24th ABCM International Congress of Mechanical Engineering
December 3-8, 2017, Curitiba, PR, Brazil

COBEM-2017- 1129
DEVELOPMENT AND EXPERIMENTAL VALIDATION OF A THREE-DIMENSIONAL MODEL IN FINITE ELEMENTS FOR STRESS ANALYSIS IN AN ENDODONTIC INSTRUMENT.

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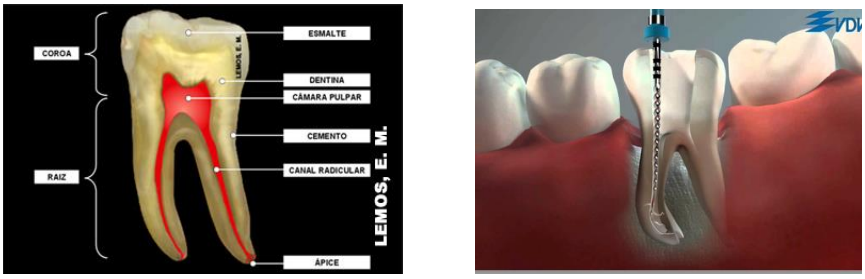
Abstract. *The Finite Element Method allows to evaluate situations involving complex geometries and loads that are difficult to find through experiments. Increasingly, it has been used in the analysis of biomechanical systems, such as instruments and dental prostheses. One of these complex situations is the endodontic treatment (canal treatment), where an instrument (file) is used to perform cleaning and shaping of the root canal. The anatomy (geometry) of the canal varies for each person and group of teeth. The instruments used must withstand different types of stresses such as shear, torsion and bending, and have the flexibility to follow the anatomy of the canal without causing deviations. Due to the difficulty of analyzing the tensions developed in the instrument during endodontic treatment, the objective of the present work was to develop and validate, through mechanical tests, a three-dimensional model of the Endodontic Instrument. Through this model it was possible to analyze the tensions developed in the instrument of different materials and for use in different anatomies.*

Keywords: *Endodontic instruments; Three-dimensional model; Finite element method.*

1. INTRODUCTION

Endodontic treatment (or canal treatment) consists of removing the pulp from the root canal in situations where it is damaged Figure 1(a). The pulp is a tissue that has nerves and blood vessels, and once it is damaged, infected or necrotic, it must be removed, and the resulting space (root canal) is cleaned, prepared and filled (sealed) Figure 1 (b). The purpose of this treatment is to avoid that this inflammation compromises the structure of the root, preventing it from spreading the contamination to the periapical tissues (around the tooth), which prevents this tooth from being extracted.



(a) (b)

Figure 1: (a) Representative design of dental structures; (b) Representation of the preparation and cleaning phase of the root canal

During the cleaning and enlargement of the canal through the biomechanical preparation, the maintenance of the original canal shape and position of the apical foramen are essential factors for success in endodontic treatment (Lopes et al., 2008). Currently, continuous rotation nickel-titanium instruments have been widely used in the preparation of root canals. These instruments offer greater flexibility and cutting efficiency (Peters, 2004; Schafer et al., 2004). In general, they produce fast, centralized and properly tapered preparations with lower indices of deviations (Schäfer et al., 2006; Sonntag et al., 2007).

With this, several studies have been carried out comparing these systems in relation to their effectiveness, in the possibility of reducing the working time, seeking the maintenance of the quality of the preparation. In order to meet these characteristics, systems with fewer instruments have been developed, as well as techniques that use them (Yared, 2008).

Many studies in the area of bioengineering have achieved great advances due to the use of several techniques, among them the mathematical method. One of the most used methods is the Finite Element Method (FEM). According Baiamonte et al. (1996). It is possible to evaluate the mechanical properties of the dental prosthesis system with the use of FEM, which is an accurate tool for this purpose. There are several studies that use FEM to analyze the behavior of implants, but this method does not yet have great application in the analysis of endodontic instruments, which are used to perform the canal treatment.

2. COMPUTATIONAL PROCEDURE

As complete information on the exact geometry of the instrument is not available, an image acquisition equipment was used by computerized micro-tomography (Skyscan 1174- Bruker-microCT, Kontich, Belgium), as a basis for the construction of the three-dimensional geometric model. For the treatment of acquired data, data manipulation and image reconstruction software were used, in this case Simpleware and MeshLab. For the final manipulation and creation of a three-dimensional structure, we used CAD (Computer Aided Design).

