rehabilitate oral functions as well as aesthetics. A post and core crown is a type of dental restoration required where there is an inadequate amount of sound tooth tissue remaining to retain a conventional crown [1]. A post is cemented into a prepared root canal, which retains a core restoration, which retains the final crown. The role of the post is firstly to retain a core restoration and crown, and secondly to redistribute stresses down onto the root, thereby reducing the risk of coronal fracture. The post does not play any role in reinforcing or supporting the tooth and can in fact make it more likely to fracture at the root. The restoration must achieve adequate retention and circumvent damage to the remaining hard tissue through the prevention of bacterial microleakage and hard-tissue fractures. Studies indicate that the tooth is less prone to fracture when less dental hard tissue is removed during the process of treatment. On the other hand, endodontic therapy is often necessitated by pulpal infection after substantial hard-tissue loss by caries or following extensive tooth preparation for crown- and bridgework. In both cases, much hard tissue has already been lost before root canal therapy. Therefore, there is often insufficient dental hard tissue left to ensure adequate retention of a functional restoration after endodontic treatment without adjuvant aids [2]. It was considered that a post with an ideal length of two-third of the total root length would reinforce the compromised tooth [3]. The length of the post is less important for the survival of the tooth than the presence of a ferrule of at least 1.5 mm. Materials with a high modulus of elasticity, like cast gold alloys [90 GPa], stainless

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steel [170 GPa], or titanium [115 GPa] were favored and, as an esthetic alternative, zirconium posts [200 GPa] were introduced. Stainless steel and titanium posts were mainly used with plastic core materials, like composite and amalgam. Gold posts and ceramic posts were used either with plastic core materials or with indirect cast gold or pressed ceramic cores, respectively. [4] About 10 years ago, glass, polyethylene, quartz, or carbon-reinforced composites [20–30 GPa] with a lower, more dentinlike [18 GPa] modulus of elasticity were introduced to dentistry. These fiber-reinforced posts fulfill the requirements of dentists who prefer to use prefabricated posts and resin-based composite core buildups. [5] The advantages of this direct post-and core technique include lower costs due to the exclusion of the dental technician, one less appointment, and the preclusion of unnecessary temporization. [4] The optimal modulus of elasticity of a post is controversial. Stiffer posts and cores may better support the coronal restoration and lead to a more uniform distribution of stress, but may result in catastrophic failure modes, like vertical root fractures, if the tooth is overloaded. A more elastic post may bend under high loads, which may lead to failure or loss of the restoration, but would leave the root intact for retreatment. On the other hand, an elastic post may allow the restoration to move and thus leak, after breakdown of the luting cement, with coronal leakage that puts the tooth at risk of secondary caries or root canal reinfection [6].

A well-adapted, passively cemented parallel-sided post is considered to be the most retentive with the least stress. However, with a flared canal, the parallel-sided post does not closely approximate the canal wall in the cervical region of the root. In such a situation, the clinician must decide whether to use a parallel-sided post and fill the space with cement or use a tapered post that closely adapts to the prepared canal. Maximum adaptation of the tapered post to the residual root structure significantly increases the fracture resistance of the endodontically treated tooth, but the tapered post results in an extensive and higher incidence of root fracture [1].

Marginal and internal adaptation of indirect restorations are both very important parameters that may affect the periodontal status and longevity of the restorations. Marginal gap is defined as "the perpendicular measurement from the internal surface of the casting to the axial wall of the preparation at the margin"[7]. Gap measurements at the margin of restorations are frequently used to quantify fit [8]. Increased marginal discrepancies are related to increased exposure of the luting material to the oral environment, leading to chemo-mechanical degradation of the cement and the adhesive interface between the tooth structure, luting agent, and esthetic indirect restoration. Internal fit is another key factor related to the long-term stability of esthetic indirect restorations. The cement interface has been described as a crack initiation area. Increased interfacial space and resin cement thickness may create increased polymerization shrinkage and interfacial stresses, resulting in decreased strength of the tooth-restoration interface. A sufficient three-dimensional [3D] fit of the restoration has been considered mandatory to obtain maximum mechanical support of all-ceramic restorations from the tooth structure. [9] A study by Iglesias et al showed that marginal gaps ranged from 7 to 23 microns and that resin patterns had statistically smaller gaps than inlay wax patterns. Studies have shown that there is a wide range of acceptable values for the upper limit [50 to 150 microns] of a clinically acceptable marginal gap [8]. At this time, there is no clinical evidence for a minimally acceptable marginal gap, however, acceptable marginal discrepancies of inlays are 20 microns at the occlusal surface and 74 microns at the gingival margin have been reported [10]. The material used in the technique is inlay wax. The advantages of this technique include the precise fit of the post into the post space along with less chairside time, as the wax pattern is not fabricated inside the patient's mouth.If the selected post closely fits or conforms to the canal shape and size , it may be a more conservative option because less dentin removal is required, thus enhancing fracture resistance of the tooth, as well as retention of the post [11].

