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ROOT CANAL SYSTEM ANALYSIS WITH A GROUP OF FIRST PERMANENT MOLARS OF UPPER AND LOWER JAW

ANALIZA SYSTEMU KANAŁOWEGO W PIERWSZYCH ZĘBACH TRZONOWYCH SZCZĘKI I ŻUCHWY

A progressive bacteria invasion on tooth tissues leads to pulp inflammation, microabscesses of the pulp, destruction and in consequence inflammation of periapical tissues. Therefore the aim of endodontic treatment is three dimensional debridement of a root canal from the vent in pulp chamber to the physiological narrowing. Therefore the aim of the study is analysis of root canal configuration, number of canals, presence of lateral canals and canal delta with the group of first permanent molars. At the same time the accuracy of the radiological examination (x-ray images) is estimated due to comprehension of X-ray images performed before teeth preparation with root canal system and after observation of transversal cuts by means of light microscopy and microtomography. This establishment is presented through the differences in conventional radiological image and clinical assessment.

Keywords: endodontics, root canal system configuration, microtomography

Postępująca inwazja bakteryjna w tkankach zęba prowadzi do zapalenia miazgi, powstawania w niej mikroropnii, zniszczenia a w konsekwencji do zapalenia ozębnej. Z tego względu celem leczenia endodontycznego stało się trójwymiarowe oczyszczenie kanału korzeniowego od jego ujścia do przewężenia fizjologicznego. Dlatego celem pracy jest analiza konfiguracji, ilości kanałów korzeniowych, istnienia kanałów bocznych oraz delty korzeniowej w grupie pierwszych zębów trzonowych stałych w uzębieniu ludzkim. Jednocześnie ocenie poddawana jest dodatkowo swoistość badania radiologicznego (zdjęcia zębowe), poprzez porównanie zdjęć rentgenowskich wykonanych przed preparacją zębów z obrazem systemu kanałowego uzyskanego na podstawie mikrotomografii oraz po wykonaniu szlifów poprzecznych i ich obserwacji na mikroskopie świetlnym. Celem tej oceny jest zaprezentowanie rozbieżności pomiędzy oceną radiologiczną systemu kanałowego a kliniczną.

1. Introduction

Endodontic treatment is a complicated procedure due to variety of root canal shapes which differ from well-known anatomical diagrams. Mostly, it is concerning a number of root canals, their route, presence of additional canals, lateral canals, connections between them which are the places of invasion of microorganisms and decrease the effectiveness of treatment [1]. This kind of morphological anomalies are often found in a group of first molars, which often need endodontic treatment (deep fissures, pure mineralization of hard tissues after the eruption and susceptibility to decay). Simultaneously in 67-70% of cases, the four or five canals are being found in these teeth [2]. In anatomical studies over 90% of upper molars indicated the presence of four canals.

Studies on morphological anomalies in first molar teeth have indicated divergence of the number of canals, observed on X-ray images and found during endodontic treatment; veracity of X-ray image with clinical status is in 48,8% of cases [3]. In the studies in vitro, destructive and non-destructive methods are being used. To the first group we can rate casting method, corrosion, capacity method, histopathological samples and grinded hard samples [2]. To the non-destructive methods, the most popular are X-ray images, digital volumetric tomography (DVT), microtomography (μCT) and MR (magnetic resonance)[4].

The present paper proposes a new strategy for reliable presentation of configuration of root canal system in a group of first human molars with special concentration on presence of additional, lateral canals, canal delta, intercanal connections, as well as estimation of precision of reproduction of these structures by X-ray images and μCT.

2. Materials and methods

The study was conducted in vitro on extracted and non-endodontical treated first human molar teeth with anatomical anomalies. The study material was divided into two groups (100 teeth): first upper molars and first down molars. After extraction the tooth from alveolar processes, it was placed in solution of alcohol and thymol (time of preserving was 6 days). Such prepared samples were taken to X-ray examination. Then microtomography and 3D reconstruction was carried out.

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Computer microtomography allows to receive flat or spatial image of the inside of the examined object. This investigation relies on multiply exposure of examined sample to X-ray beam. A beam crossing the sample is being weakened and its terminal intensity is saved by a detector. Weakening of a beam on its way to the detector depends on kind of material it is coming through. Computer microtomography gives the ability of flat or 3-dimensional inner image of examined object [4, 5]. A schematic representation of a tomography measurement system is shown in Fig. 1.

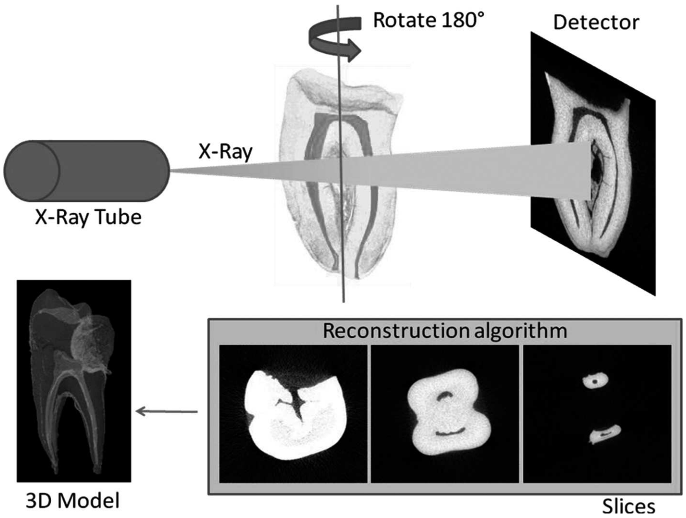

Fig. 1. A schematic representation of μCT measurement system and reconstruction process

