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EXAMINING THE STRENGTH OF THE RETENTION OF TOOTH CROWN ABUTMENT WITH GLASS FIBRE DOWEL

The paper presents strength examination for premolar dental crowns reconstructed with glass fibre dowels in terms of normal occlusal loadings. For comparison, strength examination of fillings retention was also done for crown reconstructions without dowels as well as for the so-called healthy teeth. The analyses of the results have shown a good quality of fillings reconstructed using the glass fibre technique and proved their durability and high strength properties.

1. Introduction

One of the branches of preventive dentistry is endodontics, whose main goal is to deal with the tooth pulp diseases and to recognize and treat the diseases of tissues surrounding the root of a tooth. In the case of a complete or significant loss of a tooth crown, dental techniques applied in endodontics require the use of supplementary retention elements in the crown reconstruction in order to retain the patient's own teeth. This method remains in accordance with a currently binding dental rule that the patient's own tooth root is the best implant.

Strengthening elements used in this method are commonly called dowels. They should be characterized not only by biocompatibility and easy application, but also by adequate strength properties referring to elasticity, static and fatigue strengths, and proper adhesive features. It is tradition to use metallic dowels: cobalt alloys, stainless steels, titanium alloys. They are implemented with the use of various techniques like casting, cement mounting or self-

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threading. Negative characteristics of these materials are excessive rigidity and weak retention in comparison with hard tooth tissues, poor aesthetic qualities and biocompatibility problems connected mainly with the osteolysis properties of metallic materials. Attempts to replace metallic materials with more biocompatible carbon or zirconium-dioxide ceramic materials have not yielded the expected results, mainly because of their cost, brittleness, poor aesthetics and low X-ray non-translucency. The current application of these materials is minimal and of a decreasing tendency [4]. Recently introduced glass fibre dowels seem to be the most promising implementation material. The basic advantage of glass fibre dowels is their resistance capabilities close to those of the dentin and easy application and processing, which results in the increasing use of the dowels. The modulus of elasticity of the glass fibre dowel is close to that of the dentin; hence the fatigue life of such a retention combination is more than 40 times higher than that of the metallic dowel made of implantation stainless steel [3].

The aim of this study was to evaluate the strength of tooth crowns reconstructed with the use of glass fibre dowels. The tests were conducted under in vitro conditions, typical for human premolar teeth, which are among the weakest teeth and most frequently undergo the total destruction of the crown. They are also most frequently reconstructed with the use of dowels serving as supplementary retention elements.

2. Material and methods

Endodontically treated single- and double-rooted upper and lower premolar teeth have been qualified for strength examination research. In the reconstruction of dental crowns the following materials were used: the ENAPOST 2% dowel, the ENAMEL PLUS composite material, the luting ENABOND system. All the materials are produced by the *Micerium*[®] firm [2].

ENAPOST 2% is a tapered glass fibre dowel, whose angle of flare equals 2% and the modulus of elasticity equals 20 [GPa], which is close to the dentin modulus of elasticity (18 [GPa]).

ENAMEL PLUS is a micro hybrid light-hardened composite material used in aesthetic reconstructions. It contains as follows: an acrylic monomer matrix and glass fillings, whose average size of a particle equals 0.7 μm , and highly-dissipated silicon dioxide whose average size of a particle equals 0.04 μm .

ENABOND is a single-component light-hardened system, which bonds the tooth tissues with a composite material and a dowel. Ethanol constitutes the basis of the system and thus it has a universal application. The adhesive force is more than 30 [MPa].

The tooth-samples were randomly divided into three groups (7 teeth in each group). The first group differed from the second one in terms of reconstruction method. In the first group, the tooth root canal was filled with gutta-percha; in the second group – a dowel was inserted in the root canal. The third group with healthy teeth served as a reference group. The samples were immersed in Ringer's solution all the time. The reconstructions of the crowns were prepared in the DENTIST Dental Clinic. The subsequent stages of the premolar tooth crown sample reconstructions are presented in Fig. 1.

