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Materials And Methods Used For Fabrication Of Custom Made Cast Post- A Review

Review 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.The material demand for posts has undergone a full makeover as a result of emerging care concepts. This review aims on focussing the materials used in post and core technique and their advantages and disadvantages.
Purpose: Purpose of this review was to summarize all materials and methods for fabrication of post and core so that Material science, defect analysis, force analysis, and mechanical engineering principles of preparation and designs can be used to help in decision making for post endodontic restoration according to different clinical conditions.
Conclusion: Post-and-core materials and techniques that are available to the clinician for a variety of clinical procedures and thus each clinical situation should be evaluated on an individual basis.

Keywords: Custom Made Post; Post And Core Restorations; Cast Post; Ferrule; Post Space.

Introduction

The dentist is also tasked with repairing teeth that have been endodontically cleaned. Caries caused, pulpal inflammation or painful injury to a tooth, normally necessitates root canal treatment. Trauma and decay are often synonymous with significant tooth structure degradation, necessitating a thorough crown reconstruction for esthetic and functional rehabilitation [1]. It is always difficult to obtain proper anchorage of a reconstruction in the residual dentin when a significant portion of the clinical crown has been lost to injury. A root-canal–retained restoration is expected in such cases.

Due to ample dentin bulk and axial loading conditions, post-retained cores are frequently unnecessary in molars. When chewing forces are applied to single-rooted teeth (especially incisors), more tension occurs because they are loaded non axially [2]. For decades, the cast post-and-core technique has been regarded as the gold standard in reconstruction. The related methods and materials have vastly improved since the advent of direct post and core reconstruction. Stabilization of weakened, endodontically treated teeth has also been suggested using posts and cores. Alternatives to the cast post and core have not yet seen extensive therapeutic use, even though paradigms for the reconstruction of otherwise healthy nonvital teeth are changing [3].

The manufacturing of cast posts and cores can be done in a variety of ways. The root canal may be fitted with burnt-out plastic patterns or cast-on posts, and then relined with autopolymerizing acrylic [4]. After that, an autopolymerizing acrylic core pattern can be made up and then set in dental alloy. Direct restorative therapies are also used as an option. For the construction of pulp-

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less teeth, preformed titanium, stainless steel, or carbon-fiber and zirconia posts have been recommended. The posts are bonded to the tooth, and the backbone is made of amalgam, cement, or a mixed composite material [5].

Although the literature contains several in vitro studies on various aspects of post-and core restorations [6, 7], few studies compare the effectiveness of clinically relevant restorative approaches [8] [9]. Furthermore, the materials used differ significantly (Figure 1). On the basis of in vitro trials alone, it is still difficult to support a preference for cast or direct post-and-core restorations.

The restoration of pulpless teeth that have been endodontically repaired is a difficult dental treatment [10]. Caries, endodontic surgery, or trauma-induced fractures cause tooth loss; repairing these teeth is a challenging process for a clinician. Where a tooth has lost so much structure and needs to be replaced with a crown and bridge, a post and core treatment is an alternative [11]. The post is used to keep a heart in place, and may be used to keep a definitive prosthesis in place. The decision to use a cast post or a prefabricated post is based on a number of considerations, including the canal configuration and residual tooth structure. If a canal necessitates thorough planning, it is said that a well-adapted [12].

Endodontic posts, such as gold and nickel-chromium (Ni-Cr) posts, are cast with the heart, while titanium and stainless steel posts are prefabricated. Non-metallic posts, such as fiber-reinforced polymer (FRC) and ceramic posts, have recently been proposed as potentially suitable alternatives to metal posts [13]. One of the benefits of post-and-core structures is that they increase tooth resilience by dispersing functional forces along the root range. One of the reasons influencing the stress distribution in dentin is the substance of a dental post. Stainless steel, titanium, and zirconia posts showed virtually identical stress levels across the prefabricated post models [14].

Material science, defect analysis, force analysis, and mechanical engineering principles of preparation and designs were all needed for the restoration of endodontically treated teeth. Posts made of various materials and of varying sizes, diameters, and shapes are widely used for various purposes [15]. Core products, on the other hand, have a variety of properties. Gold has excellent mechanical properties but is expensive: composites are simple to apply and use, but they accumulate water and lose structural integrity as a result of their porous characteristics [16]. Amalgam has stronger mechanical properties than composites, but it is more cumbersome due to hardening delays [17].

