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Original article

Strength comparison of anterior teeth restored with ceramic endocrowns vs custom-made post and cores

Beata Dejak[a,*], Andrzej Młotkowski[b]

[a] Department of Prosthetic Dentistry, Medical University of Lodz, Lodz, Poland
[b] Department of Strength of Materials and Structures, Technical University of Lodz, Lodz, Poland

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ABSTRACT

Purpose: The aim of the study was to compare strength of the anterior teeth restored with ceramic endocrowns versus custom-made post and core.

Methods: The investigation used the finite element analysis. Three 3-D models of maxillary central incisor were created: model A—tooth restored with metal post and core with ceramic crown; model B—tooth with leucite ceramic endocrown; model C—tooth with lithium disilicate ceramic endocrown. Each model was subjected to a 100N force applied at a distance of 5 mm from the incisal edge, at the angle of 130° to the long axis of the tooth. The modified von Mises failure criterion was used to evaluate the strength of the dentin, ceramic and resin cement, and Huber–Mises–Hencky failure criterion for cast alloy. Contact stresses in the cement-tissue adhesive interface were calculated.

Results: The lowest stresses occurred in the anterior tooth restored with custom post and core (model A). The mvM stress of 47.5 MPa concentrated in leucite ceramic endocrown (model B) and its value was close to the tensile strength of this material. The maximal mvM stresses in the lithium disilicate ceramic endocrown (model C) were 4 times lower than tensile strength of this material. In all cases contact stresses in the adhesive interface under restorations did not exceed the resin cement bond strength to dentin.

Conclusions: Leucite ceramic endocrowns in incisors may fracture during physiological loading. Endocrowns made of lithium disilicate ceramic are resistant to failure. Posts and prosthetic crowns are still recommended for anterior teeth restorations.

1. Introduction

Severely damaged crowns of endodontically treated teeth are usually restored with post and cores and prosthetic crowns. To restore them the root canal needs to be prepared up to 2/3 of its length as well as the supragingival tissues. Unfortunately, these restorations involve the loss of 58.3% of incisor structure [1]. In addition, preparing a root canal for a post carries the risk of bacterial contamination and root perforation [2].

Thanks to the development of adhesion methods, endocrowns can be used to restore damaged, supragingival structure of posterior teeth [3]. These restorations are recommended in case of damaged molars crowns, short and narrow roots, obturated canals or limited interocclusal space [4]. These restorations are mechanically anchored in pulp chambers (3 × 4 mm element) [5–7] and strongly, adhesively bonded with hard dental tissues using resin cements [8]. The advantages of using these restorations include little dental structures preparation compared with post and cores [9], as well as lack of intervention in the root canals [10]. Compared to traditional methods they need less time to be made and less interfaces between each part of the restorations and the teeth.

Endocrowns are most frequently made of feldspathic ceramic (e.g. Vitablocs Mark II, Vita Zahnfabirk, Bad Säckingen, Germany, Cerec Blocks, Sirona Dental Systems, Bensheim, Germany), leucite ceramic (e.g. IPS Empress CAD, Ivoclar Vivadent Schaan/Liechtenstein), lithium disilicate ceramic (e.g. IPS e.max Press, Ivoclar/Vivadent, Schaan/Liechtenstein) or resin composite (e.g. Lava Ultimate, 3M ESPE, St Paul, MN, USA) [11]. Ceramic endocrowns are made by sintering, pressing or more often CAD/CAM technology. The restorations are aesthetically attractive. Molars restored with endocrowns provide high strength [12] and fracture resistance during loading [13], better than these restored with FRC posts and crowns [14]. Five-year clinical observations

* Corresponding author at: Departament of Prosthetic Dentistry, Medical Faculty, Division of Dentistry, Chair of Restorative Dentistry, Medical University of Łódź str. Pomorska 251, 92-213 Łódź, Poland. Fax: +48 426757450.
E-mail address: beata.dejak@umed.lodz.pl (B. Dejak).

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reveal that 87.1% of endocrowns in posterior teeth functioned well, without fracture or debonding [15]. More treatment failures occurred in premolars than in molars (75%/90.5%) during 12 years [16].

Owing to these advantages and primarily due to their aesthetic appeal, ceramic endocrowns could be also be recommended for anterior teeth restoration. Unfortunately, the biomechanics of incisors differ from molars. Incisors' crowns are taller (10.5 mm) and more narrow (7.0 mm) than molars' (7.5 mm length of crown, 10.0 mm bucco-lingual diameter at the cervix) [17]. In accordance with the equilibrium of a lever, the bending moments on the restorations in incisors are higher than those acting on molars. In addition, the bonding surface of endocrowns in anterior teeth is an average of 30 mm^2 and is two times smaller than in molars (60 mm^2), which negatively affects the retention of these restorations [17]. Taking the preceding into account, is it still possible to use endocrowns to restore anterior teeth?

The aim of this study was to compare the strength of incisor teeth restored with ceramic endocrowns versus custom-made post and prosthetic crowns.

The hypothesis assumes that restorations of the incisors with post and core will cause less stress in the tissues than the reconstruction of these teeth using ceramic endocrowns.