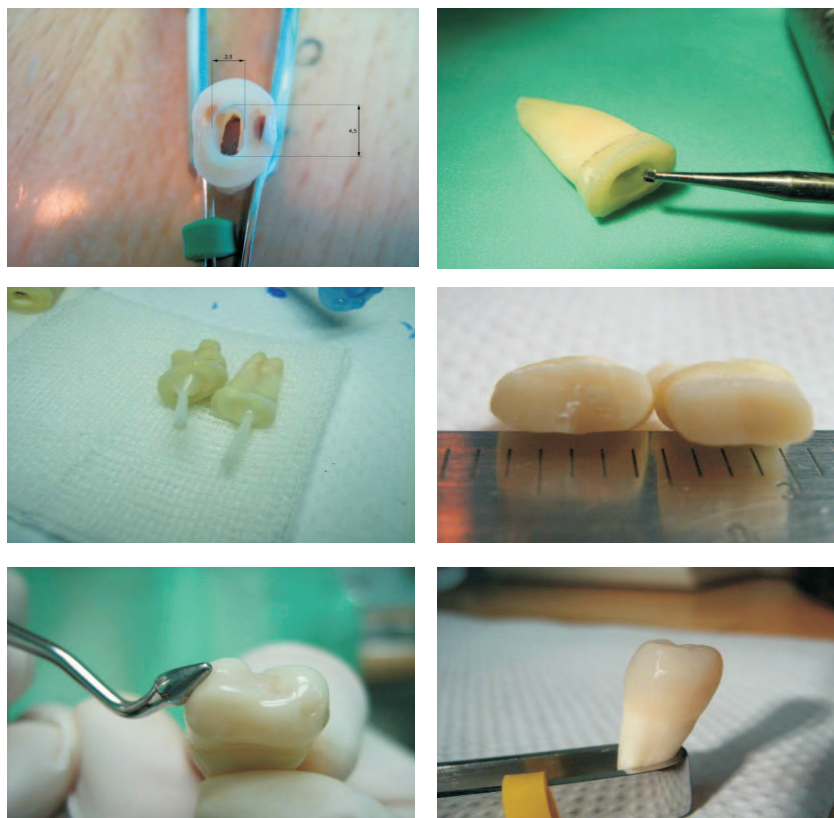


Fig. 1. Subsequent stages of the preparation and study of the premolar teeth samples reconstructed with the use of glass fibre dowels

The strength examination research was conducted in the Division of Experimental Mechanics and Biomechanics at Cracow University of Technology. The tooth-samples were planted in an aluminum alloy sleeve and immersed in epoxy resin up to the anatomical necks of the teeth. It simulated the tooth setting in the dental alveolus in the alveolar bones. In the next 24 hours, the process of resin polymerization took place and then, for another period of 24 hours, the whole set was immersed in Ringer's solution.

The strength examination under in vitro conditions was conducted in a static compression test on the strength machine INSTRON 4456 for all the three groups. The samples were attacked with a mandrel with a sphere (2.5 mm in diameter) on its end. The direction of the sphere's force action was perpendicular to the tooth occlusal surface. This mode of loading, accepted in literature [5], simulates a normal side-tooth occlusion during food grinding – Fig. 2. The following quantities were measured and analyzed: the destruction force, the destruction energy, the force and energy of the so-called first micro fractures, the displacement during the destruction of the samples.

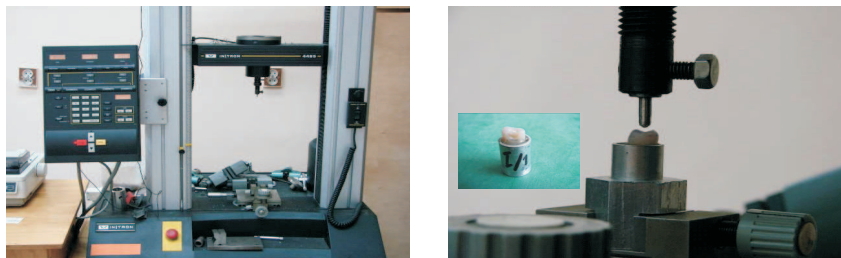


Fig. 2. Strength examination of the premolar teeth with reconstructed crowns simulating normal occlusion

3. Research results

The examination for all the three groups was conducted under identical conditions, and sample scraps were additionally checked by a dentist and classified as repairable destructions (destructions that were only within the tooth crown) and non-repairable ones (both the crown and the root were destroyed).