The material demand for posts has undergone a full makeover as a result of emerging care concepts. The material and construction choices are endless, ranging from the age of wooden posts to metal posts, and most recently, carbon fiber, glass fiber, and ceramic posts [18]. Cast metal or prefabricated metal posts have dominated the industry for nearly a century. The movement toward prefabricated metal posts, resin based composite cores, fiber reinforced resin based composite posts, and ceramic posts has shifted in recent years due to an implosion of new materials [19].

Our team has a rich experience in working on various research projects across multiple disciplines [20-34] Now the growing trend in this area motivated us to pursue this project. This review aims on focussing the materials used in post and core technique and their advantages and disadvantages.

Prefabricated Post And Core

The use of a post to replace a tooth with a broken natural crown is not a new dental procedure. The Japanese used wooden dental restorations similar to the present post crown during the Tokugawa period (1603-1867)[35]. Pierre Fauchard described a procedure for retaining a natural tooth crown or an ivory crown to a root in his book The Surgeon-Dentist, or, Treatise on the Teeth, published in 1728. The Richmond Porcelain and Gold Collar Crown was first introduced in 1876 and has since been adapted to become a one-piece post and crown [36]. The invention of cast posts was prompted by root fractures and other problems found with these early therapies.

Despite the fact that modern endodontic, prosthodontic, and periodontal treatments have helped patients to keep chronically damaged teeth for longer periods of time, rehabilitation of these teeth remains difficult. When endodontically treated teeth are recovered, despite a variety of advances and decades of study on posts, failures will still occur. The most common post complications, according to studies, are post loosening and root fracture; however, the overall clinical failure rate of posts remains poor. posts had an overall absolute rate of loss of 9%, according to data from eight surveys (7 percent to 14 percent range)[37-41].

Prefabricated posts have become popular, and there are several different systems to choose from. Several nonmetallic posts, such as carbon-fiber epoxy resin, zirconia, glass fiber-reinforced epoxy resin, and ultra-high polyethylene fiber-reinforced posts, have recently become available in response to a demand for tooth-colored posts [11].

CARBON FIBER POSTS

Properties and Characteristics: Epoxy resin posts covered with carbon fiber Properties and composition Duret and Renaud invented the carbon fiber-reinforced epoxy resin post system (CF) in France in 1988, and it was first launched in Europe in the early 1990s [42]. This post's matrix is an epoxy resin filled with unidirectional carbon fibers running parallel to the post's long axis. The fibers have a diameter of 8 m and are evenly embedded in an epoxy resin matrix [42]. The fibers make up 64 percent of the post's weight and are extended until the resin matrix is injected to improve the post's physical properties. According to reports, the post absorbs applied stresses and distributes them across the pipe. The majority of the carbon fiber is made from polyacrylonitrile, which is heated in an inert environment at 1200°C after being heated in air at 200°C to 250°C [43]. Carbon fibers are formed when hydrogen, nitrogen, and oxygen are removed from a sequence of carbon atoms.

High fatigue resistance, high tensile strength, and a modulus of elasticity comparable to dentin have all been recorded for the carbon fiber-reinforced article [44]. Originally, the post was radiolucent; however, a radiopaque version is now available. Within the article, traces of barium sulfate and/or silicate are used to create radiopacity. Mannocci et al [45] used radiography to look at five different kinds of fiber posts. Just two of the five posts had

standardized radiopacity, according to the researchers. Finger et al [46] investigated the radiopacity of seven fiber reinforced resin posts and discovered that CF posts were suitable. The post can be ordered in a variety of forms, including double cylindrical with conical stability floors and conical shapes [47].

The post's surface texture may be smooth or serrated. Serrations have been shown to improve mechanical retention in studies, though the smooth-sided post often binds well to adhesive dental resin. The post's surface has a roughness of 5 to 10 micrometers to aid mechanical adhesion of autopolymerizing luting materials, and cytotoxicity studies indicate that the post is biocompatible [48]. Epoxy resin posts covered with carbon fiber. Results of laboratory tests Physical property measurements of CF posts also showed mixed results; some found them to be greater than metal posts, while others considered their strength to be equal to or inferior to metal posts. The fracturing tolerance of extracted teeth that have been reconstructed with CF posts has been thoroughly studied [49].