The cast all-ceramic and especially the cast metal post-and-core systems with a high modulus of elasticity exhibited better and more stress-resistant marginal adaptation at the tooth-to-luting composite interface than the endo-crown or the glass-fiber-post-supported crown. The reason might be that the deformation of the root was limited by the stiff post-and-core systems, whereas the composite resin crown was proportionally more deformed than the root, leading to a slightly increased loss of marginal integrity at the luting composite-to-crown interface [4].

Previously our team has a rich experience in working on various research projects across multiple disciplines [12-26]. Now the growing trend in this area motivated us to pursue this project.

In this review we report all the factors responsible for affecting the marginal adaptability of post and core systems used in restoration of endodontically treated teeth.

Factors Affecting the Marginal Adaptability

1) Types Of Post
- Prefabricated Post
- Custom Made Cast Post

2) Design Of Post
- Parallel Post
- Tapered Post

3) Material Used For Fabrication Of Post
- Cast Metal Alloy
- Base Metal Alloy
- Zirconia
- Peek

4) Methods Used For Fabrication Of Post
- Direct Technique
- Indirect Techniques
- Lost Wax Technique
- Resin Pattern

5) Impression Techniques

6) Fabrication Method
- Casting Methods
- Cad Cam
- 3D Additive Manufacturing

Adaptation of a tapered post to a prepared canal can determine the clinical survival rate of a damaged tooth [27, 28]. The close contact between the walls of the root canal can determine the clinical survival rate of a damaged tooth. The close contact between the root canal wall and the post is necessary to achieve the passivity of fit and good marginal adaptation [29]. Moreover, it has been shown that uniform cement with minimum thickness will result in high adaptation and bond strength of posts, [30]

which in turn dissipates the imposed stress from the post equally throughout the canal [31]. Increased cement space due to the application of a non adapted post system will significantly affect the retention of the posts [32].

Types Of Post

Prefabricated Post: Combined fiber/zirconia prefabricated posts present a good alternative for restoration with posts and cores. In one of the studies, the mean load failure values for these posts were significantly greater in comparison with all the other post-and-core systems evaluated. However, it should be considered that prefabricated fiber posts have a predetermined diameter that may be too wide for some canals, especially for mandibular incisors. Also in non circular canals, a prefabricated post may be contraindicated because of poor adaptation of the post to the canal [33].

Custom Made Cast Post: High adaptation of the post to the root canal would result in a thinner cement layer. This thinner cement layer would lead to higher wettability, bond strength between the post and the dentin. Also, it would generate less tensile stress at the adhesive dentin interface due to its lower polymerization shrinkage stress and would have few defects to cause a cohesive fracture. Su et al. found that the CAD/CAM produced one-piece glass fiber post-and core had an excellent adaptation to the root canal in comparison with conventional fiber posts [34]. It was also able to achieve strong bonding properties in the canal to prevent dislodgement by minimizing the cement thickness. These features made the CAD/CAM glass fiber post-and core especially suitable in restoring the flared roots or defected teeth with incomplete ferrule [34, 35].

Design Of Post

In addition to the custom cast post and core, many commercially available pre- fabricated posts exist. For example, the axial form is either tapered or parallel, and the surface can be smooth, serrated with or without vents, or threaded using taps or self-threading. Caputo and Standlee categorize these different design features into three basic combinations:

1) Tapered, serrated or smooth- sided, cemented into a post space prepared with a matched-size post drill;
2) Parallel-sided, serrated or smooth-sided, cemented into matched cylindrical channels prepared by a post drill;
3) Parallel-sided, threaded and inserted into pre- tapped channels. [36].

In general, parallel-sided posts are more retentive than tapered posts, and threaded posts are more retentive than cemented posts. With respect to their installation mode, all posts are referred to as either active or passive. Active posts engage dentin within the root canal space and transfer more stress to the remaining root structure. Passive posts, even though they do not engage dentin in the root canal space, still transfer stress to the remaining root structure, but to a lesser extent [37].

Material Used For Fabrication Of Post

Cast Metal Alloy: Advantages of cast post and cores include their high strength, durability, and the strong union between the core and the post. However, cast posts and cores have been associated with more unfavorable deep root fractures, perhaps because of their relatively high modulus of elasticity. Cast post and cores can also offer an advantage over other post systems for teeth with extensive tooth damage, partial fixed dental prosthesis abutments, and bruxism and other heavy occlusion situations [38].

