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Influence of state of complex load on endurance of teeth strengthened by endodontic post systems

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The purpose of this study was to determine the fracture load for teeth strengthened by different endodontic post systems. The endurance of teeth was tested under conditions of complex load. For the tests, canine teeth extracted due to orthodontic or periodonthopatic reasons were examined. The samples were prepared in three separate groups: teeth filled with Endomethasone paste (without endodontic post), teeth strengthened by standard endodontic post systems, teeth strengthened by individual endodontic post systems (casted).

Keywords: standard and customised endodontic post systems, endurance under loading

1. Introduction

In order to strengthen teeth that have been subject to root canal therapy, endodontic post systems are usually applied. It is possible to use both standard post systems and those that are individually modelled and then cast.

Teeth supported by endodontic post systems are subject to occlusion load. If the post systems are pillars for larger prosthetic structures, the teeth that are strengthened by them may endure pressures higher than those resulting from regular physiological functions. The structure of a tooth with the post systems differs from its natural structure. The tooth root is weakened by the endodontic treatment, and the dentine is dead tissue. In order to obtain the post system that fulfils its functions properly, it is necessary to study the prosthetic craftsmanship [5–8, 11, 14, 15], biomaterials engineering [1, 12], construction solutions [4, 6, 16], as well as the mechanic and strength structures [2–4,13].

In Collegium Medicum's Chair of Dentistic Prosthetics, an analysis of endodontic post systems has been carried out within the framework of the Students' Research Club.

The objective of the study was to test the endurance of single-root teeth strengthened by endodontic post systems under complex load conditions. In modelling the

complex occlusion load, the maximum load that leads to the destruction was determined for teeth treated in three different ways.

2. Material and method

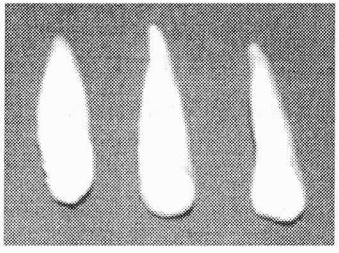


Fig. 1. The teeth applied in the analysis – unstrengthened teeth filled with Endomethasone

Canines' teeth removed for orthodontic reasons or because of periodontopathy were selected for the tests. The extracted teeth were stored in distilled water at room temperature for at least 48 hours before the start of the test. Further analysis was conducted within three groups:

- Unstrengthened teeth (filled with Endomethasone paste) (Fig. 1).
- Teeth strengthened by standard endodontic post systems of the Radix-Anker set, embedded in carboxylic cement. The crown stroma was surrounded with composite material (Herculite XR) as well as a prosthetic crown cast in silver and copper alloy (Fig. 2).
- Teeth strengthened by customised (cast) endodontic post systems in silver and copper alloy embedded in carboxylic cement. The crown part was surrounded with a prosthetic crown cast in silver and copper alloy (Fig. 2).

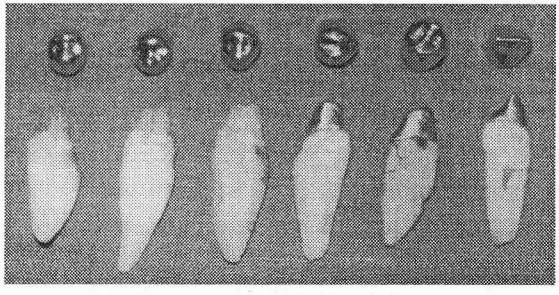


Fig. 2. The teeth applied in the analysis – teeth strengthened by standard endodontic post systems (on the left) and teeth strengthened by customised endodontic post systems (on the right)

In order to establish the research method it was necessary to determine the directions of occlusion loads for each tooth [17]. The analysis of occlusion load direction was based on gnathometric measurements according to the Schwartz (Fig. 3) and Jarabak (Fig. 4) methods [9]. The load directions of jaw and mandible opposite teeth follow from their anatomic structure and physiological functions. The angle resulting from the intersection of the long axes of upper and lower incisors, the inter incisial (ii) according to Schwartz amounts to 140± 5°, and according to Jarabak the inter incisial (JJ) (Fig. 4) amounts to 140°–150°. In the distal direction, the angle resulting

from the intersection of long axes of the succeeding opposite teeth approaches 180° (for molars). This is a physiological adaptation that follows from the increase of the load.

