Influence of Biomechanical Factors on Restoration of Devitalized Teeth

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Summary

Restoration with post and cores for fractured clinical crowns on devitalized teeth is the treatment procedure frequently used in the clinical practice of specialists and dentists in primary health care.

The paper deals with prosthetic reasons for teeth devitalization and making of post and cores, particularly when a comparatively large rests of the clinical crown are preserved, along with the indications and contraindications for their placement on devitalized teeth.

Influence of biomechanical factors is analyzed with regard to post and core retention and stress distribution over the hard dental tissue and surroundings, depending on possible variations in preparation width and length, particularly in the radicular part, for different types of post and cores.

In conclusion, the authors express their preference for individual post and core placement over prefabricated, and highlight the importance of correctly determined indication for post and core, successful selection of the type of post and core and correct treatment for extension of the lifetime of the fixed prosthetic work on the endodontically treated tooth.

Key words: *post and core, biomechanics, devitalized tooth*

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Introduction

Clinical successes in up-to-date endodontic therapy resulting from correct biomechanical preparation of the canal, recent achievements in technology of materials and new treatment methods, have helped in preventing extraction of a large number of teeth. The purpose of prosthetic restoration of endodontically treated teeth is diverse, it varies from case to case, and is related to establishing a more permanent form and tooth function, prevention of fracture of the remaining hard tissues pertaining to the crown and root, which is more common and manifest in non-vital than in vital teeth, restoration of ruined aesthetics, prevention of caries incidence and obtaining safe retention for the permanent restoration. Hard tissues of many treated teeth are often damaged by caries, earlier fillings, and/or endodontic approach so that the remaining part of the clinical crown is weakened and inadequate for retention of the prosthetic restoration (1,2). With such teeth, it is very often necessary to remove the complete clinical crown, and retention of permanent and definitive fixed prosthetic work is possible only with intraradicular retention of post and core, which precedes definitive fixed prosthetic work.

The clinical cases where endodontic therapy (devitalization of the future abutment) precedes the prosthetic therapy are quite common in everyday dental practice for the following reasons:

1. The vital crown of the tooth is too short or damaged by caries that it does not ensure adequate retention of the fixed prosthetic work, so it must be devitalized before the post and core is made.
2. The tooth has grown over the prosthetic plane and is usually in supraocclusion. The necessary grinding for the crown would open a pulp chamber, including the tooth shortening so that by its form, position and size it adapts to normal intermaxillar relations.
3. Very inclined teeth, distal abutments in the lower jaw inclined for more than 250, mostly mesially, demand devitalization for correction of the position and parallelization with the mesial abutment or with other abutments.

Different opinions on the necessity of post and core on the non-vital tooth have been expressed in literature. Some authors consider the endodontically treated tooth to be more fragile than the vital one, so it is necessary to make the post and core in order to protect the remains of the dental tissue against intraoral forces by even stress distribution over the root and its transfer on the surrounding supporting structures (root cement, periodontal ligament and alveolar bone). This results in increased fracture resistance of the tooth ensures better retention and a reliability basis for the fixed prosthetic work (3,4,5,6). Others consider restoration unnecessary if there exists even a relatively narrow trepanation opening and the dental tissue rests are preserved, since reshaping of the dental canal for the post and core mounting will unnecessarily load and weaken the tooth (7,5). Some insist that the role of post and core in stress resistance increase is not significant and its use is limited to retention of the permanent replacement (8).

Indications and contraindications for post and cores

The post and core restorations must satisfy the 3R rule - Retain (obtain retention), Reinforce (increase resistance of hard dental tissue against occlusal forces) and Restore (replace the lost parts of the hard dental tissue) (10).

The post and core requirement and selection mostly depend on the clinical finding, quantity of the remaining dental tissue, function of devitalized tooth and occlusal forces.

