Review Article

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# All About Dowels - A Review Part II Considerations After Cementation

Dentistry Section

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## ABSTRACT

The present review summarizes the published literature examining cementation of the dowel and factors related to it. The peer reviewed English language literature was reviewed from the period 1990 to 2015. Articles were searched in Pubmed/Medline for the relevant terms. Additional manual searches of some dental journals were also carried out. The original key terms resulted in 228 articles. After applying inclusion criteria, 64 articles remained to be included in part II of this review. Article search indicates that most published literature on dowels are in the form of in vitro analysis. Literature on prefabricated dowel systems far exceeds than the custom cast dowel and newer fibre dowels. Clinical evidence is not sufficient and cannot be used to inform practice confidently. However, within the limitations of this review it is suggested that adhesive fixation is preferred in case of short dowel. Dowel width should be as small as possible. A ferrule of 2 mm has to be provided. Composites have proven to be a good core material provided that adequate tooth structure remained for bonding. Dowel should be inserted if endodontically treated tooth is to be used as abutment for removable partial dentures.

**Keywords:** Dowel fixation, Ferrule, Microleakage

## INTRODUCTION

The prosthetic treatment of structurally compromised teeth remains confusing issue from a clinical perspective. Endodontically treated teeth are prone to fracture because of coronal destruction from dental caries and decreased moisture content [1]. Endodontically treated teeth may require a dowel-and-core restoration for optimum function. Most of the reviewed literature emphasizes the dowel retention, fracture resistance, ferrule effect, biocompatibility, dowel treated tooth as an abutment after insertion of dowels and during function. Few other factors, core retention with the dowel, microleakage, associated stresses in the root canal, radiopacity and esthetics are also found to influence the long term prognosis of dowel-core restoration.

The reason behind using a dowel is to provide retention to the core that replaces missing tooth structure. For dowel retention, adhesive fixation is preferable as it provides improved retention in the canal, higher resistance against fracture and microleakage [2]. Artificial crown should encircle the sound tooth structure below the margin of the core to provide the 'ferrule' effect which helps to prevent the vertical fracture of the root. If the margin of the crown and core are at the same level, the dowel is more prone to dislodging forces [3]. Cantilever prosthesis on abutment teeth that have been restored with dowel-core restoration should be avoided due to reduced level of propioception and increased bending forces [4]. Titanium alloys and non-metallic dowel materials are most biocompatible due to elimination of corrosion factor. Quartz or glass fiber reinforced epoxy resin dowel and polyethelene fiber composite dowel are used to support complete coverage restoration on anterior tooth to improve the esthetic result [3,5]. Zirconium oxide dowels are made relatively wide to compensate for their brittle nature and require substantial removal of radicular tooth structure.

This review discusses the research on the factors that have been identified to be important in successful treatment outcome of structurally compromised endodontically treated teeth with the aim of providing information that will help the clinician in treatment planning and execution.

### Review Method

The literature was evaluated for peer reviewed articles published in English between 1990 and December 2015 in Medline/Pubmed in relation to the following categories. 1. Post/posts, dowel/dowels 2. Indications 3. Design and size 4. Materials 5. Fixation 6. Retention 7. Fracture resistance 8. Biocompatibility 9. Esthetics 10. Failure 11. Retrieval. Different articles obtained from the electronic search were manually examined for the references. The search was kept limited to peer reviewed journals. Full papers were obtained wherever possible. When it was not possible to obtain the particular journal, abstracts were examined electronically. To be included in the review, the article must have been 1) any paper related to prefabricated/custom cast dowel/dowels and categories number. 5 to 11 described above. 2) only papers published in English language. 3) papers in peer reviewed journals. The method used in the presented review is consistent with the 'Non-systemic literature Review'. It does not include quality assessment of various studies. The review only contains thematic analysis of the comprehensively searched literature.

## RESULTS

The original key terms resulted in 228 articles. After applying inclusion criteria, 64 studies were included in this review [Table/Fig-1]. Of the studies identified, five were clinical surveys, two were finite element analysis, one was microscopic study, 18 were systematic/non-systematic reviews, 32 were in vitro studies, one was photoelastic stress analysis, four were retrospective clinical studies and one was prospective clinical study.

### Dowel Fixation

Zinc phosphate, polycarboxylate, glass ionomer and filled and unfilled resin cements have been investigated extensively for dowel fixation in the root canal. It was demonstrated in several in vitro studies that roots in which the dowels were adhesively cemented were significantly more fracture resistant than those using zinc phosphate cement [6,7]. In a FEA study, Soares CJ et al., [8] revealed that zinc phosphate and glass ionomer presented higher stress in root canal than resin cement and resin modified glass ionomer cement. If removal of the dowel becomes necessary, then lack of chemical bond becomes advantageous because ultrasonic vibration can dissolve most traditional cements. Resin cements provide chemical bond to dowel and tooth structure whereas glass ionomer bond only to dentin. Glass ionomer cement has retention levels similar to resin cements. Adhesive resin cements had higher bond strength to Stainless Steel and titanium dowels than