2. Material and method

The study was conducted using the finite element method (FEM). A Dental 3D Scanner D250 (3ShapeA/S Copenhagen, Denmark) was used to scan the surface of the left upper central incisor. The scans were processed using 3Shape Dental Designer CAD software. Data sets with PTS file extension, containing point coordinates on the surfaces of an examined tooth, were entered into finite element method program ANSYS 14 (ANSYS version 14, ANSYS Inc., Canonsburg, Pa, USA) [18]. Points on the tooth surface (recorded with a scanner) on horizontal layers (every 1 mm) were connected by curves and on the basis cross-section areas of the tooth were determined. These cross-section areas allowed to create solid models of a central incisor. The size and shape of the tooth was consistent with those of the anatomical atlas [17]. The crown was 10.5 mm in length, with a medial-distal width of 8.5 mm and a root length of 12 mm (the tooth was 22.5 mm long). A 0.2 mm thick periodontium was modelled around the root of the tooth. The tooth model was positioned within a system of coordinates in such way, that the Z-axis was parallel to the long axis of the tooth, the X-axis showed the mesial side and the Y-axis was directed towards the vestibular aspect of the tooth.

Afterwards, models of teeth restored with custom-made post and cores and ceramic prosthetic crowns (model A) and endocrowns (models B, C) were made (Fig. 1). All the restorations had the ferrule effect.

Model A of tooth with post and core were created. The upper central incisor was prepared for a ceramic crown according to standard clinical recommendations [19]. The inclination of the axial walls was 10°, the incisal edge was reduced by 2 mm, a 0.8 mm rounded shoulder finishing line was prepared. A scan of the prepared tooth stump was performed with a Dental 3D Scanner D250 (3ShapeA/S, Copenhagen, Denmark). A cloud of points was entered into ANSYS program and the surface of the abutment was generated in the software. The model of the tooth was dissected along this surface as well as along the plane perpendicular to the long axis at a distance of 7 mm from the incisal edge. A 12.0 mm × 1.2 mm cylinder was created in the ANSYS pre-processor. This solid was inserted into the tooth canal and then added to the model of the tooth. In this way model A of a tooth with a post (1.2 mm diameter, 8.5 mm long in the root, in a distance of 3.0 mm from the root apex) with a prosthetic crown with ferrule

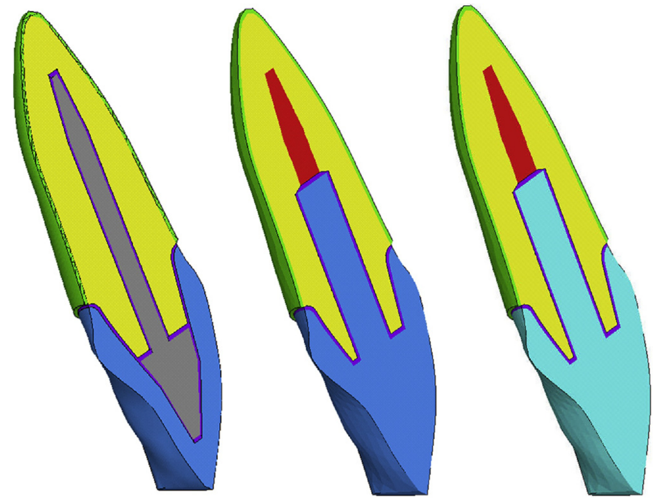

Fig. 1. Models of anterior teeth with various restorations.
a) Model A—Incisor restored with post and core and prosthetic crown.
b) Model B—Incisor restored with leucite ceramic endocrown.
c) Model C—Incisor restored with lithium disilicate ceramic endocrown.

3.5 mm high was created (Fig. 2A) [19]. A 0.1 mm cement-imitating layer was formed around the root and crown section of the post as well as under the crown.

Models B and C of teeth with endocrowns were generated. The model of the maxillary central incisor was dissected with a plane perpendicular to the long axis of the tooth at a distance of 7 mm from the incisal edge. Then it was also cut according to the surface of the abutment prepared for the crown. An 8 mm × 2 mm cylinder was created in the ANSYS pre-processor and was inserted into the canal of the tooth. The volumes of the cut-off crown and root section were combined in an endocrown solid and added to the tooth model. This way a tooth with the endocrown, with 3.5 mm ferrule (model B) was created. The retention element in the root was 2 mm wide, 4.5 mm long and in a distance of 7.0 mm from the root apex (Fig. 2B). A 0.1 mm layer imitating cement was generated

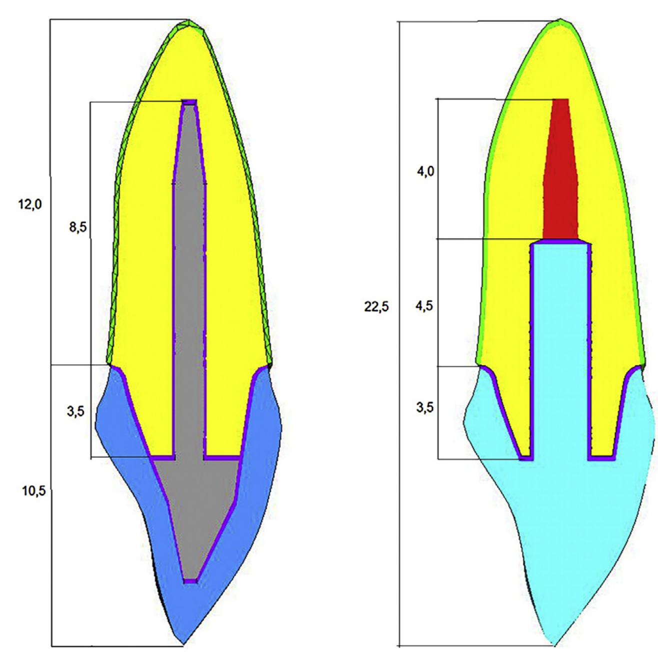

Fig. 2. Model dimensions (cm).
a) Tooth with post and core and prosthetic crown.
b) Tooth with endocrown.

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