Indications for post and cores are:

1. When complete or almost complete clinical crown is missing and what remains does not enable sufficient retention for filling or individual fixed restoration.
2. When the retention surface of the clinical crown is reduced by high-degree attrition or abrasion and the post and core is performed for protective and/or prophylactic reasons.
3. When the non-vital tooth is to be protected against fracture as the bridge abutment.

Contraindications for posts and cores are:

1. When the non-vital tooth has not been endodontically treated or has been insufficiently treated. When the prior endodontic treatment has not been applied, it is an absolute contraindication for post and core restoration. Relative contraindication is when the tooth has been overfilled or when there is a persisting periapical process, or the tooth has been insufficiently filled although there is no periapical process.
2. When the periodontal tissue of a non-vital tooth is so weakened that it shows vertical mobility or when the bone resorption to the apical third of the bone is visible, there is good reason for exclusion of this tooth from the prosthetic treatment.

The post and core techniques include:

1. Cast - individual post and core which by its form imitates morphology of the prepared root canal, while the extracoronal part imitates the ground form and position of the tooth. Impression of the root canal is made either directly or indirectly, and during laboratory proceedings post and core are cast in one piece of in metal (5,11).
2. The prefabricated post and core are usually made of metal, in the form of posts of different shapes and sizes; however, posts of glass-reinforced material have recently become available (Cos-

mopost or Zirconia). The intraradicular part of the post is placed in the prepared tooth canal which is shaped to fit the post form by standardized root drills. The extraradicular part takes the form of a stump made of amalgam, composite resins, reinforced composite resins or glass-ionomer cements (5,12,13,14).

Effect of biomechanical factors on post and cores

The biomechanical factors are particularly important for root canal preparation of post and cores. The form and length of the post are the most important factors affecting the retention and tooth stress distribution. Unfortunately, the morphology of the post and core surface with reinforced retention causes more intensive strains in the root during the post placement and in its later functioning. This particularly relates to the prefabricated posts with sharp threads, which has been proven by photoelastometric analysis (15,16,17).

Depending on the direction of masticatory forces, the retention weakens as a consequence of shear stress on the post and core, cement or dentine surface.

1. The post and core form considerably affects retention. The tapered-end posts have ensured the poorest and the posts with parallel sides the best retention.
2. The retention increases with the depth of post placement in the canal.
3. Effect of cement on retention is statistically negligible, but for cementing of smooth tapered-end posts, the zinc-phosphate cement characteristics have proven the best.
4. The post diameter does not affect retention (16).

Adequate length of the intraradicular post as compared to the tooth is one of the prerequisites for successful post and core. The intraradicular post length affects the post and core retention. Also, the length affects the distribution of forces caused by functional and parafunctional occlusal contacts. The form of the prepared canal imitates the post form and the conic post and core causes lower tensions in the apical dentine area.

By application of the FEM method, Pao *et al* (18) have proven that for teeth with normal supporting tissue the cylindrical post with wider diameter and larger length causes less dentine tension than the post and core with conic sides and of lower diameter. When the alveolar ridge is resorbed, the shear stress effect concentrates around the post and core tip surrounded with a thin wall of the dentine rests, which shows high risk of root fracture. The apical dentine tension is lower for the conic post and core because there are no sharp edges around which the forces would concentrate (19). The vertical stress on the cylindrical restoration causes high pressure on the apical part of the root, while the conic post and core causes lower strain around the cemento-enamel junction. The change in direction of the force acting on the post and core causes strains on the cemento-enamel junction in both types of post and core. The post with conic sides has always indicated lower strain in the apical part of the root (20).

Standlee *et al* (21) investigated tensions in dentine and surrounding bone after post and core placement, by using the polarized light method. They concluded that:

1. Reduction of stress and shear forces concentrated around the post and core is achieved by increase in the length of the root part of the core.
2. If a shorter post needs to be used, athreaded post should be used because it results in better tension distribution.
3. Threaded post stress increases when the thread fully engages the dentine notches.
4. Conic posts cause longitudinal root fracture and the stress is concentrated in the coronal third of the root.
5. Tension is induced when the post is incorrectly screwed.
6. The smooth post and core without notches for drainage of surplus cement during cementing cause, because of the hydrostatic pressure, dentine strains in the apical third of the root.

