Fracture Resistance of Teeth Restored with Post-retained Restorations: An Overview

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Abstract

Introduction: Posts have been used efficiently to retain restorations for badly destructed teeth. This article critically analyzes the concerned topics related to the fracture resistance of teeth restored with dowel-retained restorations. **Methods:** A systematic review of PubMed/MEDLINE, Cochrane, and Scopus databases was completed (from 1960 to 2010). Single or combined key words were used to obtain the most possible comprehensive list of articles. Checking the references of the relevant obtained sources completed the review along with a manual search to locate related articles on the topic. *In vivo* and *ex vivo* (laboratory, computer-based finite element, and photoelastic stress analysis studies) investigations related to the topic were included. **Results:** Many factors have been proposed to influence the fracture resistance of post-restored teeth. Recognizing the significance of these factors on the fracture resistance of teeth would aid in choosing the suitable treatment modality for every individual case. Fracture resistance was improved if tooth structure loss was limited, a ferrule was obtained, a post with similar physical properties to natural dentine was used, and adhesive techniques for post luting and coronal restoration were used. Adhesively luted resin/fiber posts with composite cores appear to be the best currently available option in terms of tooth fracture and biomechanical behaviour. **Conclusions:** Most guidelines were based mainly on *ex vivo* studies and to a lesser extent on limited *in vivo* studies. The lack of long-term controlled randomized clinical studies was the main hindrance to reaching a conclusive and undisputable opinion regarding endodontic posts in terms of tooth fracture and biomechanical behaviour. *(J Endod 2010;36:1439–1449)*

Key Words

Endodontic post, failure modes, fracture resistance, review

Endodontically treated teeth were claimed to be weaker and more prone to fracture than vital teeth (1). Fennis et al (2) investigated 46,000 insurance claims and reported a higher incidence of tooth fracture among endodontically treated teeth. The loss of water and collagen cross-linking might underlie the brittleness and weakness of enododontically treated teeth (3, 4). On the other hand, some studies reported that tooth substance of endodontically treated teeth had comparable biomechanical and physical properties to vital teeth (5–7).

The loss of structural integrity is the main reason behind the vulnerability of endodontically treated teeth and their reduced resistance to fracture (5, 8). Most endodontically treated teeth suffer massive reduction in their structural stability because of the great loss of coronal dental structure caused by caries, fractures, and access preparations.

Tang et al (9) summarized the risks that increased the potential of tooth fracture after endodontic treatment. The risks included loss of tooth structure, stresses attributed to endodontic and restorative procedures, access cavity preparation, instrumentation and irrigation of the root canal, obturation of the root canal, post canal preparation, post selection, coronal restoration, and inappropriate selection of tooth abutments for prostheses.

Vertical root fractures of endodontically treated teeth prepared to receive endodontic posts were more frequent in the teeth of older patients and when dentine thickness was reduced (10). In their review, Dietschi et al (11) concluded that changes in tooth biomechanical behavior, tissue composition, and moisture after the loss of tooth vitality and proper endodontic treatment were limited and negligible. However, they found that teeth became weaker as they lost more coronal tissue because of caries or restorative procedures.

Another possible reason behind their inferior resistance to fracture is the reduced proprioception of endodontically treated teeth (12). Consequently, they will be subjected to more harmful forces without a protective reflex. Because of their inherent weakness, endodontically treated teeth need to be restored in a manner that would provide protection for the remaining tooth structure but would also allow the restoration of esthetic and functional demands (13).

The restoration of endodontically treated teeth should aim at increasing tooth fracture resistance especially in cases with extensive tooth destruction (13). Some researchers recommended the use of posts for support and reinforcement of remaining tooth structure. This claim was supported by the ability of posts to distribute stress in a favorable way that would improve the fracture resistance of restored teeth (14–19). Salameh et al (17, 20) showed that endodontically treated teeth restored with fiber posts and ceramic crowns were more resistant to fracture and had less catastrophic fracture patterns than the ones restored with ceramic crowns and no posts. In another study, Salameh et al (21) used porcelain fused to metal, Empress II (Ivoclar

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Vivadent, Schaan, Liechtenstein), SR Adoro (Ivoclar Vivadent, Noble Park North, Victoria, Australia), and Cercon (Dentsply Ceramco, York, PA) crowns to restore endodontically treated maxillary incisors and reported similar conclusions as described previously regardless the type of used crown. Also, Cagidiaco et al (18) and Ferrari et al (19) showed that the placement of fibre posts did improve the survival rate of endodontically treated premolars.

Furthermore, Nam et al (22) found that the fracture resistance of endodontically treated premolars with one to four remaining coronal walls was significantly increased when they were restored with fiber posts. Moreover, teeth showed better stress distribution and fracture patterns when restored with fiber posts. However, fracture resistance of teeth with no remaining coronal walls was not improved when fiber posts were used. Figure 1*A* through *D* presents some fracture modes that associate metal, glass fiber, and carbon fiber posts.

