Finite element analysis of devitalized teeth

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Abstract

Elimination of a large part of dental tissues during root canal treatment affects the mechanical behavior of devitalized teeth. The present study addresses how much dentin removal affects changes in mechanical behaviors of the intact tooth and tooth with root canal treatment. In order to estimate the tooth weakening, we performed aн experimental assessment of critical force and numerical Finite Element Method (FEM) analysis with the intention to analyze stresses distributions. The results showed that root canal treatment had significant influence on stress distributions. By analysis of retrieved results, it is concluded that this study is an efficient framework which could be applied in a number of different cases, so that practitioners could analyze and prepare the treatment with more certainty.

Keywords: Devitalized teeth, Finite Element Method

1. Introduction

It is well known that every tooth restoration leads to loosing of mechanical performances, thus causing the unexpected failure. As there is a large number of studies, there are many factors influencing tooth fracture resistance. Elimination of a large part of dental tissue at some point in endodontic treatment is needed, which surely affects the mechanical behavior of these teeth. So far, investigators mostly used destructive methods which are based on experimental loading until fracture point. However, destructive methods cannot provide important data about stress distribution on tooth structures. As a solution, recently, Finite Element Method (FEM), which gives the biomechanical analysis, is applied. FEM shows high-stress concentration points and structure-stress distribution in dental tissues, as well as in the dental restorations used in the treatment. First FEM analyses were based on basic tooth models (Asmussen and Peutzfeldt 2008) or models of average teeth proportions (Ren et al., 2010). However, since the accuracy of FEM analysis depends on accurate input information, the most reliable data are received from the real teeth CT scans further used to generate the FEM model (Soares et al., 2008). Furthermore, although this is rarely practiced, the best FEM studies include experimental verification of the obtained results (Soares et al., 2008). Thus, the scanned teeth are subjected to the in vitro experiment, with the same setting as those in FEM analysis. The aim of this study is root canal treatment with two surface cavity.

2. Materials and methods

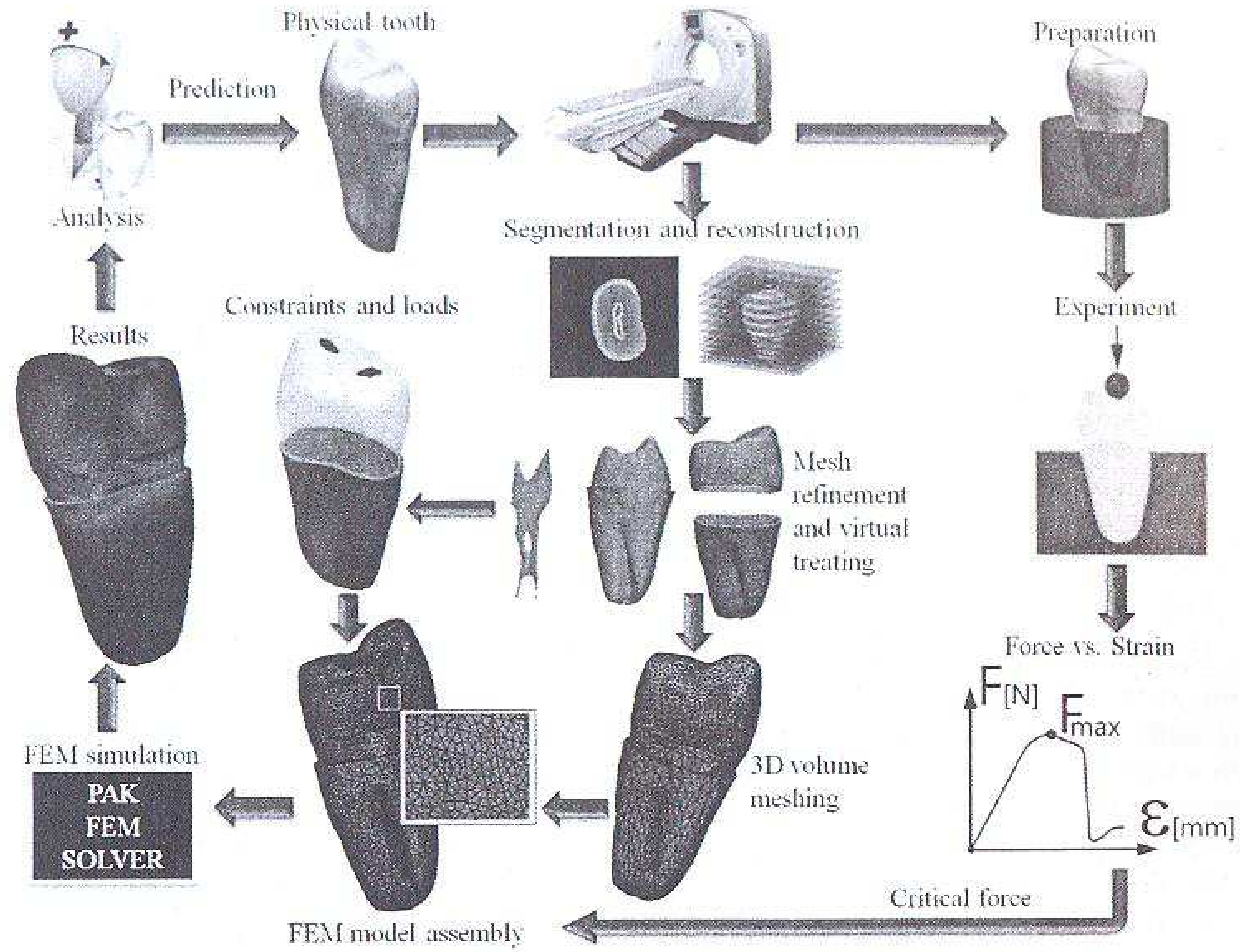

Fig. 1. Schematic overview.

Two intact upper second premolars were used in this study (Approved by the Ethics Committee of the School of Dentistry, University of Belgrade). X-rays of the teeth were made to confirm the similarity of the morphology. One tooth underwent an in vitro root canal procedure and the other remained intact. A mesio-occlusal (MO) Class II preparation was performed with root canal enlargement. The canal was filled with cold gutta-percha. The tooth was restored with composite resin. Both teeth were scanned on CT (Siemens Somatom Sensation 16). After imaging acquisition, the fracture test was performed on these teeth. The compression test was completed on the computerized measuring system for material testing ZWICK ROELL Z 100 Zwick GmbH & Co. KG. Compressive loading was applied with the use of a steel bar with a round tip, placed in the center of the tooth, with the test speed 5 mm/min. The precision of force measuring was 1N, and the precision of the compressive strain was more than 0,001 mm. The process of teeth segmentation and generation, and generation of a surface mesh from CT dicom data were performed in Mimics 10.01 (Materialise, Leuven, Belgium). In order to prepare the mesh for performing FEA, refinement and assembly of every part of the models were done in Gemagic Studio 10 (Geomagic GmbH, Stuttgart, Germany). In model 1 (intact tooth), four separate parts were modeled: enamel, dentin, pulp chamber, periodontal ligament (Fig. 2).