The Effect of Root Canal Preparation Depth on Retention of Endodontic Dowels

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Summary

When more than half of the crown of the endodontically treated tooth is missing, reinforcement with a cast post or a prefabricated dowel is needed. Four factors affect dowel retention: diameter, design, length, and employed cement. The purpose of this study was to measure the influence of root-canal preparation depth on retention force, and evaluate the commonly used principles. Thirty teeth were divided into 3 groups, root canals were prepared to 5.7 and 9 mm, and dowels were cemented. After 40 hours the tensile force needed to dislodge the dowels was recorded. At 5 mm depth it was 174.17 ± 29.45 N, at 7 mm 235.5 ± 46.93 N, and at 9 mm 255 ± 72.74 N. There was significant difference between dowel retention at 1/3 and at 1/2 of the root depth (5 and 7 mm). Difference between retention at 1/2 and at 2/3 of the root depth (7 and 9 mm) was not significant.

Key words: *dowel, preparation depth, retention.*

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Introduction

Teeth with marked crown destruction can be successfully treated/restored by contemporary dental therapy. The method of reconstruction depends on the amount of tooth crown remaining. When a large part of the crown has been preserved, conservative therapy is possible. However, when more than half of the crown is missing reinforcement is needed to enable reconstruction of the function and aesthetics of the tooth (1-3).

Reinforcement in the prepared area of the root canal provides a satisfactory biomechanical basis for the crown. Reinforcement of the tooth, weakened by endodontic treatment, strengthens and protects it from internal loading and fracture of the root.

Reinforcement can be prefabricated from metal by casting, by direct or indirect method from ceramic, or an endodontic dowel can be used. Construction of a cast reinforcement requires two appointments with the therapist, while an endodontic dowel can be inserted during one appointment. Because of the

simplicity of the morphology of root canals, endodontic dowels are more frequently used in the area of the front teeth.

The diameter, form, appearance and size of the surface, the type of cement used for cementing and the depth of the implantation all have an effect on retention of the endodontic dowel. All these factors have been well investigated, apart from the last one, which has been the subject of interest of only a few authors (4-17).

A question which is most often asked in connected with the use of reinforcement is "how long does the reinforcement need to be?" (1). The dentist is frequently confronted with the problem of cementing a dowel in a short root, either because it has been resected or because of natural reasons.

The depth of the preparation of the root canal may be restricted by curvature of the root canal, the presence of a silver post in the root canal which cannot be removed to sufficient depth or the presence of an old reinforcement which cannot be extracted.

The intraradicular part of the dowel may be too short, although the root is of satisfactory form and length, because the dentist had not prepared the root canal sufficiently deep. Various recommendations exist for the ideal depth of the insert, and opinions differ (1, 16, 17). The factor of dowel retention has relatively poorly been experimentally investigated.

The aim of the present study was to obtain and compare data on the effect of the depth of root canal preparation on retention of endodontic dowels.

Materials and methods

For the experiment 37 permanent upper frontal teeth were used, incisors and canines. The teeth were kept in 70% ethanol from the moment of extraction until use. The crowns of the teeth were cut off vertically on the longitudinal axis of the tooth at the height of the most apical part of the cemento-enamel junction, on the vestibular side. After examination and measurement 30 roots were selected which were suitable for the experiment, and divided at random into three groups of 10 specimens.

The root canals of the first group were prepared up to 1/3 of the length of the root, i.e. 5 mm depth. The root canals of the second group were prepared up to 1/2 of the length of the rooth (7 mm depth) and the root canals of the third group up to 2/3 of the length of the root (9 mm).

The dowels were prefabricated from round steel wire, diameter 1.4 mm. After cutting to a length of 20 mm the dowels were sanded to increase the surface retention.

The canals were gradually expanded by Kerr--expanders (Maillefer Instruments, Ballaigues, Switzerland). Mechanically up to ISO size 110, and then manually up to ISO size 140 (12, 13). The canals were prepared up to the envisaged depth for each group. After which the canals were examined to verify that the dowels passively fitted into the canals.

Prior to cementing the canals were rinsed with distilled water and dried by compressed air. For the experiment glass-ionomer cement was used (Ketac--Cem, ESPE, Seefeld, Germany). The cement was prepared and used in accordance with the manufacturer's instructions. Before cementing the dowels were dipped in the cement, and the root canals filled with cement by means of a spiral, according to Lentul. For the duration of the hardening the dowels were pressed with the fingers, which is the usual clinical practice (14). After hardening the excess cement was removed. The period from cementing to measuring amounted to 40 ± 5 hours. After cementing the samples were left in the dry.

Measurement of tensile loading was performed in the Laboratory for Testing Mechanical Properties at the Department of Materials Faculty of Mechanical Engineering and Shipbuilding University of Zagreb. In the mechanical (kidalicu?), manufactured by Faculty of Mechanical Engineering and Shipbuilding, measuring volume 2000 N, class accuracy I) an attachment was inserted of our own construction to hold the specimen (Figure 1). The attachment had a 2 mm diameter hole through which the extraradicular part of the dowel could pass freely, but not the root. Each specimen was exposed to tensile force in the direction of the longitudinal axis of the dowel, until continuity between the dowel, cement and tooth was broken, i.e. until the dowel was dislodged from the root canal.

Statistical analysis of data was performed on a PC, by means of the SPSS programme. Kolmogorov-Smirnov test was used to confirm that the

distribution of the obtained values corresponded to normal distribution. Statistical significant differences between the experimental groups were determined by a combination of (parallel?) analysis of variance and Student-Newman-Keuls test.