After the complete geometric construction of the endodontic instrument model, it was exported to the Finite Element software for discretization of the model and subsequent simulation of the problem. The software that will be used is ANSYS software, version 15.

The experimental data were obtained through the torsion test performed according to the standard ISO 3630-1 (1992).

The answers obtained from the two methodologies, experimental and numerical simulation were confronted. The functional characteristics of the model will then be varied in order to determine which are the most relevant for creating a reliable and accurate model.

3. RESULTS AND DISCUSSION

The instrument was scanned in a computerized micro-tomography. Using the image obtained, the instrument design was developed in Solidworks software.

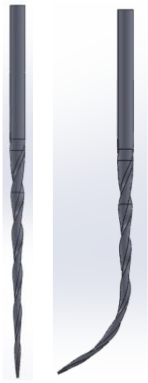


Figure 2: Image of an instrumental (file) designed in Solidworks software

Using a torsion machine, a test was performed on the instruments to obtain the curve torque by deformation or torque by angle. Through these results it was possible to verify if the three-dimensional model of the instruments was adequate.

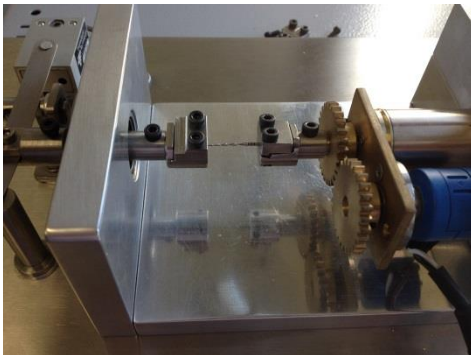


Figure 3: Image of an instrument positioned for a torsion test

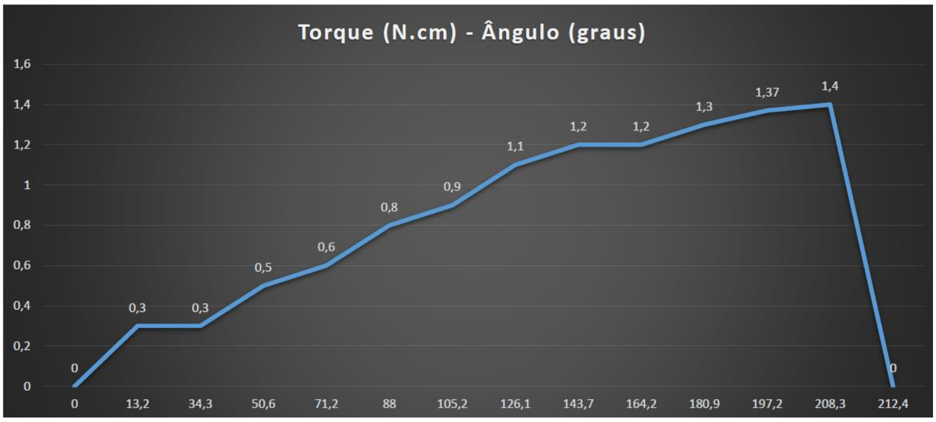


Figure 4: Image of the result of the torsion test an instrumental (file).

A three-dimensional model of the instrument was obtained using Solidworks and Ansys software.

To simulate the behavior of the instrument to the torsion test, a torque of 14 N.mm was applied in the region of larger diameter, and while the other end of the was fixed (region approximately 3 mm).

