Comparison of the Bond Strengths of Zinc Phosphate, Glass-Ionomer, and Compomere Cement for Dowel Cementation

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Summary

In spite of numerous previous studies, there is no final conclusion on which type of cement is the best for dowel cementation. The purpose of this study was to compare the retention of dowels cemented with three different cement types: zinc phosphate, glass-ionomer, and compomere.

Thirty teeth were divided into 3 groups, root-canals were prepared to ISO 140, to 7 mm depth and dowels were cemented. After 40 hours the tensile force needed to dislodge the dowels was recorded. For zinc phosphate it was 175±33.17 N, for glass-ionomer 235.5±46.93 N, and for compomere 275.63±96.42 N.

The dowels cemented with compomere had significantly higher tensile strength than those cemented with zinc phosphate or glass-ionomer cement. Glass-ionomer cement had significantly higher tensile strength than zinc phosphate cement. The advantages of zinc-phosphate are its low price and simple usage. Thus, in many clinical situations it may be the cement of choice.

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Introduction

Today the restoration of endodontically treated teeth represents a specific challenge, due to the fact that endodontic treatment, old fillings and caries frequently leave an insufficient amount of dental tissue for the final reinforcement. The method of restoration depends on the amount of remaining dental substance. When a significant part of the tooth crown remains it is possible to restore by conservative methods. However, when much of the dental substance is missing it is necessary to construct a reinforcement and crown which will replace the missing dental structure.

Endodontic dowels have two functions: to protect the tooth weakened by endodontic therapy from internal loading and root fracture, and to ensure adequate retention for the prosthetic replacement in different dentitions. A review of the literature shows that the length, diameter and shape of the reinforcement are factors which influence retentive force (1-18). In studies on the dependence of retentive force of the reinforcement on the type of cement used, no one cement has shown significant advantage.

Standlee et al (1) studied the effect of four factors on retention: the type of cement, diameter, length and shape of the dowel. Their results showed that the effect of the type of cement was statistically significant only in the case of conical dowels. Retentive force of conical dowels cemented with different cements was weakest for epoxide cement, stronger for polycarboxylate cement and strongest for zinc-phosphate cement.

On the other hand, more recent investigations have shown that there is significant difference in retention between individual types of cements, regardless of the shape of the dowel.

Gontar et al (2) found significant differences in resistance to tensile force between dowels cemented with composite cement and the same dowels cemented with the same cement in a canal previously smeared twice with dentin adhesive. In a similar investigation the same authors changed the composite and added a group of dowels in which prior to cementing low viscous resin was introduced, but without the introduction of adhesive. It was found that the dowels cemented with the dentin adhesive were twice as resistant to tensile forces than the examined group cemented without dentin adhesive (2-6).

An investigation by Standlee and Caputa (3) showed that cementing with composite cement after removal of the remaining layer of dentin from the root canal was one of the most efficient methods for retention of the dowel. The investigators were inclined to believe that their study supports the notion that passive cementing of dowels can be just as efficient as mechanically fixed dowels.

Chan et al (4) studied the retention of prefabricated dowels, using different cements and root canal widths. The results of this experiment indicated greater tensile strength of the dowels secured with composite cement than those secured with zinc-phosphate cement. Composite cement was significantly better than the other three types of examined cements in tightly adhering canals. There was no significant difference between the other types of cement. In canals wider than the dowels composite cement held the strongest, followed by zinc-phosphate, glass-ionomer and polycarboxylate cement. There were no significant differences between zinc-phosphate and glass-ionomer cement. In contrast Paschal and Burgess (5) determined that dowels cast from Rexillium 3 alloy and cemented with zinc-phosphate cement held much stronger than those cemented with composite cement.

Mendoza and Eakle (6) established that dowels cemented with C&B Metabond cement were much more retentive than those cemented with Ketac-Cem, Panavia or All-Bond 2 cement, and that Ketac-Cem was significantly stronger than All-Bond 2.