Results

The values obtained from statistical analysis are presented in a table and graph (Table 1, Figure 2).

The different depths of the preparations had an effect on retention of the dowels. In all cases, increased depth of the preparations resulted in increased retentive force. The mean retentive force at a preparation depth of 5 mm amounted to 174.17 N, and at a depth of 7 mm 235.5 N, which represented an increase of 35.2%. In the root canals prepared to a depth of 9 mm the mean retentive force amounted to 255 N, which was 8.3% more than in the preparations of 7 mm.

Statistical analysis of the effect of the depth of preparations on retention of endodontic dowels showed that the differences in retention between 5 and 7 mm, and between 5 and 9 mm were statistically significant. There were no statistically significant differences in retention between the dowels cemented at 7 and 9 mm.

Discussion

The mean length of the roots used in the experiment was 14 mm. Three depths of preparation of root canals were used in the experiment. The depth of 9 mm was chosen because of the principle that the optimal depth for cementation of a reinforcement is 2/3 of the root length. The depth of 7 mm was chosen because of the principle that the minimal depth on which a reinforcement should be cemented must be at least 1/2 of the length of the root. The depth of 5 mm was 1/3 of the length of the root and represented an insufficiently prepared root canal.

Colley et al. (15) studied the influence of shape and size of the dowel on retention. Dowels were cemented at depths of 3.5, 5.5, 6.5, 7.5 and 8 mm. The retentive force of dowels cemented at the greatest depth was 2-3 times greater than that of dowels cemented at the smallest depth. The relative increase in the retentive force when the depth of cementing was increased from 3.5 to 8 mm had no connection with the appearance of the surface of the dowel, i.e. both smooth and roughened cylindrical dowels amounted to approximately 200%. The smooth dowels were poorly impacted and thus the retention of the smooth dowels at a depth of 8 mm was comparable with retention of the roughened dowels at a depth of 3.5 mm. The effect of increasing the depth of cementation was significantly more marked for cylindrical dowels than conical. When increasing the depth of the preparation from 3.5 to 8 mm with roughened dowels the increase in retentive force amounted to more than 200%, while in the case of roughened dowels with convergence of sides of 4o it was only 65%.

In their investigation Johnson and Sakumura (16) compared different opinions on the effect of the depth of cementation of the dowel on retention. The recommendation that the dowel reaches up to 1/2 of the depth of the root was interpreted as a depth of 7 mm. They accepted two existing principles with regard to the depth of 9 mm: that the depth of the dowel must be equal to the height of the tooth crown, and that the depth of the insert must amount to two thirds of the length of the tooth root. In a third group the dowels were cemented up to a depth of 11 mm, in accordance with the principle that the dowel must reach up to three quarters of the length of the root. No statistically significant difference in retentive force was found between the dowels cemented at depths of 7 and 9 mm. The difference in retention between the depth of 7 and 11 mm and between 9 and 11 mm was statistically significant. Increase in the retentive force between the depth of 9 and 11 mm amounted to 24-30%. This investigation confirmed the principle of cementing dowels up to half of the root depth, and the principle of cementing dowels up to three quarters of the root depth, whenever possible. Preparation up to two thirds of the root is not significantly more retentive than preparation up to half of the root, and it significantly thins/tapers and weakens the tooth. It is also recommended that the preparation is deepened rather than widened as an effective method of increasing retention.

Standlee al. (17) compared retentive force in dowels cemented at depths of 5 and 8 mm. In almost

all cases they obtained a statistically significant increase in retention, by increasing the depths of the cementing. Conical dowels, 1.5 mm in diameter and roughened dowels, 1.8 mm in diameter, cemented with carboxylatic cement, were exceptions.

Our results are in agreement with other investigations which demonstrated that increase in the depth of the root canal preparation always resulted in an increase in retention (15,17). Our results corroborate the results of Johnson and Sakumure (16).

Preparation of the root canal of 5 mm showed insufficient retention. Increasing the depth from 5 to 7 mm significantly increased retention by 35.2%. The saving in dentine in the case of a short preparation was negligible compared to the problems caused by insufficient retention of the reinforcement. Thus, it is necessary to make the preparation up to at least half the length of the root whenever possible.

Depth of the preparation of 7 mm reflects the principle that the dowel should take up at least half of the root length. Comparison with a preparation of 9 mm did not show significantly reduced retention when shortening the preparation from 9 to 7 mm. Clinically, in cases when insertion of a dowel in the root of the length of the crown is impossible, half the length of the root is the depth of choice. A preparation of 7 mm in comparison with a preparation of 9 mm provides similar retention, and less preparation of the canal is needed. This reduces the possibility of tooth root fracture, and a larger amount of guttaperka remains in the apical part of the root canal. Consequently this also reduces the possibility of apical leaks and reinfection of the root canal, which leads to unsuccessful therapy (18).

Depth of the preparation of 9 mm supports the principle that the dowel must be the same length as the crown, and that the dowel must reach up to 2/3 of the root depth. No statistically significant differences were found between the preparations of 7 and 9 mm. This experiment did not support the above two rules.

Conclusions

Preparation of the root canal of 5 mm showed insufficient retention. Increasing the depth from 5 to 7 mm significantly increased retention by 35.2%.

Preparation of the root canal of 7 mm provides similar retention to preparation of 9 mm, and less canal preparation is needed.