| Study | Journal | Year of publication | Method | Outcomes |
|---|---|---|---|---|
| Morgano SM, et al., [3] | J Prosthet Dent | 1993 | Review of retrospective studies | High failure rate of cast dowel-core restoration was mostly due to inadequate length of the dowel. |
| Al-Omiri MK, et al. [4] | J Endod | 2010 | Review | Adhesively luted fiber dowels with composite cores is the best available option in terms of tooth fracture and biomechanical behaviour. |
| Stockton LW [11] | J Prosthet Dent | 1999 | Review | Parallel sided passive dowel can be used successfully to restore most endodontically treated teeth. |
| Fovet Y, et al., [33] | Dent Mater | 2000 | Comparative Analysis | Electrochemical behaviour of carbon fibre dowels is very similar to other metal type dowels. |
| Heling I, et al., [34] | J Prosthet Dent | 2002 | Meta-analysis | To improve the prognosis of root canal treated teeth, it is very important to seal the canal as soon as possible. |
| Mannocci F et al., [36] | J Prosthet Dent | 2001 | Scanning electron microscopic study | The three step adhesive showed better marginal seal than that obtained with the self etching primers. The use of endodontic sealers and temporary filling materials containing ZOE can be used without compromising marginal seal of the dowel in the canal. |
| Yang HS et al., [42] | J Prosthet Dent | 2001 | Finite element analysis | The non-metallic dowel and cores generated higher thermal stresses in the restorations and dentin than the metallic dowel and cores. |
| Cagidiaco MC, et al., [56] | Int J Prosthodont | 2008 | Review | Debonding is the most common type of failure observed in the literature with fiber reinforced dowels. |
| Parisi C, et al., [62] | J Prosthet Dent | 2015 | Retrospective study | Success rate of quartz fibre dowel is 85% at 6 years. Dowel debonding was the most frequent failure mode, followed by endodontic failure. No root fractures were recorded. |
| Torbjörner A and Fransson [63] | Int J Prosthodont | 2004 | Review | Favourable occlusal contacts on prostheses is more important for survival of dowel-core restoration than is the dowel type used. |

**[Table/Fig-1]:** Characteristics of important studies

carbon-fiber dowels [9]. Titanium dowels cemented with resin cement showed superior bond strength when compared to zinc phosphate [10]. Peroz I et al., [2] in their review recommended adhesive fixation for any kind of dowel. Stockton LW [11] reviewed two potential problems with resin cements: more unfavourably affected by improper root canal preparation and more technique-sensitive due to short working time. Luting agent can be placed on the dowel surface or can be placed into the prepared canal with the help of the lentulospiral, endodontic file, explorer, paper point. Needle tube can also be used for the same purpose. Lentulospiral was found to be superior method of placement [11]. Once the luting agent is placed in the canal, the dowel is coated with the luting agent and inserted. Goracci C and Ferrari M [12] questioned the long term durability of self adhesive resin cements bond in fibre dowel cementation. The study concluded the silicoting followed by silanization as most effective method for pre-treating FRC dowels.

During dowel fixation, an increase in stress within the canal system has been reported. This stress is due to hydrostatic pressure of luting cement within the canal system. The pressure causes root fracture [1] and prevents proper seating of dowel. Cement viscosity, also affects this pressure. More the viscosity, more the hydrostatic pressure. Dowel design with cement vent is recommended to reduce the pressure effect [1]. Tapered dowel design is considered self venting.

## Dowel Retention in the Root

Dowel retention varies with dowel design, dowel composition and cement type and obturation material. The parallel-sided dowels provided superior retention when compared with tapered dowels. Threaded dowels are considered the most retentive, followed by parallel dowels, with tapered dowels the least retentive. Dowel surface with serrations increases retention when compared to smooth surface. Relationship of dowel diameter to dowel retention is unclear. Dowel length is the most important factor affecting retention than dowel diameter. Retention increases as dowel length increases. Stainless steel dowels have been shown to be more retentive than carbon fiber dowel when cemented with either resin or zinc phosphate cement [13]. Retention of cast dowel has not been shown to be affected by direct or indirect fabrication technique [14]. However, others have shown no difference in retention when cemented with resin cement [15,16]. Failure has always been observed at the cement-dowel junction [13]. Compared with metal dowels, carbon fiber dowel failed more due to root fracture [17]. This is because carbon fiber dowel is less stiff. Dowel with a circular cross-section rotates inside the root canal during function. When sufficient tooth structure remains coronally, remaining vertical coronal wall prevents rotation. Rotation can be prevented by placing a small groove in the bulkiest canal wall. Retention for all types of dowels is affected by cement selection. Zinc phosphate provide retention through mechanical means whereas resin cements and glass ionomer bond to tooth structure. Glass ionomer bond to dentin but not to the dowel. One study found higher bond strength of adhesive resins to stainless steel and titanium dowel than carbon-fiber dowel [18]. A recent study found that there is no effect of various obturating materials on retention bond strength of fiber dowels [19].