Utter et al (7) compared the retention of zinc-phosphate, composite and zinc-phosphate cement in combination with etched canals. They also attempted to simulate thermal changes in the mouth, which were found to have a significant effect on the cement. In order to reduce the effect of different types of dentin they worked with three-rooted teeth, in which each experimental group was allotted one root. It was found that etching had no effect on retentiveness of the zinc-phosphate cement and that the composite cement was much stronger than the zinc-phosphate cement. The effect of temperature decreased the strength of cement bonding (8, 9).

In spite of all the investigations on this theme, a review of the literature shows that the results of previous studies are not uniform. Possible reasons for this disagreement is the lack of standard methodology and the use of extracted teeth in the investigations. The quality of dentin can vary for a number of reasons: origin of the tooth (human or animal), age of the patient, consequences of previous treatment or method of nutrition and dental disinfection (4).

The aim of this investigation was to examine and compare retention of prefabricated dowels cemented with three different types of cements: zinc-phosphate, glass-ionomer and compomere.

Materials and methods

The sample comprised 35 permanent upper frontal teeth, stored in 70% ethanol. The crowns of the teeth were cut vertically on the longitudinal axis of the tooth at the level of the most apical part of the cemento-enamel junction on the vestibular side. After examination and measurement of lengths, 30 roots were chosen which were suitable for the investigation, and divided into three groups of 10 samples by the method of random selection.

Three types of cement were used in the experiment: zinc-phosphate (Harvard Cement, Richter & Hoffman Harvard Dental-Gesellschaft, Berlin, Germany), glass-ionomer (Ketac-Cem, ESPE, Seefeld, Germany) and compomere (Fuji Plus, GC, Tokyo, Japan).

The root canals were prepared up to a depth of 7 mm from the cut surface. The average length of the roots used in the experiment was 14 mm, and the depth of 7 mm represented the rule that the minimal depth for cementing the reinforcement had to amount to at least 1/2 the root length.

The dowels were constructed of round steel wire, 1.4 mm in diameter. After cutting to a length of 10 mm the dowels were sandblasted.

Canals were gradually widened by Kerrwideners (Maillefer Instruments, Ballaigues, Switzerland), initially mechanically up to ISO size 110, and then manually up to ISO size 140 (19). In each group canals were prepared up to the planned depth for the group. A check was than made to ensure that the dowels fitted passively in the canals.

Prior to cementing the canals were rinsed with water and dried with compressed air. All the cements were prepared and used according to the manufacturer's recommendations. Before cementing the dowels were dipped in cement and the root canals were filled with cement by spiral according to Lentul. According to normal practice, during the period of hardening the dowels were pressed by the fingers, which is equivalent to force of approximately 70 N. After hardening excess cement was removed with a dental probe. Between the cementing and measuring of tensile strength 40±5 hours passed. After cementing the samples were stored in a dry area.

Measurement of tensile loading was carried out in the Laboratory for Examination of Mechanical Properties at the Department of Materials, Faculty of Mechanical Engineering and Ship-building University of Zagreb. The mechanical tensile force (Faculty of Engineering and Ship-building, Zagreb, Croatia, measurement range 2000 N, class I precision) was adapted by the author to enable measurement. Namely, the part added had a small hole, 2 mm in diameter, through which the extraradicular part of the dowel could freely pass, but not the root. Each sample was exposed to tensile force in the direction of the longitudinal axis of the dowel and the force measured when continuity between the dowel, cement and tooth was interrupted (Figure 1).

Statistic analysis of data was performed on a computer, programme SPSS. Normal distribution of the obtained values was confirmed by Kolmogorov-Smirnov test. Statistically significant differences between the experimental groups were determined by a combination of unidirectional analysis of variance and Student-Newman-Keuls test.

Results

The obtained values after statistical analysis are presented in Table 1 and Figure 2.

The weakest retentive effect was shown by zinc-phosphate cement, for which detachment of the dowel occurred during average tensile force of 175 N. The strongest retentive force was found for compomere cement, for which the average detachment force amounted to 275.63 N, which is 57.5% greater value than for zinc-phosphate cement. The detachment force for glass-ionomer cement was on average 235.5 N, which was exactly halfway between the values of the detachment forces of the other two cements. Statistic analysis showed significant difference ($p<0.05$) in the retention of zinc-phosphate and glass-ionomer cement, and in the retention of zinc-phosphate and compomere cement. The same difference was also observed in the retention of glass-ionomer and compomere cement.