After ageing, the titanium system showed the highest marginal gap [14%] at the cement-crown interface. At the cement-tooth interface the restorations with titanium posts showed the least marginal deterioration after ageing, followed by the fibre-reinforcement system and the system without post [39].

The success rates reported by Sorensen and Martinoff are not in agreement with three in vivo studies. [40] Bergman et al recorded a success rate of more than 90% in a retrospective study of 96 teeth treated with cast posts and cores, and they concluded that the traditional custom cast post and core can be recommended. [41] Weine et al .reported a failure rate of only 6.5% after more than 10 years for 138 teeth treated with tapered smooth cast posts developed from plastic burnout patterns. [42] Hatzikyriakos et al examined 154 post and core restorations for a 3-year period and noted a 94.5 % success rate for single crowns restored with three different post systems: screw posts, parallel-sided serrated posts, and cast metal posts. A failure rate of 16.4% was recorded for pulpless teeth serving as abutments to fixed partial dentures, and abutments to removable partial dentures also had a higher failure rate than single crowns. Nevertheless the type of post did not influence the success rate [43]. Additional compar- isons of the failure rate of teeth restored with cast posts that closely reflect traditional treatment advocated by contemporary texts might be more informative.

Zirconia: The evolution of nonmetal post systems, including fiber-reinforced resin posts, has led to improved esthetics and more favorable stress distribution patterns [44].

Ageing caused an increase of marginal gap to 7% for Cera post restorations and to 8% for the Vectris system. It was remarkable that the application of the brittle ceramic system, using the post with highest Young's modulus, decreased the marginal adaptation by about 10% with the same interface. These results indicate that the flexibility of post and bonding within the range of human dentine helps distribute low mastication forces evenly within the restorative system . In contrast, we suppose that a stiff post transfers force peaks to the weakest point of the restoration – generally the bonding between cement and tooth. [39].

The cast all-ceramic and especially the cast metal post-and-core systems with a high modulus of elasticity exhibited better and more stress-resistant marginal adaptation at the tooth-to-luting composite interface than the endocrown or the glass-fiber-post-supported crown. The reason might be that the deformation of the root was limited by the stiff post-and-core systems, whereas the composite resin crown was proportionally more deformed than the root, leading to a slightly increased loss of marginal integrity at the luting- composite-to-crown interface [4].

The results of the study indicate that 1-piece milled zirconia posts and cores behaved similarly, without a statistically significant difference, compared to cast posts and cores, offering an acceptable

alternative for restorations of anterior teeth with high esthetic demands and when a custom post and core is required [45].

There was a significant difference in marginal gap distance when comparing 1-piece milled zirconia posts and cores versus the acrylic resin patterns. After adjustments, the posts fit passively into the canal and did not bind, as no pressure spots were observed when using a silicone disclosing agent. However, the posts were not fitting accurately, probably due to dimensional changes. Regardless, the load values in both the pilot study and definitive study resulted in similar load values between the 1-piece milled zirconia posts and cores and cast gold post and cores [33].

PEEK [Poly ethyl ether ketone]: PEEK material is also being used as a post and core system. In one of the study the push out bond strength for modified PEEK post in the apical region [7.593 ± 1.422] was found to be highest followed by middle region [6.279 ± 1.088] and least in the coronal region [6.178 ± 1.048]. The mean push-out bond strength for glass fiber post in the coronal region was found to be significantly higher than that of the modified PEEK post and the difference was found to be statistically significant. The mean push-out bond strength of the glass fiber post in the middle region was found to be significantly higher than that of the modified PEEK post and the difference was found to be statistically significant. The mean push-out bond strength for glass fiber post in the apical region was found to be significantly higher than that of the modified PEEK post and the difference was found to be statistically insignificant [46].

Methods Used For Fabrication Of Post

Marginal adaptability of post and core also depends on the method of fabrication of post and core. According to one of the study, the overall space between the canal walls and posts made with the direct technique ranged between 7.86 and 17.39 mm3, with a mean value of 12.25 mm3, whereas with the indirect technique, the space ranged between 6.68 and 18.02 mm3, with a mean of 11.92 mm3.Although most dental prostheses are fabricated indirectly in the dental laboratory, which is more convenient for both the dentist and the patient, many practitioners prefer the direct technique for post pattern fabrication because they assume it provides a more accurate fit. [47].

All cast metal posts were shorter than the impressions. The mean reduction for the metal posts was 2.3% for direct in anterior teeth, 5.7% for direct in posterior teeth, 6.3% for indirect in anterior teeth, and 7.2% for indirect in posterior teeth [all P<.05]. Statistically significant differences were found between time of technique and tooth position [P=.031], with the direct technique more time consuming than the indirect technique [P<.001] for both tooth positions. For the indirect technique, the impression times for both tooth groups were similar [P=.459][48].