The torsion caused by the conic post in the tooth root walls is more intensive than the tension caused by the parallel-sided threaded post, so root fracture may be avoided by correct selection of the prefabricated post shape(22).

In investigations conducted by Sorensed and Engelman (23), the incidence of root fractures caused by prefabricated posts was higher, but the conic posts caused more massive fractures since they act as wedges.

Kahn *et al* (24) compared the occurrence of fractures in non-vital teeth without post and core and those with threaded posts. The teeth with posts showed no significant increase in the number of fractures in comparison with the teeth without post and core. The conclusion was that this type of post is safe to use.

According to Ross *et al* (25), the dentine tensions during post placement depend on:

1. Differences between the diameters of the prepared canal and post. The differences result from the conic form of the natural canal, and when the canal has markedly conic form, the threads do not engage before the apical third.
2. Thread-to-thread distance on the post and core (larger distance is more favorable).
3. Depth of post thread or dentine notch (Dentine is an elastic tissue and the stress caused threading decreases with time. The tests have proven that dentine relaxes between two rotations).
4. Difference in diameter of various types of posts. (The posts of larger volume have larger threads, and they cause higher tension in the dentine.)
5. Post threading depths (Screwing to the bottom of the preparation increases the strain).

Decay of prefabricated post and core results from decreased material strength or, more frequently, from lack of retention in the root canal. The retention depends on the post configuration, its depth and diameter, and type of cement used for cementing in the reshaped root canal of the non-vital tooth. The data from the literature indicate that the depth of the intraradicular part of the post and core is proportional to the retention - the longer the root part the better the retention. Best retention is achieved with the threaded post with parallel sides, than the post with parallel sides and narrow striated surface. The poorest retention is achieved with posts with smooth parallel sides. Cement plays unimportant role in achieving retention, except by lack of contact between the post and canal walls, and when the conic posts with smooth sides are placed (19,26,27).

The investigation of retention of cemented post and cores with different morphologies, exposed to torsional and shear strengths conducted by Miniatinopulos et al (28) demonstrated that the threaded post and core has better resistance to shear strength, while the post and core with a narrow surface are more resistant to torsional forces.

Good resistance to tensile forces is an important factor in successful prosthetic treatment of the devitalized tooth. Coneh et al (29) determined that the threaded posts have considerably higher tensile strength compared to the non-threaded posts. The authors believe that higher tensile strength results in better post and core retention.

Similar results were obtained by Burgess et al (30) who showed that the threaded post has higher tensile strength than the post with smooth sides, which is particularly important for anterior teeth treatment.

Stegaroiu *et al* (31) investigated the influence of the cyclic loading and retention force acting between the prefabricated steel post with parallel sides and parallel furrows on the surface and the cast post and core, and came to the following conclusions:

1. The retention achieved with the prefabricated post was much better compared to the loaded cast post and core.
2. Cyclic loading made no significant difference in retention in both types of post and core, but the cyclic loaded prefabricated post showed considerably poorer retention than the unloaded post of the same type.

The research results obtained by Johnson and Sakamura (32) indicate that increase in the post and core length of 7 or 9 mm to 11 mm results in retention increase by 30% or 40%, respectively, while the increase of length from 5 mm to 8 mm results in retention increase by 1.23 times.

The short or curved root, or the root with unsuitably placed silver pin or poorly fixed post and core do not allow for satisfactory preparation depth (33, 34).

Opinions on optimal or ideal post and core length differ among authors (5, 35-42). The preparation depth is determined by the root and root canal morphology, apical third of the root, required retention of permanent restoration and alveolar bone. If the post and core length is compared with the proportion of the natural crown and root, the post and core lengths may be:

1. Equal to one half of the remaining root length.
2. Equal to two thirds of the root length.
3. Equal to three quarters of the root length.
4. Equal to four fourths of the root length.
5. Approximately equal to the length of the clinical crown.
6. Equal to the permanent restoration length.
7. Should be placed centrally between the root tip and the highest point of the alveolar septum.