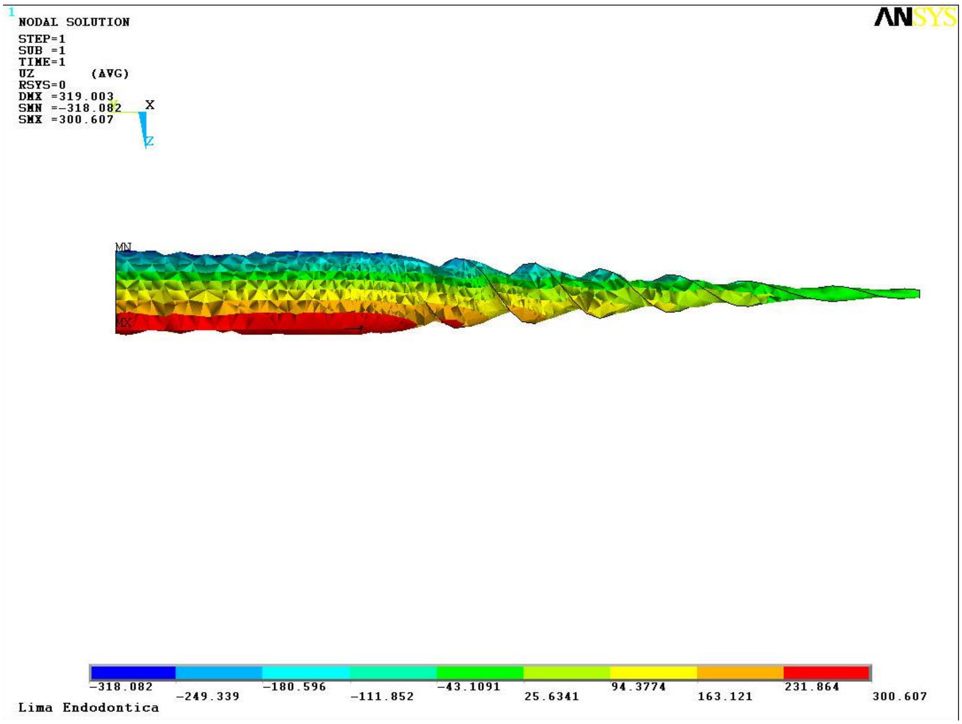


Figure 5: Result of response in rotation simulated in Ansys software.

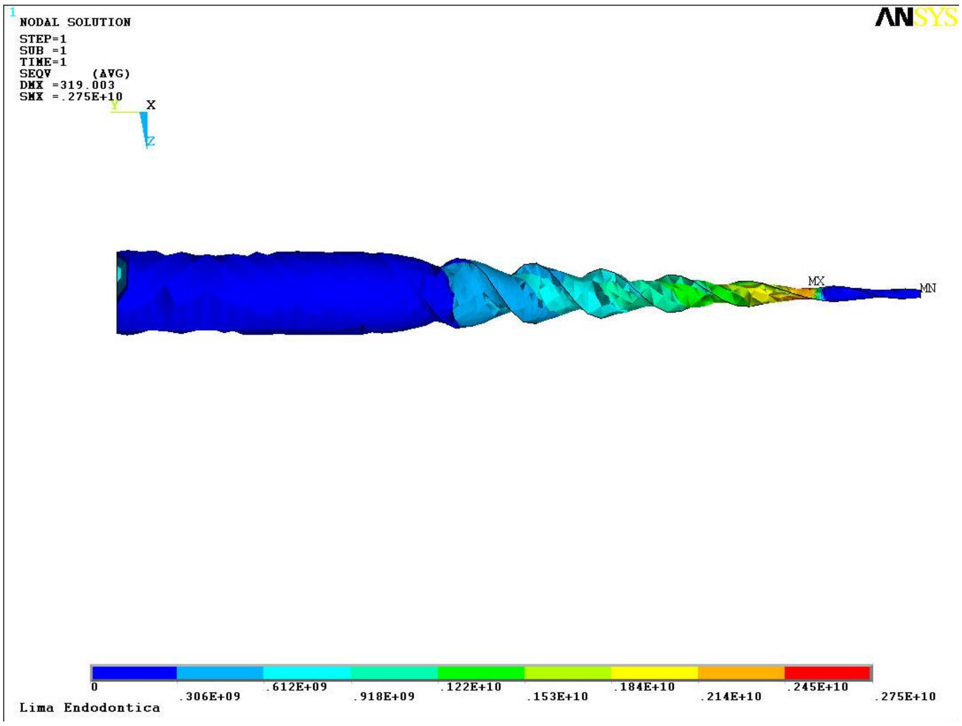


Figure 6: Result of Von Misses Stress simulated in Ansys software

4. CONCLUSIONS

Comparing the data obtained in the torsion test with the finite element model, it was possible to verify that the developed model adequately represents the behavior of the instrument. Through this work it will be possible to compare the different materials and geometries of the instruments, and to simulate the interaction between each instrument with different canal anatomy, such as bending angle, which will give us information about the resulting efforts in each situation. Knowing the efforts and behavior of the instrument, it will be possible to evaluate which is the best instrument for each condition of use, in addition to making it possible to compare the response of the tooth root to the different instruments and techniques of canal treatment.

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