Several studies [50] have shown that CF posts are less likely than metal posts to cause root fracture; however, two studies found no substantial difference in tooth fracture tolerance, and one study found that cast metal posts have a slightly higher fracture threshold. Multiple studies found that after thermal cycling and cyclic loading, the strength properties of CF posts decreased [51]. The flexural resistance of CF posts was also decreased when they came into contact with oral fluids. The simplicity with which broken CF posts can be removed is said to be one of their benefits. For post-removal, a removal package has been proposed, with the caveat that it should be a one-time use object [52].

Laboratory and Clinical Outcomes

Physical property measurements of CF posts have shown mixed results; some experiments considered them to be heavier than metal posts, while others found them to be equal to or inferior to metal posts [53]. Extracted teeth restored with CF posts have been thoroughly tested for crack tolerance. Several tests have shown that CF posts are less likely than metal posts to cause root fracture; however, two studies found no substantial difference in tooth fracture tolerance, and one study found that cast metal posts have a slightly higher fracture threshold. Studies found that after thermal cycling, the strength properties of CF posts decreased [54, 55].

Post loosening, periapical pathology, root fracture, crown debonding, secondary caries, periodontitis, post fracture, tooth extraction for unclear reasons, and failures of unexplained causes have all been recorded [56-60]. Seven studies confirmed post loosening, although five studies reported no loosening at all. Just five of the studies that recorded post loosening quantified the amount of loosened posts. In five trials, periapical disease was seen in 2 of 100, 2 of 59, 10 of 99, and 10 of 775 failures, respectively. Periapical pathology was seen in one study, but the number of deficiencies caused by this source was not determined. In three of the trials, root fracture occurred in 2 of 173, 14 of 99, and 14 of 775 roots. Three experiments confirmed crown debonding, while one study reported post fracture.

GLASS FIBRE POSTS

Properties and Characteristics: Glass or silica fibers are used to stabilize the glass fiber-reinforced epoxy resin post (GF) (white or translucent). Electrical glass, high-strength glass, or quartz fibers may both be used to create glass fiber posts. In comparison to other oxides, silica-based fibers (50 percent to 70 percent SiO2) are widely used [55]. The GF post comes in a variety of shapes, including cylindrical, cylindroconical, and conical. Parallel-sided GF posts are more retentive than tapered GF posts, according to an in vitro evaluation of many GF post structures. The structure of the glass fibers in the matrix has a significant impact on the post's weight. Naumann et al [61] compared the crack resistance of two GF posts with different glass fiber weight ratios. They discovered that the higher glass fiber content in the post added to the post's increased resilience.

Laboratory and Clinical Outcomes

The kind of glass fiber used has no bearing on the flexural strength of GF posts. Carbon-fiber, quartz-fiber, and glass-fiber posts were tested for flexural strength in one study [62]. Since the epoxy resin used to join the fibers together was of the same concentration and form, the posts acted similarly. In vitro, the yield strength of GF, titanium, and zirconia posts was also assessed [63]. When GF posts were comparable to zirconia and titanium posts, the yield strength was considerably greater.

Post loosening, periapical pathology, root fracture, crown debonding, post fracture, core collapse, reconstruction fracture, and failures for unexplained reasons have all been recorded. Studies documented post loosening, although two studies did not mention any loosening [64-68]. The following post loosening data were given in these five studies: 5 out of 210 posts were loose, 2 out of 205 posts were loose, 7 out of 225 posts were loose, 2 out of 105 posts were loose, and 7 out of 162 posts were loose.In five trials, periapical pathology was seen in 11 of 210, 7 of 225, 4 of 100, and 5 of 162 failures, respectively. Periapical pathology was seen in one study, but the number of deficiencies caused by this source was not determined. In two of the trials, one out of every 210 and one out of every 105 posts shattered. One study found crown debonding and another found post fracture.

