

# Mechanical weakening of devitalized teeth: three-dimensional Finite Element Analysis and prediction of tooth fracture

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## Abstract

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**Aim** To determine to which extent cavity preparation and each step of dentine removal in the process of root canal treatment (access cavity preparation and root canal enlargement) both individually and jointly contribute to the weakening of the tooth.

**Methods** Numerical analysis using finite element method (FEM) of separate and combined influence of two-surface Class II preparation and root canal treatment was undertaken to evaluate the decrease in tooth strength. The influence of the two stages in root canal treatment, access cavity preparation and root canal enlargement, was also analysed separately and jointly. After each of these phases, the crown was restored with composite resin, and the FEA was performed only on restored teeth. To estimate the influence of all these procedures on tooth fracture resistance numerically, a Failure Index based on the maximum principal stress criterion (MPCS) was applied. Compressive and tensile stresses were analysed separately and corresponding Failure Indices were calculated.

**Results** A two-surface resin composite restoration weakened the tooth by 23.25%. Nevertheless, the Failure Indices showed that this tooth was not likely to fracture even under high occlusal stress (710N). However, after access cavity preparation, the Failure Indices reached the point where, under high occlusal force that may occur in the posterior area, a tooth fracture occurred. The enlargement of root canals had an additional, but relatively small impact on tooth weakening, making the tooth even more susceptible to fracture. The combined influence of both cavity preparation and root canal enlargement led to weakening of 62.6% under a load of 710N, ultimately causing tooth fracture.

**Conclusion** The combined finite element method and the maximum principal stress analysis gave insight into the fracture mechanisms of teeth with two-surface composite restorations followed by root canal preparation. Removal of tooth tissue, despite its subsequent restoration with dental materials, weakened the tooth by changing the stress intensity and distribution through tooth structures. Access cavity preparation had the greatest influence on tooth strength whilst canal enlargement did not contribute to this process substantially.

**Keywords:** devitalized teeth, finite element method, fracture resistance.

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## Introduction

There are various factors which may affect tooth fracture resistance; however, the influence of each particular factor remains unclear. Some authors support



