## Core Retention with Dowel

Dowel head design is an important factor in core retention. The combination of prefabricated metal dowel with direct core made of glass ionomer, composite or amalgam is less reliable than a one piece cast dowel and core [3]. Any mechanical dowel core assembly of different materials, however, is at risk for separation of the core from the dowel. One piece dowel and core traditionally were custom cast metal but now include zirconia, ceramic and fiber reinforced composite systems. They have been termed as 'monoblock' or 'monocore' technique. With the dissimilar materials for the dowel and the core, one study reported fracture of core structure along with root fracture in 33% to 47% cases while homogenous dowel and core unit failed without damage to root [20]. Purton DG and Payne JA [21] showed that composite cores had better retention to stainless steel dowels than carbon fiber dowels. In the study, however, smooth carbon fiber dowels and serrated stainless steel dowels were evaluated. It has been shown that retention is similar where carbon fiber dowels were serrated [16]. This suggests that mechanical retention of the core may be more important than chemical bonding between dowel and core. According to some [22], dowel head design is crucial and that the lack of retentive features of the dowel head may reduce dowel to core retention. Dowels with various head designs i.e. Serrated :- FlexiPost, (Essential Dental Systems, NJ, USA) and RadixAnchor (Dentsply Maillefer, OK, USA), flat :- ParaPostXP (Parapost X System, Coltene/Whaledent Inc. OH, USA), round :- ParaPost Fiber Lux (Parapost X System, Coltene/Whaledent Inc. OH, USA) rounded with undercut :- ParaPostXH and ParaPostXT (Parapost X System, Coltene/Whaledent Inc. OH, USA) rounded with perforation :- IntegraPost (Premier Dental, PA, USA) are available.

## Fracture Resistance

Numerous in vitro studies exist, but relatively few clinical studies have been conducted. Assif D et al., [23] concluded that there was no advantage from the point of view of fracture mechanics in restoring endodontically treated tooth with either dowel type. Increase dowel length and reduced dowel width shows better stress distribution, increase fracture resistance and decreased incidence of vertical root fracture. Dowel shape plays an important role in the etiology of root fracture [24]. Tapered cast dowel and core was found to be more failure prone compared to Para Post-cores. Threaded dowel systems can induce cracks in dentin during insertion that can progress to root fracture under masticatory load. Cormier CJ et al., [25] evaluated fracture resistance of tooth at four stages of clinical condition – dowel only, dowel in root, dowel and core in root and dowel, core and crown combination. Dowel, core and crown combination is more fracture resistant than a dowel or dowel and core combination. It has been proved that failure with cast metal dowel is more likely to induce irreparable root fracture than with fiber based dowel [25-30]. It is highly recommended to avoid the use of a dowel-core crown restored tooth as abutment for distal extension RPDs or cantilever FPDs [31] as forces acting in these situations are not physiologic one. The findings of the laboratory studies on fracture resistance should be interpreted with caution as number of teeth in these studies were low. This can produce conflicting results and lead to uncertain guidelines for dowel-core placement.

## Ferrule

A ferrule, in respect to tooth is defined as a vertical band of tooth structure at the cervical margin of a crown preparation. One to two millimetres of tooth tissue coronal to the finish line of the crown preparation significantly improves the fracture resistance of the tooth. Crown ferrule or ferrule effect is usually provided by the cast restoration encircling against the remaining supra-gingival tooth structure with a metal band thereby bracing the tooth below the margin of the core, preventing fracture and providing resistance to dislodgement. Core ferrule or secondary ferrule is independent of the crown ferrule. A contrabevel is incorporated in a cast dowel and core tooth preparation to have a cast core with a metal collar that encircles the tooth. There is very little advantage reported to this additional feature [3]. Crown ferrule with a diameter of 1.5 mm is recommended for labial and lingual side whereas ferrule of 1 mm diameter is sufficient on mesial and distal sides due to decreased stress in this direction. Presence of ferrule increases the fracture resistance of dowel-core restored teeth [30]. One study has evaluated the effect of ferrule on restoration of endodontically treated tooth [32]. Libman WJ and Nicholls JI [32] have found failure in 1.5 mm and 2 mm ferrules at a much higher number of cycles when investigating the effect of cyclic loading on cast dowel and cores with ferrules of 0.5 mm,1 mm,1.5 mm and 2 mm height. The study showed decreased incidence of vertical root fracture in teeth restored with ferrule, if failure occurs, compared with teeth restored without ferrule. When a full 360° ferrule is not achievable, placing the preparation margins significantly subgingivally is not advisable due to the violation of the biologic width. Crown lengthening and/or orthodontic extrusion may lead to incorporation of perfect ferrule. Crown lengthening surgery may result in a poorer crown to root ratio, loss of the interdental papilla and compromised aesthetics. Orthodontic extrusion may resolve some of these problems, however, it adds an additional fee and significant time to the whole procedure. It is desirable to use a bonded cast or prefabricated dowel rather than a traditionally cemented metal dowel, where a good ferrule is not attainable [27]. Although complete ferrule is desirable, adopting a partial ferrule is still better in some clinical circumstances than the alternative treatment options [27]. It is not the number of walls but the location of walls that is important. Maxillary and mandibular anterior teeth are loaded from palatal and buccal side respectively. Adequate ferrule on the lingual aspect of maxillary anteriors and buccal aspect of the mandibular anterior teeth is of most significance to resist the load. When buccal and lingual wall thickness of less than 1 mm is anticipated after preparation for full coverage restoration, partial coverage restoration is considered. It will lead to the preservation of walls that might be eliminated in full crown preparation. For premolars, maxillary buccal and mandibular lingual wall is important for partial ferrule placement.