POLY-ETHYLENE FIBRE POST

Posts of polyethylene fiber reinforcement Composition, properties, and outcomes of laboratory tests Polyethylene fiber-reinforced posts (PF) are made of twisted polyethylene fiber ribbon with an ultrahigh molecular weight (Ribbond, Ribbond Inc, Seattle, WA). It is a polyethylene-woven fiber ribbon coated with a dentin bonding agent and packed into the canal, where it is then light polymerized in place, rather than a typical post [63]. Due to a leno weaving or a triaxial architectural pattern, the Ribbond material has a three-dimensional (3D) shape. These designs feature a large number of nodal intersections that help to avoid crack propagation while also providing mechanical retention for the composite resin cement [69]. As PF posts were tested in the lab against metal posts, the fiber-reinforced posts had a lower rate of vertical root fracture. The post complex's strength was improved by adding a small-size prefabricated post to the PF post; however, the PF post's strength did not approach that of a cast metal post. The PF posts were also found to support the remaining tooth structure as opposed to other fiber-reinforced composite post structures [63].

The mean load-to-failure value of PF posts seems to be significantly affected by the inclusion of a significant amount of core material and an adequate dentin bonding region coronally. Cobankara et al [70] used a fracture intensity evaluation and a finite element analysis to analyze two post structures. They discovered that tension accumulated around the tooth's cervical region as well as the buccal bone. Within the PF post scheme, the least amount of stress was reported [71]. They suggested that the PF post could be useful in the reconstruction of teeth that have had their apicals resected.In terms of microleakage, the use of PF posts to repair endodontically treated teeth tends to be a viable alternative to stainless steel and zirconia posts. In vitro, Buyukyilmaz et al [72] compared the microleakage of three esthetic, adhesively luted post systems to a standard post system. When compared to zirconia posts, they discovered that PF and GF posts had fewer microleakage. Clinical results PF posts have been scientifically tested in one study [73]. After a median of 2.9 years, the failure rate was estimated to be 2.4 percent. The failure of the PF post was stated to be caused solely by post loosening [74].

ZIRCONIA CERAMIC POSTS

Meyenberg et al.[75] were the first to introduce zirconia posts, claiming that their flexural forces (900-1200 MPa) were equal to cast gold or titanium, and that the same post measurements as high gold alloys or titanium were feasible. Because of its chemical durability, strong mechanical efficiency, high hardness, and a Young's modulus close to that of stainless steel alloy, zirconia is currently a commonly used material in prosthodontics [76]. Transformation toughening is a physical property that gives partially stabilized zirconia its high initial strength and fracture toughness. Apart from its advantageous chemical and physical properties, zirconia also has the esthetic benefit of possessing a colour that is identical to real teeth [77]. Zirconia posts, on the other hand, fall short of the perfect post's ability to be quickly withdrawn when retreatment is required, so zirconia posts are almost impossible to remove from the root canal when a malfunction occurs [78]. While it is difficult to grind a zirconia post down, ultrasonic vibration removal of a broken zirconia post has been shown to induce a temperature increase in the post and on the root surface. Apart from its advantageous chemical and physical properties, zirconia has the esthetic benefit of possessing a colour that is closer to that of real teeth [79]. Zirconia posts, on the other hand, fall short of the optimal post's ability to be quickly withdrawn when retreatment is needed, as zirconia posts are almost difficult to extract from the root canal when they fail. While grinding away a zirconia post is impractical, ultrasonic vibration removal of a broken zirconia post has been shown to induce temperature rise on the post and root surface [76].

1. Advantages of zirconia as a post material

The key benefits of zirconia are its translucency and tooth-colored shade, which allows it to be used for all-ceramic anterior crowns. To maximize the esthetic effect at the root while ensuring sufficient pressure, a patient with a high lip line and thin gingival tissue will entail the use of a zirconia post with an all-ceramic crown. Furthermore, zirconia is recommended for teeth with extreme coronal destruction, since composite materials are not strong enough to sustain crowns [80].

2. Disadvantages of zirconia as a post material

Vertical root fractures can be exacerbated by the greater rigidity of zirconia posts relative to FRC posts. As a result, zirconia is not recommended for bruxism patients. Furthermore, retreating teeth restored with zirconia posts is almost impossible due to the difficulty of grinding away the zirconia post and removing it from the root canal [81].