When compared with no post treatment, Nothdurft et al (23) reported better fracture resistance of premolars with class II cavity preparations after they were restored with zirconia, fiber, or titanium posts. They concluded that posts in premolars with class II cavities would improve tooth resistance to the extra-axial forces. In another study, Nothdurft et al (24) reported no difference in fracture resistance of premolars with class II cavities restored with crowns alone or crowns and posts (titanium, zirconium dioxide, glass fiber, and quartz fiber posts). From these two studies, it can be concluded that the use of crowns might cancel the effect of posts on fracture resistance of restored teeth.

On the other hand, many studies challenged the use of posts for support and reinforcement of remaining tooth structure and even considered post placement as a risk factor that weakened the remaining tooth structure and predisposed tooth fracture. These studies showed that restoring endodontically treated teeth using cast metal, prefabricated metal, or fiber posts had negative effects on teeth fracture resistance (25–30). Unlike other modes of failure, root fracture of post restored teeth is the most catastrophic and almost always results in extraction of the involved tooth (27, 28). A higher incidence of vertical root fractures was reported among teeth restored with titanium, zirconia, and prefabricated/cast metal endodontic posts (26, 28, 31, 32). This was greatly attributed to stress concentration within the radicular dentine during post placement and, consequently, the altered pattern of stress distribution upon loading (32–34).

Fokkinga et al (35) reported that the presence or absence of metal/fiber posts did not affect the fracture resistance and failure modes of endodontically treated premolar teeth with resin composite crowns and no retained coronal tooth structure. Therefore, they suggested that posts are not necessary for the restoration of such teeth. Also, Mohammadi et al (36) found no difference in fracture resistance of premolars restored with direct resin composite in the presence or absence of fiber post and cusp coverage.

Furthermore, Soares et al (29) found that the loss of dentinal structures and the presence of fibre posts caused more stress concentration in tooth and restoration and decreased the fracture resistance of teeth. However, they found that fiber posts were associated with less catastrophic fracture modes when there was an extensive loss of tooth tissues.

An *in vitro* study by Pilo et al (30) showed that endodontic therapy for upper bifurcated premolars caused loss of more dentine at bifurcation area of both roots in comparison to outer areas. Furthermore, the preparation of post canals undermined root strength because it left less than the recommended 1-mm dentine thickness around the post canal. Buccal roots were more affected by this pitfall. Therefore, they recommended limiting the use of posts in upper bifurcated first premolars, and when necessary the posts should be used in lingual roots rather than the buccal ones.

The literature is full of controversial conclusions regarding the best post to use for the restoration of endodontically treated teeth. This article critically analyzes the concerned topics and controversy related to the fracture resistance of teeth restored with dowel-retained restorations.

Methods

A systematic review of PubMed/MEDLINE (from 1960 to 2010), Cochrane, and Scopus databases (to 2010) was completed. Single or combined key words (fracture resistance, endodontic post and core, fiber posts, adhesive luting, and endodontically treated teeth) were used to obtain the most possible comprehensive list of articles. Checking the references of the relevant obtained sources completed the review along with a manual search to locate the most relevant articles on the topic. *In vivo* and *ex vivo* (laboratory, computer-based finite element, and photoelastic stress analysis studies) investigations related to the topic were included in this review. Because the number of long-term randomized controlled clinical trials (RCTs) was limited in this field, retrospective, prospective, descriptive, review, and RCT studies were included. Studies describing post and core systems to restore endodontically treated teeth and their mechanical and physical properties were included. Also, articles investigated fiber posts, ceramic posts, cast posts, and prefabricated metal posts, and different core systems were included. Furthermore, articles studied failure modes and fracture resistance of teeth restored with different post and core systems were included.

Results

Methods Used to Assess Stress Distribution and Fracture Resistance of Post-Restored Teeth

Few RCT studies have investigated the fracture resistance of teeth restored with post and core restorations. This might be attributed to the difficulties encountered in controlling related factors clinically such as force magnitude and direction, teeth geometry, and remaining tooth structure (13). *In vitro* studies, on the other hand, are easier to control and conduct, but their recommendations should be interpreted with caution because of their limitations and conflicting results.

It is impossible to accurately simulate intraoral conditions by *in vit*ro studies (13). However, attempts were made to investigate fracture resistance of endodontically treated teeth restored with posts and cores experimentally (37). Three methods have been frequently used for this purpose including laboratory experiments, photoelastic analysis, and finite element analysis (13, 37).

Although most mechanical laboratory studies were aimed at investigating the failure loads and modes of restored teeth, photoelastic and finite element analysis studies were used to investigate stresses within restored teeth upon loading and the effect of post placement on stress values and distribution (13).

Laboratory Experiments

Many mechanical studies were conducted to investigate the effect of post placement and related factors on the fracture resistance of endodontically treated teeth (38-43). Extracted teeth, especially incisors and premolars, were used in these studies. Static loading at a constant angle was applied to restored teeth in some studies (41, 44). However, actual masticatory forces are multidirectional and repeatedly applied on larger areas (13). In order to mimic such conditions, cyclic loading was also applied in some studies (42, 43, 45). Hayashi et al (46) applied simultaneous static and cyclic loading to restored teeth in both horizontal and vertical directions and reported that teeth restored with fiber posts and composite cores were more