The dental scraps were selected into four main groups:

- a) the cusp of a tooth breaking off; it means that the reconstruction was properly conducted and it fulfils endodontical therapy expectations. This type of tooth destruction takes place under natural conditions, regardless of the applied reconstruction,
- b) delamination of the composite, also known as fracture; in this type of destruction a composite layer gets separated from the tooth tissues or from another composite,
- c) delamination of the enamel (the enamel gets separated from the dentin),
- d) complete splitting of the tooth crown and root.

Figure 3 presents the exemplary results of the compression tests simulating normal premolar teeth occlusion for the group of teeth reconstructed with glass fibre dowels.

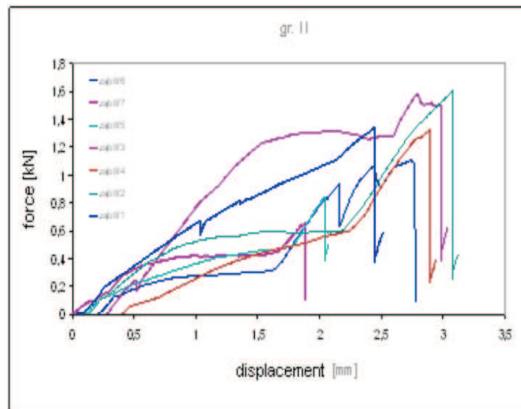


Fig. 3. Examination results for the premolar teeth reconstructed with glass fibre dowels

The examination results were statistically analyzed with the Kruskal-Wallis test. It was checked whether there were differences between the groups (establishing the degree to which results were statistically significant). When the differences were found, a multiple comparison test was conducted in order to locate these differences. The test results with the level of significance less or equal to 0.05 ($p \leq 0.05$) were pronounced as statistically typical. Calculations were made with the STATISTICA 7.1 statistical program.

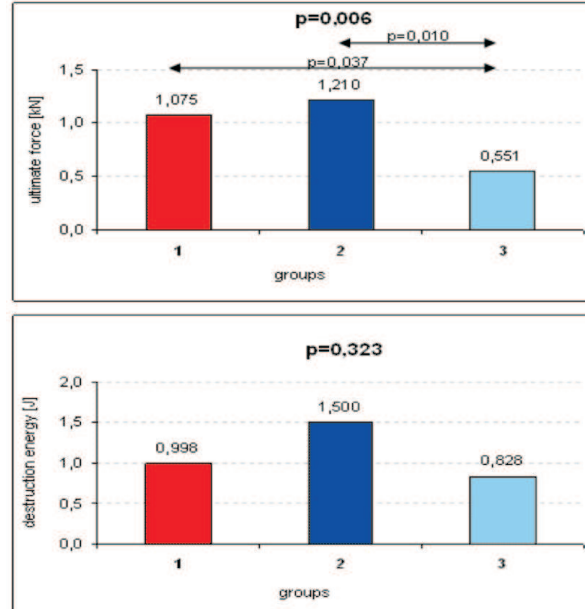


Fig. 4. Histograms of the average values and the level of significance distribution for the destruction force and destruction energy

Summing up the strength examination results of the premolar teeth group with a complete crown reconstruction with the use of glass fibre dowels in comparison with the first group, we should state that the strength parameters in this group are about 25% higher. Also a very important fact discovered in the research is that both the reconstruction of a tooth with a glass fibre dowel and without it prevents 100 percent catastrophic breaking (damage that cannot be reversed, filled in or reconstructed).

The results of the third group, with respect to mechanical and dental tests, turned out to be relatively the weakest. This group comprised healthy teeth, which were only disinfected and with tooth scale and soft tissues cleaned off. In four out of seven cases, non-treatable damage was observed. Widely scattered results and low strength parameters were the consequences of local dental crown destruction (visible even with the naked eye), including those caused by tooth decay.

4. Conclusions

The main research conclusions are as follows:

- ✓ from the clinical and strength point of view, complete reconstructions of glass fibre dowels show the best properties; this method is recommended for the endodontical premolar tooth therapy,
- ✓ from the statistical point of view, there is no significant destruction force difference between the construction of a glass fibre dowel and reconstruction by filling the tooth root canal with gutta-percha; however, the statistical significance is present in the destruction energy parameter,
- ✓ from the statistical point of view, there is a significant difference between a healthy tooth and an endodontically treated tooth (both with the dowel and without it) in all the analyzed strength parameters.

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**Badania wytrzymałościowe retencji wypełnień koron zębów wzmocnianych
wkładami z włókien szklanych**

S t r e s z c z e n i e

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