The major advantages of cast posts are low cost, no clinical technique or special cement for fixation, a long history of clinical use, and excellent radiopacity. However, the result of dental lost-wax casting techniques is greatly influenced by the inherent properties of the dental materials, such as the expansion and contraction of all materials used, including impression materials, waxes, gypsum products, plastics, and metals.Distortions in the casting process result in a nonuniform pre- cementation space and absence of passivity and fitting between tooth and metal and inadequate endodontic healing [49].

A few studies have compared the accuracy of the cast metal posts considering impression techniques and tooth position. The indirect technique with polyvinyl siloxane impression material has been found to reproduce the details of the root canal space is faster and easier than the direct technique, especially when multiple posterior teeth are involved or when shorter clinical chair time is necessary; yet the direct technique is reliable and has several advantages, including easy manipulation of acrylic resin, dimensional stability, easy adjustment in the mouth when needed, and less working time at the laboratory, albeit with longer clinical time [50] Although we found differences between the replicated post space and cast post lengths, they were considered clinically irrelevant, with a mean reduction of 2.3% [0.3 mm] for direct in anterior teeth, 5.7% [0.7 mm] for direct in posterior teeth, 6.3% [0.6 mm] for indirect in anterior teeth, and 7.2% [0.7 mm] for indirect in posterior teeth. These results showed that metal posts fabricated with the direct technique presented fewer differences between impressed post space and cast posts but without any statistically significant difference. The indirect technique presented a higher percentage of shortage, probably because the dental technician creates a relief in the gypsum cast on which the acrylic resin pattern is made; this results in a greater probability of inaccuracy in the cast. Seating interferences from the resin patterns in the dental laboratory often occur with the indirect technique and are probably linked to ability of the technician and the inherent distortions of the materials used with the indirect technique [47].

CAD CAM Designed Post And Core

Nowadays, CAD/CAM technology can facilitate the fabrication of different dental prostheses, ranging from a single crown to complex fixed and removable dental restorations. Since the accuracy of the digital workflow seems to be the same as conventional systems, CAD/CAM technology has been used for post-and-core fabrication as well. Digital workflow has several advantages over conventional casting, such as eliminating the need for impression material and transportation, reducing the time-consuming laboratory procedures, and increasing patient comfort. [51-54]. Until recently, scanning the intra-canal space was not possible in most cases because of the anatomy of the canal. However, 3Shape has developed special scan posts to improve accuracy [55]. The full-digital dual-scan workflow using 3Shape scan posts has been claimed to accurately record the exact depth and anatomy of the root canal. This method makes it possible to design all layers of a post and core in a single digital work-flow. The available commercial scan posts have a circular shape [54]. With the application of digital technology, posts and Cores can be designed and manufactured in a single Laboratory session, which is convenient and time-saving, Especially in patients needing multi-unit restorations. Therefore, a digital workflow eliminates the complications of conventional casting, such as choosing a tray, Preparation of the impression materials, disinfection of The impressions, and transferring the impression to the Laboratory [56, 57]. Nevertheless, digital workflow should meet a criteria to be used in clinical settings. A 10-year retrospective study concluded that adequate Post adaptation dramatically increases tooth survival rate [58]. Active fit of a post and a non-homogeneous Cement layer might exert off-axis stress on the tooth Structure and increase the stress peaks, which in turn Increase the fracture risk of the restored

teeth.[27, 29]. The cast posts had less apical gap compared to the milled posts. Cast posts conform better to irregularities and Fit perfectly with the canal, which is evident from their Long history of success in clinical settings. Among the Milled posts, as it was anticipated, the round canals resulted in less apical gap than the oval canals, as the scan Posts could reach further into the round canals. 2-mm apical gap is an acceptable clinical cut-off point, below which dislodgement and fracture may occur [59].

Our institution is passionate about high quality evidence based research and has excelled in various fields [16],[60-69].

Conclusion

The restoration of endodontically treated teeth with the use of custom made cast post-core material displayed promising performance in matter of microgap and load-bearing capacity.Most of the CAD-CAM restorations/infrastructures were within the clinically acceptable marginal discrepancy range. The performance of a CAD-CAM system relative to marginal adaptation is influenced by the restorative material. Digital workflow has several advantages over conventional casting, such as eliminating the need for impression material and transportation, reducing the time-consuming laboratory procedures, and increasing patient comfort. More clinical and in vitro studies are required to drawn conclusion relative to marginal adaptation about the superiority of CAD CAM milling technology as opposed to the DMLS processes.

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