## Biocompatibility and Dowel

Corrosion of the dowel and fracture of the root has been reported in the literature [1]. Corrosion of the dowel is due to the electrolytic interaction on the dowel surface. It is through microleakage around the coronal restoration, through cementum and dentin of the root surface, or either via root fracture produced during dowel preparation.

Although not to a significant extent, base-metal alloys disintegrate in oral environment. Ideally, dowel and cores are made of the same alloy. Corrosion of the less noble metal occurs with the use of dissimilar alloys due to galvanic action. The corrosion product acts by obliterating the adjacent dentinal tubules and thereby increasing the intratubular pressure. This pressure overcomes the strength of the root and results in a root fracture. The fracture would be either longitudinal or oblique [1].

Titanium alloys used for dowel are most corrosion resistant. Corrosion is not an issue if the cast dowel and core are fabricated completely from nonreactive gold alloys. The most significant corrosion occurs in Stainless Steel dowels. With the availability of non-metallic dowel materials, the corrosion factor can be eliminated.

Fovet Y et al., [33] examined electrochemical behaviour of carbon fiber dowel with the gold, Ni-Cr and amalgam in an artificial saliva medium. Galvanic activity was observed upon contact with amalgams but may also occur in contact with Ni-Cr alloy, though this was unlikely with precious alloy. The study suggested that amalgam should not be used in conjunction with dowels.

## Endodontic Considerations

The literature suggests that after the completion of root canal therapy it is important to seal the canal and complete the definitive prosthodontic treatment as soon as is practical to improve the prognosis [34].

No dowel and cement combination has been shown to form a liquid proof seal against microleakage [35]. Bachicha WS et al., [35] used a quantitative fluid filtration method to compare Stainless Steel and carbon fiber dowel cemented with different techniques. They found no significant difference between the two dowel types. Both types exhibit less microleakage when cemented with resin cements than when cemented with glass ionomer or zinc phosphate. The study had not assessed the effect of thermal or mechanical loading. Mannocci F et al., [36] investigated teeth restored with carbon fiber dowels and composite cores using confocal microscopy and dye penetration. The authors demonstrated that the use of zinc oxide eugenol based endodontic sealer had no detrimental effect on the marginal seal of carbon fiber dowel and composite core restoration. The resin based cement groups leaked significantly less than a control group of carbon fiber dowels cemented with zinc phosphate. This investigation showed that a three step dental adhesive resulted in a better marginal seal than that obtained with two self etching primers. One study [37] revealed significant differences in sealing ability among different fibre reinforced dowel systems.

## Dowel and Associated Stresses in the Rootcanal

High stress can be produced during placement, particularly with smooth parallel sided dowels that have no vent for cement escape. Threaded dowels can also generate high stress concentration during insertion and subsequent loading, but distribute stress evenly if the dowels are backed off a half-turn during insertion. Dowel diameter affects the shear type stresses in the root canal [38]. Maximum dowel length and minimum dowel diameter preserve the root canal dentin and thereby reduce the stresses in the root canal.

Torsional forces on the dowel-core-crown unit may lead to loosening and displacement of the dowel from the canal, causing failure of the system [39]. Burgess JO et al., [39] reported association between anti-rotational feature and greater resistance to torsional forces. Threaded dowel doesn't require anti-rotational feature to be as resistant to torsional forces as the other dowels tested. Threaded dowels were also found most resistant to axial forces. Small failure rate of threaded dowels of adequate length in which both axial and torsional forces were effectively resisted by the threads and by rotation locks, has continued to be observed, in addition, threaded dowels acting as overdenture retainers (Kurer Press Stud overdenture retainer, Teledyne Getz) or as fixed partial denture abutments, which receive no torsional forces, continue to exhibit a failure incidence that is not expected [40].

The forgoing observations suggest that it is the forces in the transverse plane that are most destructive to the integrity of the dowel system because the above-described dowels are highly resistant to forces in other two planes. Transverse forces have only recently been identified as being the most destructive forces at the crown dowel-root interface [40].

## Dowel and Abutment Tooth

Abutment for either fixed or removable partial denture is subjected to greater vertical and horizontal forces [41]. In addition to these forces, abutment for distal extension partial denture is subjected to torquing stresses. Failure rate for endodontically treated tooth used as an abutment was found more than double than that with non-abutment tooth [31].

## Thermal Change

Infinite element analysis, Yang HS et al., [42] suggested that metal dowels produce lesser stresses within the root canal when exposed to thermal change than fiber dowels systems. The paper demonstrated reduced temperature gradient throughout the restored system with metal dowels due to high thermal conductivity whereas a reduced heat flow into dentin with fiber dowels may cause concentration of thermal stresses. The authors argue that this may lead to cement failure and recommended the use of a metal dowel and core.

## Radiopacity

Cast metal, Stainless Steel and zirconia dowels are highly radiopaque and visible on radiographic films. The radiopacity of titanium dowels are similar to gutta percha and are difficult to distinguish in radiographs with densely condensed, gutta percha filled canal [43].