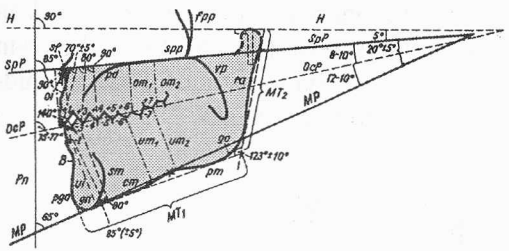


Fig. 3. The planes, lines and angles applied in gnathometric measurements in the Schwartz method

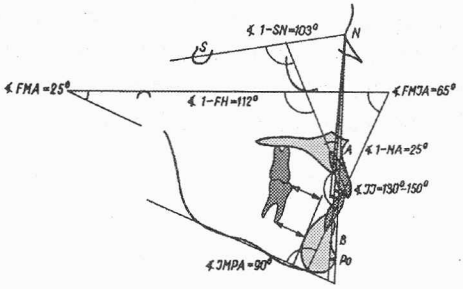


Fig. 4. The planes, lines and angles applied in tooth analysis in the Jarabak method

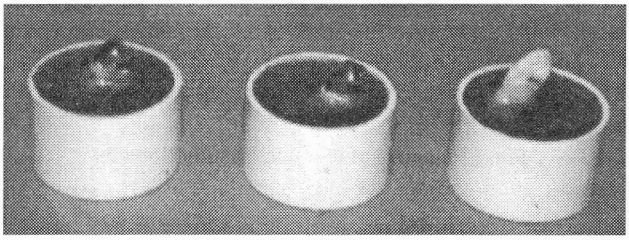
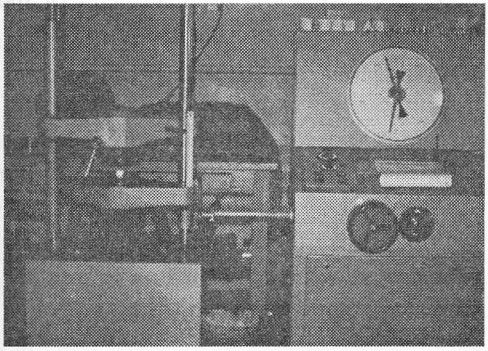
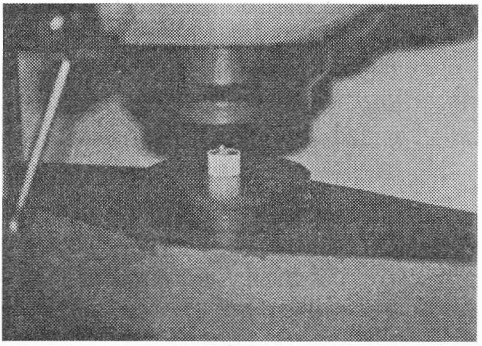


Fig. 5. The samples of the tooth prepared for endurance analyses



a



b

Fig. 6. The testing machine: a) general outlook, b) a tooth set in an epoxy resin-filled sleeve

In order to obtain real complex load conditions, in the analysed sample the angle between the tooth's long axis inclination and the pressure vector was set at 32±2°.

The angle is determined in the normal plane of the tooth's lip surface and is set according to the results obtained from the analysis of the occlusion load. The right inclination of the tooth was ensured by placing it in the desired position in viscous wax, basing on a special spatial construction. Then the analysed teeth were placed in 20 mm high and 1'' diameter sleeves filled with epoxy resin (Fig. 5). Once the resin hardened, the sleeves with the samples were kept in an environment of 100% humidity (distilled water) for a period of a week before the start of the tests.

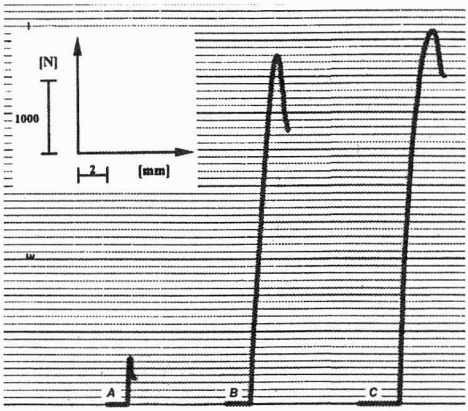


Fig. 7. Diagram of tooth destruction strengths

The experiment was conducted on a standard tensile testing machine with a hydraulic load system (Fig. 6). The tested sample was subjected to the changing load, whose values were registered continuously. Figure 7 illustrates sample diagrams of loads that lead to the destruction of the teeth. The ordinate axis represents the load under which the tooth is destroyed, and the abscissa axis – the displacement of the breaking crown under the load.

3. Results

The test results worked out statistically (with the Statistica 5.0 software) are presented in the Table and in Fig. 8.

