3D method to evaluate different steps of endodontic therapy.

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1. Introduction

Inflamed or infected pulp very often causes a toothache. To relieve the pain and prevent further complications, the tooth must be treated by a dentist. Root canal treatment, also known as endodontic treatment, is a common dental procedure to repair and save the tooth. Each tooth has a tooth chamber and root canal or canals containing pulp which is a soft tissue with blood vessels and nerves. Shapes of these chambers and canals are very variable what makes endodontic treatment very difficult. The main steps of root canal treatment is removing vital or non-vital pulp from pulp chamber and root canal/s and shaping canal/s conically with endodontic instruments. These instruments can be used manually or mechanical with rotating or oscillating hand pieces. A good knowledge of the root canals anatomy is crucial to achieve success in this therapy [1]. Clinically the main tool to visualize root canals morphology is dental radiology. Unfortunately dental radiographs are only two dimensional pictures of very complicated three dimensional structures. The other way to visualize teeth canals morphology is a computed tomography which gives three dimensional views of diagnosed structures. However the resolution and accuracy of the method is not good enough to see all details in this field. Computed microtomography (μCT) has a very good accuracy and allows to show three dimensional models of canals system, in details. This technique cannot be used clinically because of radiation dose limits and limited size for examined object. Nevertheless μCT is a superior tool to visualize teeth anatomy in-vitro using species of extracted teeth. Moreover accuracy of this method allows to compare canals shape before and after endodontic therapy. Moreover the three dimensional root canal visualisations by means of using μCT can be considered as a perfect educational aid for dental students and dentists.

2. Methods and materials

Ten specimens of extracted human teeth were prepared and marked. All teeth after extraction were cleaned and disinfected. Access to the pulp chamber of each tooth was prepared according to endodontic standards. They were divided for two groups. Each tooth was installed in polystyrene foam blocks. A way of installation allows removing and recurrently placing the tooth at place, what ensures repetitive conditions during measurement. As an initial step each specimen was scanned by means of the SkyScan μCT scanner with the x-ray tube working at 100kV and 100 μA using an aluminium filter of 0.5mm. The samples were rotated over 180 degrees with the rotation step of 0.5 degree and the pixel size was 20μm. The visualization of the untreated root canals allows to measure the working length of the canals for following steps of root canal treatment. After that five specimens were instrumented with mechanical oscillating endodontic files and the other five with mechanical

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rotary endodontic files. Then the specimens were scanned again. Comparison of scans and visualizations before and after instrumentation was done.

3. Results and discussion

Complex inner anatomy of human teeth was shown by means of μCT (fig 1). The 3D models were created and they prove to be very useful for an immediate understanding of geometry of entire sample. Examples of projection and model created from this study data is showed in figure 1. The main canals have accessory branches. There are also connections between multiple canals in one tooth. The difference in shape of canals space before and after instrumentation can be visualize with μCT as well (fig 2). Scans show also details in shaping canals with different types of endodontic instruments as well as accuracy of canals instrumentation.

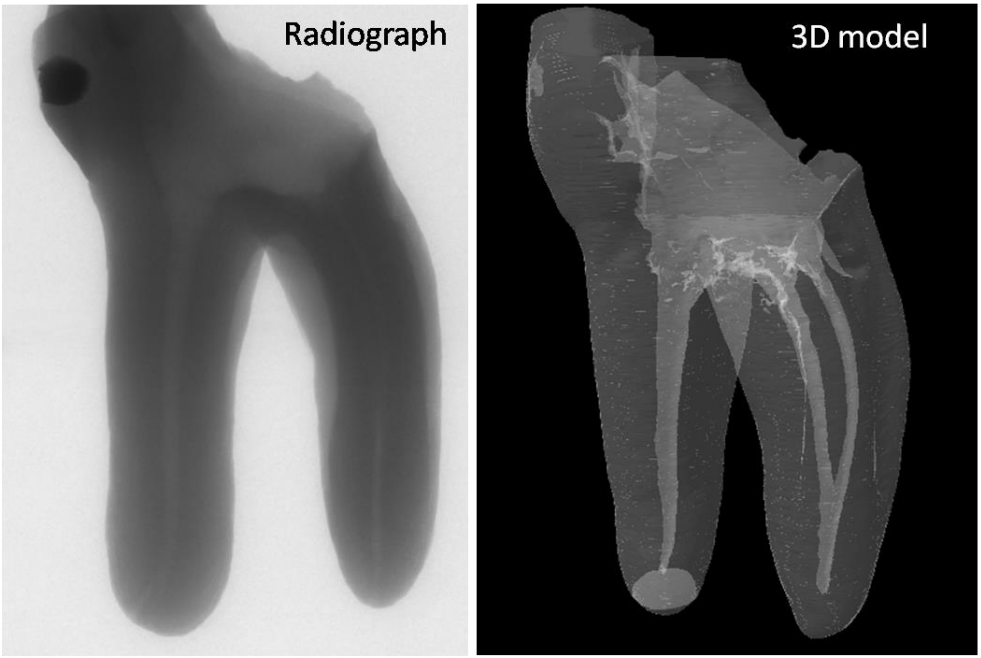

Fig. 1. The X-ray image of the tooth and reconstructed 3D model of the same sample

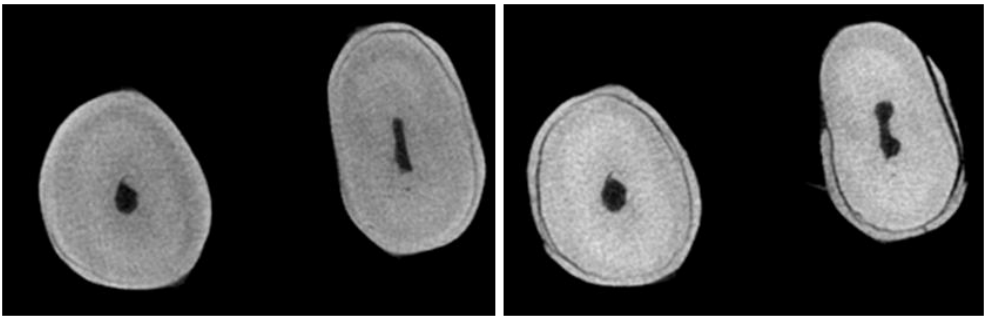

Fig. 2. The μCT cross-section images of the tooth before and after instrumentation (left and right, respectively)

There is a difference in shaping root canals with oscillatory and rotary endodontic instruments. Rotary files looks to be better fit to canals round in shape and oscillating for oval and irregular [3]. Each kind of instrument leaves some parts of canals walls untouched. That ensures the need of use a high volume dissolving and disinfecting irrigants during endodontic treatment [2]. Scans show that during the canals irrigation, using special endodontic rinsing needles, some of the debris can stay in the canals space after therapy.

Although μCT scanning cannot be used clinically it is superior method to visualize very complicated inner structure of human teeth. This tool can be used as an educational aid to help dental students and dentists to imagine how complicated system of root canals can be. Understanding of this could be crucial for proper diagnosis of endodontic problems. Moreover it can explain some cases of reinfection in canals space which can be causes by bacteria survived in untouched canals parts.

The use of μCT to analyse teeth anatomy is more accurate and less laborious than an alternative method. The teeth sectioning may create several artefacts, such as shearing, production of debris and smear layer. Moreover the μCT allows to create a digital three dimensional model of whole canals systems.

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