Fiber dowels are only faintly visible on radiograph as an outline of the radiopaque luting cement. Mannocci F et al., [44] briefly examined five dowel types for radiographic appearance. Composipost (RTD, St. Egreve, France), Aestheti-Plus quartz fiber dowels (RTD, St. Egreve, France), Carbotech carbonfiber dowels (Ganges, France), Light posts (RTD, St. Egreve, France), and Snowposts (Carbotech, Ganges, France). Twenty-one dowels for each type were examined radiographically. They found only Composipost and Snowpost to be uniformly radiopaque. Finger WJ et al., [45] examined the radiopacity of selected dowels outside the tooth and inside extracted canine before and after cementation. One titanium dowel was included as a reference. Two randomly selected radiographs for each dowel group were ranked for radiodensity and clinical acceptability by 20 dental practitioners. All the dowel groups were radiolucent or having clinically unacceptable radiodensity except for titanium dowel, Snowlight (Carbotech, Ganges, France), Snowpost (Carbotech, Ganges, France) and FibreKor (Jeneric/Pentron, USA), a quartz-fibre dowel. Goracci C et al., [46] verified the influence of cement filler load on the radiopacity of various fiber dowels. The study concluded that the radiopacity of the luting agent contributed to the overall dowel radiovisibility within the root.

## Esthetics and Dowel

The dowel material should be esthetically compatible with the crown and the surrounding tissues. Carbon fiber dowel and metallic dowels are considered non-esthetic. These dowels are black or metallic in colour, which reflect through gingiva, tooth structure or all ceramic units. They are appropriate with gold or porcelain fused to metal crowns. This led to the introduction of the silica fiber dowels which are translucent and more tooth colored. These dowels are also called glass fiber and quartz fiber [5].

The composite core depends on the thickness in masking the metallic color of the dowel. The influence of non metallic fiber dowel and zirconia dowel on all ceramic crown depends on the substructure (opacity) and thickness of crown [47]. Spectrophotometric analysis [47] has shown that all ceramic restoration to exceed 2 mm to fully mask the dark coloured opaque dowels. The use of all-ceramic crowns was contraindicated where less than 1 mm of ceramic thickness could be provided [47]. The porcelain fused to metal crown will allow the use of any dowel and core material.

The availability of various cement shades do minor esthetic corrections under all ceramic units [47]. Opaque porcelain can be fused to the core portion of the dowel system in order to eliminate the greyish effect of cast metal.

## Dowel Retrieval

If the endodontic treatment fails or dowel fractures, it may be necessary to remove the dowel with the aid of ultrasonic energised instruments [5,48].

Removal of a metal dowel particularly cast dowel and core system needs removal of additional tooth structure around the dowel which could prove detrimental to the already weekend tooth structure. Carbon fiber dowel removal is easy, rapid and predictable [49] while ceramic dowel removal has been found to be more difficult [50].

De Rijk WG [51] described simple and predictable technique for removal of fibre-dowel by using specially designed reamers. Dowel removal is carried out by using specially designed reamers drilling through the middle of the dowel. The new set of reamers has to be used for each case. This particular topic requires further exploration and research.

Commercially available dowel removal systems include Messeran Kit (Medidenta International Inc, NY), Endodontic Extractors (Brasseler Inc, Ga) and Dowel Removal System (Sybron Endo, California), Roto-Pro bur (Ellman International, NY), Cavi-Endo (Dentsply International, Pennsylvania). Tube extractors with cynoacrylate are also available which aid in dowel removal by breaking up the cement.

## Failure with Dowel

Several studies are available to calculate the clinical failure rate of dowels and cores. Based on various studies [31,52-54]. The absolute percent of failure ranged between 7 to 14%. Dowel loosening was the most common cause of dowel and core failure followed by root fracture. Root fracture was the only failure mode encountered with the cast dowel and core [55]. The most common type of failure with fiber reinforced composite dowel is debonding [56,57]. Rasimick BJ et al., [57] in a systemic review determined the clinical failure modes for dowel core restorations luted with resin based cements. Loss of retention (37%) and endodontic lesions (37%) were reported a major mode of failure followed by crown dislodgement (11%), root fracture (3%) and Dowel breakage (1%). Less common mode of failure includes core fracture, core debonding, secondary caries and periodontitis. Dowels luted using non-adhesive cements appear 50% more likely to fail via debonding compared to resin luted dowels [57]. The hollow design zirconia dowels showed significantly higher fracture strength than solid zirconia dowels and FRC dowels [58]. The hollow design allows root canal access without any dowel removing procedure when retreatment is necessary. Significantly more favourable failures occurred with prefabricated fiber reinforced composite dowel systems than with prefabricated and custom-cast metal dowel systems [59-61]. Ceramic showed lower failure loads than prefabricated fiber reinforced composite dowel systems, whereas custom-cast dowel systems showed higher failure loads [60].

An estimated success probability of cast fiber dowel restorations is 85% at 6.17 years [62]. Dowel debonding and endodontic failure were the two most frequent failure modes. Mentink A et al., [52] found 9 tooth fractures and 30 dowel loosening in a study involving 516 dowels over a 10 year time period. Torbjorner A et al., [53] reported loss of retention as the most frequent dowel failure in a six year clinical study.

Weine FS et al., [54] observed 9 failures in 138 dowels after 10 year follow up, out of which none of due to loss of retention.