Table. The destruction forces for the three groups of analysed samples

Group	No. of samples	Destruction forces [N]			Standard deviation
		Mean	Min.	Max.	
An unstrengthened tooth filled with Endomethasone paste	5	526.0	490.0	560.0	27.02
A tooth strengthened by a standard endodontic post system	5	4850.0	4700.0	5000.0	127.47
A tooth strengthened by a customised endodontic post system	5	5020.0	4920.0	5120.0	72.11

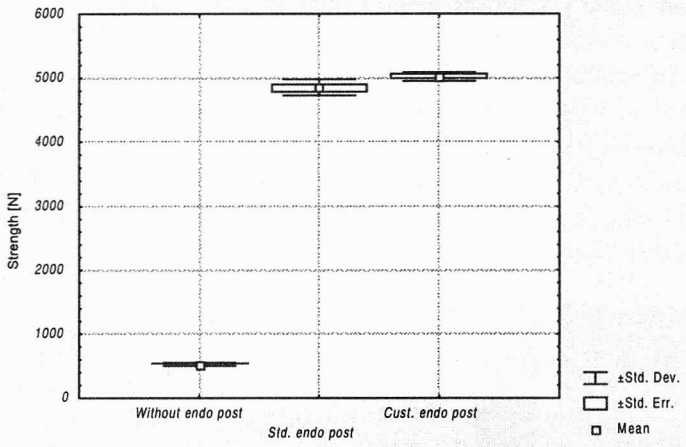


Fig. 8. Graphic representation of the research results' statistical analysis;
without endo post – an unstrengthened tooth filled with Endomethasone paste;
Std. endo post – a tooth strengthened by a standard endodontic post system;
Cust. endo post – a tooth strengthened by a customised endodontic post system

Damage took place at the point when the prosthetic crown was displaced from the root stroma or the tooth was broken (in the case of unstrengthened teeth filled with Endomethasone paste) (Fig. 9). No cases of post systems breakage were reported, only their distortion. This is due to the fact that the strengthening of a tooth by the post system considerably increases its endurance.

4. Discussion

The constructional-mechanic-endurance shape of an endodontic post system should result from Caillet's principle [1], according to which the biomechanical structure must be based on the analysis of the appropriate system and load that the construction of treatment-support elements provides. The system to be analysed comprises the tooth, the post system and the material used to reconstruct the crown part of the tooth. The treatment's success is determined by professional implementation of the requirements of the manufacturer of standard endodontic post systems or the procedure of constructing customised endodontic post systems.

Generally, the following advantages and disadvantages of the particular post system applied should be examined:

- the stress pattern resulting from the particular construction of the system and the embedding (cement variety) applied,
- the constructional solutions applied in fixing of the crown on the reconstructed stroma,
- the influence of the complex occlusion load on the constructions applied,
- the fatigue strength of the elements applied.

The resistance analysis of teeth with standard endodontic post systems that have been discussed in professional literature [2–4] concerns the following aspects:

- fracture strength analyses [2],
- endodontic post systems retention and determining the stress patterns [4],
- torsional strength analyses [3].

Those analyses were aimed at evaluating the constructional and material solutions in standard endodontic post systems as well as the materials used for the reconstruction of the crown stroma.

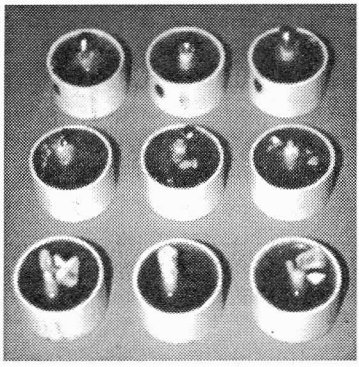


Fig. 9. Tooth samples after the resistance tests

The new research method that is described in the present analysis can be applied both to standard and to customised post systems. It takes into account the direction and stress pattern of occlusion loads that differ, depending on the position of the tooth in the alveolus, and allows for individual modelling of the tooth's long axis angle setting. The analyses were conducted under extreme conditions, which may lead to the destruction of a completely reconstructed crown stroma on the supporting post system. It is the use of fully reconstructed teeth that is characteristic of the present research.

Such modelling of load directions could also be used in fatigue-type analysis. In this case, the steadily increasing loading of the sample would be replaced by cyclic variations of the load.

The appropriate modelling of load kinematics and geometry is a significant issue in the research described here, being the element that determines whether the experiment has been carried out properly.

5. Conclusions

Fifteen samples of endodontically treated teeth with reconstructed crown stroma, with either standard post systems or customised systems were prepared and analysed. For all of those, the load leading to the destruction of the reconstructed tooth was measured.

The preparation of the samples required analysing the directions of loads that are produced in occlusion. The analysis focused on measuring an average fracturing strength.

The research was conducted on a universal testing machine with continuous load registration.

On the basis of the analysis conducted the following conclusions can be drawn:

- Supporting a tooth by an endodontic post system considerably increases its resistance to destruction under complex load conditions. The resistance of such a tooth increases ten-fold in comparison to a tooth filled with Endomethasone paste.

• The resistance of a tooth strengthened by a customised post system is stronger than that of a standard post-system tooth.

It is planned to conduct fatigue experiments basing on the research methods developed during the present tests. Moreover, the methods will also be used for the retention analysis of false teeth in acrylic prostheses in the different groups of constructing the root part of the false tooth.

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