Discussion

If we compare the results of this investigation with those already published, it can be seen that they agree on the whole with the results of more recent studies (2, 3, 4, 6, 7). In an investigation carried out by Standlee et al (1) the strongest retention was found for zinc-phosphate cement, while in this investigation it showed the weakest resistance to tensile force. In this investigation compomere cement showed significantly stronger retention than zinc-phosphate cement, which disagrees with the results of the investigation by Paschal and Burgess (5). Partial congruity exists between the results of this investigation and those of Mendoze and Eakle (6) who determined that glass-ionomere cement, Ketac-Cem, was stronger than one cement (All-Bond 2) and weaker than another (C&B Metabond) type of composite cement. As found in the investigation by Gontar et al (2) the use of dentin adhesive proved to be justified, because in our investigation there was significant difference in retention between the glass-ionomer and the compomere cement, and in the experiment the compomere used was, according to its properties, closer to the composite than to the glass-ionomere cement (20, 21).

Comparison of zinc-phosphate and glass-ionomer cement is interesting, as various investigators have obtained very different results, and some give the advantage to one type and others to another. Rosin (23) noticed a very interesting occurrence in this connection. His initial results showed significantly better retention of zinc-phosphate in a group in which the samples were only stored in water. However, in a group of samples which were also thermocycled, the results of the detachment force for glass-ionomer cement remained the same, while the results for zinc-phosphate were significantly closer. In a third group, stored in water, thermocycled and exposed to mechanical stress the detachment force for the zinc-phosphate cement continued to fall, while for the glass-ionomer cement it increased to 70% in relation to the initial value, and thus it had become practically twice as great as zinc-phosphate. The investigator explained this result by the positive effect of mechanical stress on the bonding of free water in glass-ionomer cement. It is known that glass-ionomer cements need several months to attain their final strength, and bonding of free water is considered the mechanism by which it is achieved (24).

The great variability of obtained values for bond strength in the case of compomere is interesting. Similar results were obtained by other investigators, in which standard deviation amounted to around 30% of the measured values (22-24). One explanation was put forward by Xie et al (25) in whose investigation compomere cement was the only cement which showed the characteristic of plastic deformation, indicating that marginal force for cracking of cement does not exist, but the interval of force during which cracking occurs.

Also, in some investigations glass-ionomere cements modified with resin showed very poor results, which is contrary to our results (22-24). The authors attempted to explain this by the fact that the method of determining the ratio of powder and liquid by spoon and drop is relatively inaccurate. In addition, it is possible that the manufacturers, in an effort to produce material consistency suitable for cementing, reduced the ratio of powder and liquid and consequently caused weakening of the cement, compared to the relatively compact cement for filling. This was supported by the fact that traces of cement remained on the dowels, indicating that cracking occurred in the cement structure and not on the cement-dentin or cement-metal border. Mount (26) hypothesised that glass-ionomer cement, modified with resin, with a reduced ratio of powder and liquid, contains an increased amount of HEMA, and consequently greater potential for the bonding of water to this hydrophilic resin and weakening of the cement structure. In the above investigations, in contrast to ours, the samples were kept in water before testing, which is a possible reason for the significantly lower values of detachment force for compomere.

Although statistical data indicate significant differences between zinc-phosphate and other tested cements, this does not decrease the clinical importance of the use of this cement. The tensile strength of zinc-phosphate is relatively high. If the sensitivity of the new cements to technical work and manipulation are taken into account, and their high cost, zinc-phosphate remains the material of choice in many clinical situations. On the other hand, certain factors favour the newer cements. Namely, their ability to permanently release fluoride, with the consequent caries-protective effect, and their ability to bond chemically to the metal dowel and dental tissue, with consequent prevention of micro leakage.

Conclusions

1. Compomere cement is significantly more retentive than zinc-phosphate and glass-ionomer cement. Glass-ionomer cement has significantly greater retentive strength than zinc-phosphate cement.
2. The advantages of zinc-phosphate cement are its reduced sensitivity to error during work and its relative cheapness, and in many clinical situations it remains the cement of choice.