Al-Omiri MK et al., [4] suggested ferrule, adhesive technique and limited tooth structure loss as limiting factors for fracture resistance of endodontically treated tooth.

### Clinically Relevant Factors

- The use of dowels seem not to be mandatory for the restoration of a non-vital tooth, unless an insufficient retention of the core is obvious [59].
- Rotational resistance can be obtained by preparing a small groove in the root canal. Resistance to root fracture can be obtained by extension of the axial wall of the crown apical to the missing tooth structure.
- Dowel-treated teeth show periapical infections more frequently than do other endodontically treated teeth; care to avoid microleakage during dowel canal preparation and dowel cementation has a positive effect on the life of dowel treated tooth [63].
- Microleakage can be minimized when the dowel preparation is performed immediately after root canal obturation. This approach has an added advantage as the morphology, length, and direction of the canal are still fresh in the operator's memory.
- Concerning microleakage, the use of prefabricated dowels in a direct technique has several advantages. The exposure time of the remaining root canal filling to the oral cavity is minimized, and the risk of massive bacterial contamination is eliminated.
- A diagnostic radiograph is essential to evaluate the root and dowel space to determine the dowel length, diameter, and type to be used.
- Cementation technique has an important role in the longevity of dowel. Uniform thin layer of cement between dowel and root canal wall is favourable for stress transfer. Before cementation, the canal should be cleaned with 17% ethylenediaminetetraacetic acid (EDTA) followed by rinsing with 5.2% sodium hypochlorite followed by rinsing with water and dried with paper points [1].
- Zinc phosphate, glass ionomer and resin cements are mostly used as dowel luting cements. For many years, zinc phosphate cement has demonstrated its reliability and its ability to provide consistent retention. Glass ionomer and resin modified glass ionomer cements has advantages of chemical bonding to tooth structure and improved flow and wettability characteristics. Resin cement has been shown to provide greater retention and resistance, but should be chosen only in conditions when the clinician is well versed in its manipulation, as this cement is technique sensitive [6,64]. Adhesive Resin cement is most recommended for dowel cementation in mutilated tooth [64]. For fiber reinforced dowel systems, resin cement should be used to provide micromechanical bonding to the dowel and tooth structure [47].
- Lentulospiral is the superior method of placement of conventional cements in the root canal. With contemporary resin cements, lentulospiral is contraindicated as this can excessively accelerate setting. Spread cement to the dowel and place it in the pretreated root canal. Apply moderate pressure to hold it in position. Vibrate the dowel slightly during insertion to avoid inclusion of air bubbles.

## CONCLUSION

It is important to assess the forces that a restored tooth may be exposed to. Favourable occlusal prosthesis design is probably far more important for survival of structurally compromised endodontically treated teeth than is the type of dowel used. Retention and resistance to fracture are two important factors that must be achieved with dowel-and-core retained restorations. All other variables of dowel should be checked with respect to retention and fracture resistance when selecting the particular type of dowel. From biomechanical driven concepts, it can be stated that in the restoration of non-vital tooth, the conservation of tissue and adhesion are the most relevant elements for improved long-term success.

The use of novel technologies in ceramic and composite for dowels and cores contribute to the optical properties of the anterior restorations to meet the esthetic needs. Translucent dowels allow light curing of luting agents in the canal. It facilitates evaluation of dowel position prior to setting. Instead of dowels made of quartz or glass fibres surrounded by epoxy resin matrix, polyethelyne fibre ribbon have suggested to construct direct dowel in the canal. Dowel constructed of polyfiber strands and surgical stainless steel wires (Spirapost, ZenithDental, NJ) adapts to the natural canal configuration, eliminating the need to remove additional tooth structure. The future application of braiding technology to dental dowel can achieve the requirement of stiffness change along the length of the dowel. The incorporation of low braiding angle polymer in coronal and high braiding angle polymer in apical area of single dowel results in high stiffness in coronal and low stiffness in apical end. However, high quality randomized controlled clinical trials will be necessary before fully adopting theses newer dowels in clinical practice.

## REFERENCES


[1] Fernandes AS, Dessai GS. Factors affecting the fracture resistance of post-core reconstructed teeth: A review. Int J Prosthodont. 2001;14:355-63.
[2] Peroz I, Blankenstein F, Lange KP, Naumann M. Restoring endodontically treated teeth with posts and cores-A review. Quintessence Int. 2005;36:737-46.
[3] Morgano SM, Rodrigues AHC, Sabrosa CE. Restoration of endodontically treated teeth. Dent Clin N Am. 2004;48:397-416.
[4] Al-Omiri MK, Mahmoud AA, Rayyan MR, Abu-Hammad O. Fracture resistance of teeth restored with post-retained restorations: An overview. J Endod. 2010;36:1439-49.
[5] Bateman G, Ricketts DNJ, Saunders WP. Fibre-based post systems: a review. British Dental Journal. 2003;195:43-48.
[6] Mendoza DB, Eakle WS, Kahl EA, Ho R. Root reinforcement with a resin-bonded preformed post. J Prosthet Dent. 1997;78:10-14.
[7] Utter JD, Wong BH, Miller BH. The effect of cementing procedures on retention of prefabricated metal posts. J Am Dent Assoc. 1997;128:1123-27.
[8] Soares CJ, Raposo LH, Soares PV, Santos-Filho PC, Menezes MS, Soares PB, et al. Effect of different cements on the biomechanical behavior of teeth restored with cast dowel and cores in vitro and FEA analysis. J Prosthodont. 2010;19:130-37.
[9] O'Keefe KL, Miller BH, Powers JM. In vitro tensile bond strength of adhesive cements to new post materials. Int J Prosthodont. 2000;13:47-51.
[10] Lencioni KA, Menani LR, Macedo AP, Ribeiro RF, de Almeida RP. Tensile bond