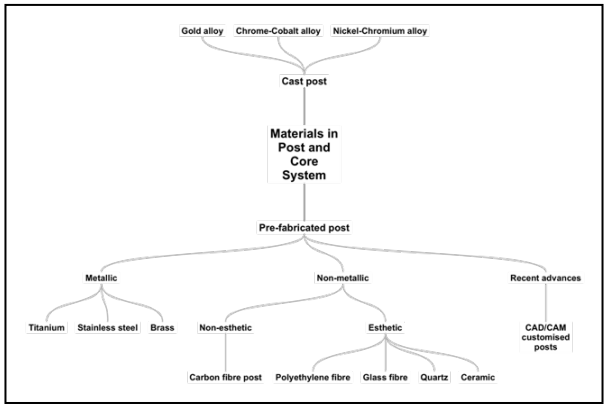
3. Post space preparation

The rules of post space planning for zirconia posts are identical to those for other post systems. To stop unnecessary forming, the clinician must have a basic understanding of root canal configuration. Drills can be used at a slow speed to avoid perforation. The post should be two-thirds the length of the root canal, and the planning of the post room should not compromise the integrity of the remaining root canal filling. A more stable post system, such as zirconia, would be preferable if a limited diameter post were to be used [78].

4. Post retention and microleakage

Coronal leakage can be reduced by using a dependable luting cement for post-cementation. When it comes to zirconia posts, resin cements are preferred to traditional cements because they have been proven to achieve better bonding to both the zirconia surface and the dentin. Panavia, a phosphate methacrylate-based dual-cured resin cement, appeared to have higher bond strength values to zirconia posts than other cement forms in most trials [82].

Figure 1. Types of materials in post and core systems.



Metallic Prefabricated Posts

Stainless steel, nickel chromium alloys, and titanium alloys are commonly used. With the exception of titanium alloys, they are very stable and solid. They provide little resistance to rotational forces due to their circular shape. If sufficient tooth structure remains, this is not a problem; but, if only partial tooth structure remains, antirotation features such as slots or pins must be integrated into the post preparation [83]. The heart can be made of bonded steel. Since their tapered form resembles the overall canal anatomy, passive, tapered posts provide the least preservation of the prefabricated posts while allowing limited radicular dentin removal [84]. They're a good option if you have enough canal length, particularly in thin roots like maxillary premolars. A sufficient length is described as more than 8 mm. A parallel post, the use of resin cement, or the use of an active post will also help to increase retention.

The titanium alloys used in many of the prefabricated posts, as well as brass, are used in others. Because of corrosion problems, titanium posts were added. The radiodensity of most titanium alloys used in posts is identical to gutta-percha and sealer, making them difficult to identify on radiographs [85]. Titanium posts have a low fracturing strength, making them unsuitable for use in thin post channels. Titanium posts are difficult to remove since they can snap when force is exerted using a post removal tool. To extract titanium posts, it might be possible to use a lot of ultrasonic energy, which may be harmful to the tooth and surrounding tissues [86]. Titanium and brass posts can be avoided for these purposes, since they have no particular benefits over the stronger metal posts.

Custom Made Cast Post And Core

It is the best way for a durable and strong restoration and is made with precious, semi precious or other alloys (mainly chromium – cobaltium). Indicated in teeth with extensive loss of tooth. Need an appointment for dental impression and send to the dental laboratory .This procedure requires casting a post and core as a separate component from the crown .It almost always requires minimum tooth structure removal [10]. The casting can be made with gold type III or IV .Have high tensile strength, compression and deformation (High modulus of elasticity)(not screwed).They have fallen from favor because they require two appointments, temporization, and a laboratory fee. Nonetheless, there are studies that report a high rate of success with cast post and cores and they offer advantages in certain clinical situations [14]. For example, when multiple teeth require posts, it is sometimes more efficient to make an impression and fabricate them in the laboratory rather than placing a post and buildup in individual teeth as a chair-side procedure.

A cast post and core may be indicated when a tooth is misaligned and the core must be angled in relation to the post to achieve proper alignment with the adjacent teeth. Cast post and cores also may be indicated in small teeth such as mandibular incisors, when there is minimal coronal tooth structure available for antirotation features or bonding [87]. Cast posts and cores are generally easy to retrieve when endodontic retreatment is necessary. Perhaps the biggest disadvantage for cast posts and cores is in areas that require an esthetic temporary restoration. Temporary post/crowns are not effective in preventing contamination of the root-canal system When a temporary post and crown is needed, a barrier material should be placed over the obturating material, and the cast post and core should be fabricated and cemented as quickly as possible a post was removed and endodontic treatment was performed.