The root canal preparation must be as deep as possible, but it must not damage the apical part of the guttapercha or filling, as the case may be. The removal or damage to that part of the root canal filling causes opening of the periapical space and its communication with the oral cavity through the prepared canal (42).

Different lengths are recommended for the filling remaining after the canal preparation. Colman, Schillingburg and Kahn leave a minimum 3 mm, Zmaner 4 mm, Baraban 3.5 to 4 mm, Perel and Muroff 3 to 5 mm, and Camp 5 mm of filling (34,37,43, 44,45,46). The unprepared apical part of the root longer than 5 mm would reduce the post and core retention, and longer preparation is not necessary since it is equal to two thirds of the root length (33).

The root lengths of the upper and lower teeth (expressed in millimeters) and post and core lengths are given in Table 1.

Changes in preparation diameter increases slightly post and core retention (15). The attitude that the post and core diameter should be limited proportionally to the root diameter, root canal morphology and residual dental tissue is acceptable. Increase in preparation width necessary for the post and core functioning results in unnecessary weakening of the root canal walls and increase in lateral fracture risk (11).

If the diameter of the intraradicular part of the post and core is too small, there is no risk of the root wall opening or fracture. However, the post and core is more prone to bending, fracturing or falling out of the canal (47). The short and wide conic post and cores must be avoided because of the concentration of forces on the cervical part of the root (40).

There is no uniform opinion on the post and core diameter. Lloyd and Palik (49) attempted systematization of the attitudes into three groups. The first group includes conservationists that advocate the narrowest diameter for fabrication of a dowel to a desired length. They advocate minimum instrumentation after removal of the guttapercha and consider that such preparation should reduce the chances of root wall fracture. The second group encompasses the proportionists who consider that minimum quantity of dentine around the post and core is sufficient to prevent the root fracture. For example, Caputo and Standlee recommend only 1 mm of dentine around the post and core. The third group are proportionists who advise that the post and core diameter should be equal to one third of the root width. Such proportional relation ensures sufficient width of dentine which will resist stresses. Tilk et al (41) prepared a table showing indicated and optimum diameters for prefabricated post preparation. The root part of the post and core should not exceed one third of the root width; however, the root canal must be surrounded with a minimum 1 mm of dentine (Table 2). The apical area is particularly problematical, since that is where the root narrows under concentrated forces. Preparation with a narrower diameter has higher resistance to stresses, and the width has no significant effect on the post and core retention (4,5,11, 36,50).

Conclusion

Accurate diagnosis and indication, successful selection of post and core type and accurate placement into the root canal of the abutment tooth prolong the lifetime of the fixed prosthetic work on the endodontically treated tooth. The post and core must ensure good and lasting retention of the crown

or bridge and provide for adequate stress transfer on the entire root and the surrounding supporting tissue. Individual cast post and core shows better clinical results when it restores the whole clinical crown, than the prefabricated post and core design. This results from difference in individual post and core which enables precise imitation of the morphology of the prepared clinical crown and root.

Retention of the prefabricated post and core depends on the length and shape and on morphological characteristics of the intraradicular part surface (grooves, notches or thread). The retention of the prefabricated threaded posts with parallel sides is best, they are followed by posts with parallel grooved sides, while retention of posts with smooth parallel sides is the poorest.

The extraradicular part of these post and cores is not sufficiently resolved as regards retention, since it is either too small or of insufficient retention in the replacement of the complete clinical tooth crown. The surface of the extraradicular part of the prefabricated post and core, which is increased by application of composite, amalgam, glass-ionomer cement or reinforced composite in order to achieve larger retention areas, is still questionable from the biomechanical aspect.

When the canals are short or curved, particularly in multi-radicular teeth, and the preparation length does not provide for sufficient post and core retention, it is questionable whether to use the prefabricated threaded post or one with a grooved surface, as combined or additional retention.