strength of cast commercially pure titanium dowel and cores cemented with three luting agents. J Prosthodont Res. 2010;54:164-67.
[11] Stockton LW. Factors affecting retention of post systems. A literature review. J Prosthet Dent. 1999;81:380-85.
[12] Goracci C, Ferrari M. Current perspectives on post systems: A literature review. Aust Dent J. 2011;56:77-83.
[13] Cohen BI, Pagnillo M, Musikant BL, Deutsch AS. Comparison of the retentive and photoelastic properties of two prefabricated endodontic post systems. J Oral Rehabil. 1999;26:488-94.
[14] Al-Omari WM, Zagibeh AM. The retention of cast metal dowels fabricated by direct and indirect techniques. J Prosthodont. 2010;19:58-63.
[15] Drummond J L. In vitro evaluation of endodontic posts. Am J Dent. 2000; 13(Spec No): 5B-8B.
[16] Love RM, Purton DG. The effect of serrations on carbon fibre posts-retention within the root canal, core retention, and post rigidity. Int J Prosthodont. 1996;9:484-88.
[17] Stockton LW, Williams PT. Retention and shear bond strength of two post systems. Oper Dent. 1999;24:210-16.
[18] O'Keefe KL, Miller BH, Powers JM. In vitro tensile bond strength of adhesive cements to new post materials. Int J Prosthodont. 2000;13:47-51.
[19] Aggarwal V, Singla M, Miglani S, Kohli S. Effect of different root canal obturating materials on push-out bond strength of a fiber dowel. J Prosthodont. 2012;21:389-92.
[20] Christensen G. Post and cores: State of the Art. J Am Dent Assoc. 1998;129(1):96-97.
[21] Purton DG, Payne JA. Comparison of carbon fiber and stainless steel root canal posts. Quintessence Int. 1996;27:93-97.
[22] Chang WC, Millstein PL. Effect of post design of prefabricated post heads on core materials. J Prosthet Dent. 1993;69:475-82.
[23] Assif D, Bitenski A, Pilo R, Oren E. Effect of post design on resistance to fracture of endodontically treated teeth with complete crowns. J Prosthet Dent. 1993;69:36-40.
[24] Isidor F, Brondum K, Ravnholt G. The influence of post length and crown ferrule length on the resistance to cyclic loading of bovine teeth with prefabricated titanium posts. Int J Prosthodont. 1999;12:78-82.
[25] Cormier CJ, Burns DR, Moon P. In vitro comparison of the fracture resistance and failure mode of fiber, ceramic and conventional post systems at various stages of restoration. J Prosthodont. 2001;10:26-36.
[26] Isidor F, Odman P, Brondum K. Intermittent loading of teeth restored using prefabricated carbon fiber posts. Int J Prosthodont. 1996;9:131-36.
[27] Jotkowitz A, Samet N. Rethinking ferrule – A new approach to an old dilemma. Br Dent J. 2010;209:25-33.
[28] King PA, Setchell DJ. An in vitro evaluation of a prototype CFRC prefabricated post developed for the restoration of pulpless teeth. J Oral Rehabil. 1990;17:599–609.
[29] Akkayan B, Gulmez T. Resistance to fracture of endodontically treated teeth restored with different post systems. J Prosthet Dent. 2002;87:431-37.
[30] Aggarwal V, Singla M, Yadav S, Yadav H, Sharma V, Bhasin SS. The effect of ferrule presence and type of dowel on fracture resistance of endodontically treated teeth restored with metal-ceramic crowns. J Conserv Dent. 2014;17:183-87.
[31] Hatzikyriakos AH, Reisis GI, Tsingos N. A 3-year postoperative clinical evaluation of posts and cores beneath existing crowns. J Prosthet Dent. 1992;67:454-58.
[32] Libman WJ, Nicholls JI. Load fatigue of teeth restored with cast posts and cores and complete crowns. Int J Prosthodont. 1995;8:155-61.
[33] Fovet Y, Pourreyron L, Gal JY. Corrosion by galvanic coupling between carbon fiber posts and different alloys. Dent Mater. 2000;16:364-73.
[34] Heling I, Gorfil C, Slutzky H, Kopolovic K, Zalkind M, Slutzky-Goldberg I. Endodontic failure caused by inadequate restorative procedures: review and treatment recommendations. J Prosthet Den. 2002;87:674-78.
[35] Bachicha WS, DiFlore PM, Miller DA, Lautenschlager EP, Pashley DH. Microleakage of endodontically treted teeth restored with posts. J Endod. 1998;24(11):703-08.
[36] Mannocci F, Ferrari M, Watson TF. Microleakage of endodontically treated teeth restored with fiber posts and composite cores after cyclic loading: A confocal microscopic study. J Prosthet Dent. 2001;85:284-91.
[37] Sarı T, Özyesil AG. Microleakage of teeth restored with different adhesive dowel systems: An in vitro study. J Prosthodont. 2014;23(1):45-49.