The apical segment was packed with gutta-percha and a self-curing, glass-ionomer material was placed adjacent to the gutta-percha to protect it from contamination during the period of temporization and while clinical procedures are performed by the restorative dentist [4]. A self-curing material should be used in most cases because of the difficulty of obtaining effective light curing deep in the canal. Other materials may be used for this purpose such as zinc oxide and eugenol materials or self-curing dentin adhesives and composites.

Also, because it is cast in an alloy with a modulus of elasticity that can be as high as 10 times greater than natural dentin, this possible incompatibility can create stress concentrations in the less rigid root, resulting in post separation and failure [88]. Additionally, the transmission of occlusal forces through the metal core can focus stresses at specific regions of the root, causing root fracture. Furthermore, upon aesthetic consideration, the cast metallic post can result in discoloration and shadowing of the gingiva and the cervical aspect of the tooth.

CAD-CAM Manufactured Posts

Advances in computer-aided design (CAD)/computer-aided manufacturing (CAM) technologies and ease of application have allowed the development of new treatment concepts for modern dentistry [89]. CAD/CAM applications offer a standardized manufacturing process, resulting in a reliable, predictable and cost-effective workflow for individual and complex tooth-supported restorations [89]. CAD/CAM technology has advantages, including fingerprints and digital models, and the use of virtual articulators. However, the implementation of this technology is still considered expensive and requires highly trained personnel [90]. Currently, design software has more applications. The precision of the restoration manufacturing can be better achieved with 5-axis milling units [90].

Computer-aided design and manufacturing technology (CAD-CAM) simplified the planning and manufacturing procedures involved in partial roofing restorations and also led to the development of new materials with homogeneous structures that suffer less contraction when polymerized [91]. The development of hybrid and metal-free materials, combining two main restoration components (resin and ceramic), provided a wide range of materials with visual indications and improved biomechanical properties [92]. Digital dentistry has been developed to increase workflow precision and to accelerate the production process [93]; generally, use of CAD-CAM to realize customized posts generally was limited to scanning plaster models obtained from traditional impressions [94].

Other authors proposed a different digital workflow in which a traditional silicon impression is scanned to mill a personalized CAD-CAM post and core [95]. Studies show that both impressions and stone replicas can be digitized with a high reliability

[96]. Direct acquisition was considered quicker, more accurate and less invasive than indirect methods [97], however an accurate intraoral scanning requires the skill, experience and knowledge of the operator, which might affect the outcome due to patient-related factors such as intraoral humidity, tongue movement and saliva flow. CAD-CAM-fabricated posts combine the advantages of traditional custom posts and prefabricated fiber posts [98]. The use of CAD-CAM fabricated post and core restorations has been suggested, and CAD/CAM fabricated zirconia post and core have been investigated However, it is nearly impossible to retrieve zirconia post if fracture occurs, which leads to an irreversible tooth failure [99]. Recent resin-based, computer-aided and computer-aided manufacturing (CAD-CAM), have been used to restore endodontically treated teeth. Adaptation of the restoration is important for clinical success [100]. The precision of the CAD-CAM post and core restoration allows for a minimal amount of cementing composite resin and can result in a better adhesion to the dentinal walls.

The post made with this system has precise adjustment in the canal, showed high esthetic and can be used in cases where there is no coronal remaining, besides being able to support extensive prostheses. The main advantage of the CAD-CAM technique, when compared to the traditional method, is the speed of preparation of the restoration, however more clinical studies are necessary to evaluate whether this method could make crowns satisfactory enough to resist for long periods [101].

Our institution is passionate about high quality evidence based research and has excelled in various fields [24, 102-111].

Conclusion

Although the quest for the ideal material to restore lost tooth structure continues to be a focus of modern dental research, the aforementioned review indicates there are many post-and-core materials and techniques that are available to the clinician for a variety of clinical procedures and thus each clinical situation should be evaluated on an individual basis.

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