[38] Holmes DC, Diaz-Arnold AM, Leary JM. Influence of post dimension on stress distribution in dentin. J Prosthet Dent. 1996;75:140-47.
[39] Burgess JO, Summitt JB, Robbins JW. The resistance to tensile, compression and torsional forces provided by four post systems. J Prosthet Dent. 1992;68:899-903.
[40] Kurer HG. The classification of single-rooted, pulpless teeth. Quintessence Int. 1991,22:939-43.
[41] Testori T, Badino M, Castagnola M. Vertical root fractures in endodontically treated teeth: A clinical survey of 36 cases. J Endod. 1993;19:87–90.
[42] Yang HS, Lang LA, Guckes AD, Felton DA. The effect of thermal change on various dowel and core restorative materials. J Prosthet Dent. 2001;86:74-80.
[43] Goss JM, Wright WJ, Bowles WF. Radiographic appearance of titanium alloy prefabricated posts cemented with different luting materials. J Prosthet Dent. 1992;67(5):632-37.
[44] Mannocci F, Sherriff M, Watson TF. Three-point bending test of fiber posts. J Endod. 2001;27:758-61.
[45] Finger WJ, Ahlstrand WM, Fritz UB. Radiopacity of fiber-reinforced resin posts. Am J Dent. 2002;15:81-84.
[46] Goracci C, Juloski J, Schiavetti R, Mainieri P, Giovannetti A, Vichi A, et al. The influence of cement filler load on the radiopacity of various fibre posts ex vivo. Int Endod J. 2015;48:60-67.
[47] Vichi A, Ferrari M, Davidson CL. Influence of ceramic and cement thickness on the masking of various types of opaque posts. J Prosthet Dent. 2000;83:412-17.
[48] Abbott PV. Incidence of root fractures and methods used for post removal. Int Endod J. 2002;35:63-67.
[49] Freedman GA. Esthetic post and core treatment. Dent Clin North Am. 2001;45:03-16.
[50] Mannocci E, Ferrari M, Watson TF. Intermittent loading of teeth restored using quartz fiber, carbon-quartz fiber and zirconium dioxide ceramic root canal posts. J Adhes Dent. 1999;1:153-58.
[51] De Rijk WG. Removal of fiber posts from endodontically treated teeth. Am J Dent. 2000;13(Spec No):19B-21B.
[52] Mentink A, Meenwissen R, Kayser A, Mulder J. Survival rate and failure characteristics of the all metal post and core restoration. J Oral Rehabil. 1993;20:455-61.
[53] Torbjorner A, Karlsson S, Odman PA. Survival rate and failure characteristics for two post designs. J Prosthet Dent. 1995;73:439-44.
[54] Weine FS, Wax AH, Wenckus CS. Retrospective study of tapered smooth post systems in place for ten years or more. J Endod. 1991;17:293.
[55] Goodacre CJ. Carbon fiber posts may have fewer failures than metal posts. J Evid Based Dent Pract. 2010;10:32-34.
[56] Cagidiaco MC, Goracci C, Garcia-Godoy F, Ferrari M. Clinical studies of fiber posts: a literature review. Int J Prosthodont. 2008;21:328-36.
[57] Rasimick BJ, Wan J, Musikant BL, Deutsch AS. A review of failure modes in teeth restored with adhesively luted endodontic dowels. J Prosthodont. 2010;19:639-46.
[58] Özkurt Z, Baybora Kayahan M, Kazazoğlu E. In vitro comparison of fracture strength of experimental hollow and solid design zirconia dowels. J Prosthodont. 2012;21:385-88.
[59] Dietschi D, Duc O, Krejci I, Sadan A. Biomechanical considerations for the restoration of endodontically treated teeth: A systematic review of the literature, Part II (Evaluation of fatigue behavior, interfaces, and in vivo studies). Quintessence Int. 2008;39:117-29.
[60] Fokkinga WA, Kreulen CM, Vallittu PK, Creugers NH. A structured analysis of in vitro failure loads and failure modes of fiber, metal, and ceramic post-and-core systems. Int J Prosthodont. 2004;17(4):476-82.
[61] Aggarwal V, Singla M, Miglani S, Kohli S. Comparative evaluation of fracture resistance of structurally compromised canals restored with different dowel methods. J Prosthodont. 2012;21:312-16.
[62] Parisi C, Valandro LF, Ciocca L, Gatto MR, Baldissara P. Clinical outcomes and success rates of quartz fiber post restorations: A retrospective study. J Prosthet Dent. 2015;114(3):367-72.
[63] Torbjörner A, Fransson. A literature review on the prosthetic treatment of structurally compromised teeth. Int J Prosthodont. 2004;17:369-76.
[64] Lodha K, Verma M. Conventional and Contemporary Luting Cements: An Overview. J Indian Prosthodont Soc. 2010;10:79-88.

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