The extracted teeth were examined by μCT on a SkyScan 1172 system. The scanner was set at 80kV and 100uA and scans were performed using a pixel size of 20 μm over 180 degrees with a rotation step of 0,5 degrees and frame averaging of 10. Aluminium filter 0,5 mm was used. Additionally, ring artifacts were reduced through selection of a random movement amplitude of 50. The images were reconstructed and analyzed using the SkyScan NRecon and CtAn software; 3D images were generated using SkyScan CTvol.

After μCT analysis, the samples were sealed in technical resin. The transversal cuts were done with metallographic grinder LABPOL- STRUERS 21 and polished by the use of polishing machine LABOPOL STRUERS. The samples were then analyzed in an optical microscope NEOPHOT 2.

The percentage comparison of precision of reproduction of root canal system obtained by X-ray images, μCT and optical microscopy was done.

3. Results and discussion

In figures 2, 4 and 6 only two canals are visible – one in mesial root and one in distal root. On sagittal cut obtained from μCT reconstruction, a buccal canal is also visible. On transversal cut from μCT two canals in mesial root are observed (buccal and lingual). Their presence was confirmed during observation under optical microscope. Moreover 3D models were created and they prove to be very useful for an immediate understanding of geometry of entire sample and of its details even if they presented a complex microscopic structure. Examples of models created from this study data are showed in figures 3,5 and 7. The 3D reconstruction confirmed presence of two canals in mesial root and connection between them in periapical area. The estimation of decay depth and its attitude to the pulp chamber was also possible.

Exploring the root canal system without surgery microscope and basing only on the X-ray image may lead to treatment failure. The results show that tooth primary classified as having two canals, has three canals when compared with μCT study (Fig. 3). Leaving even one canal untreated leads to inflammatory process of unextirpated pulp and in consequence to periapical lesions.

Moreover, the advantage of using a μCT method is that it was possible to detect the presence of canal delta in the molar teeth; 25% in the first upper molars and 80% in the first lower molars (TABLE 1). The existence of canal delta in periapical area makes total debridement of root canal system impossible and forces to use at least 5,25%NaOCl as rinsing solution to dissolve pulp tissue.

Thanks to μCT we could also recognize the places of obliteration in root canals which complicate reaching the working length. It is very useful during treatment in making decision of eventually resection of a root instead of using ultrasounds to obey this obstacle (possible only in cases of partial obliteration).

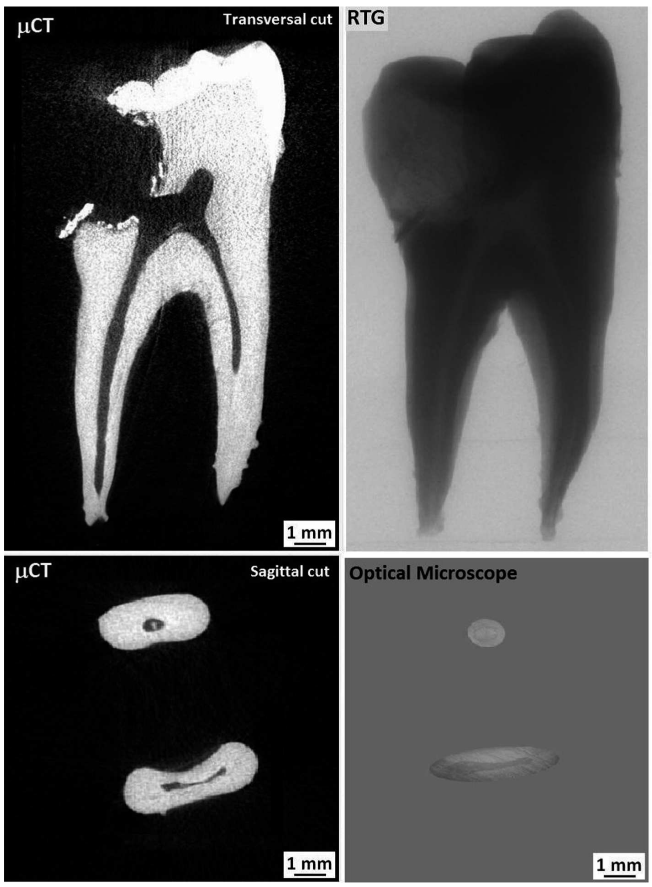

Fig. 2. The images of canal system of first mandibular molar observed by X-ray image, microtomography and optical microscope

In Fig. 3, the three canals are visible: one in distal root and two in mesial root. Connection between them has also been revealed.

Fig. 3. The 3D model of the root canal system of the sample presented in Fig. 2. The additional canal is marked by arrow

Fig. 5. The 3D model of the root canal system of the sample presented in Fig. 3

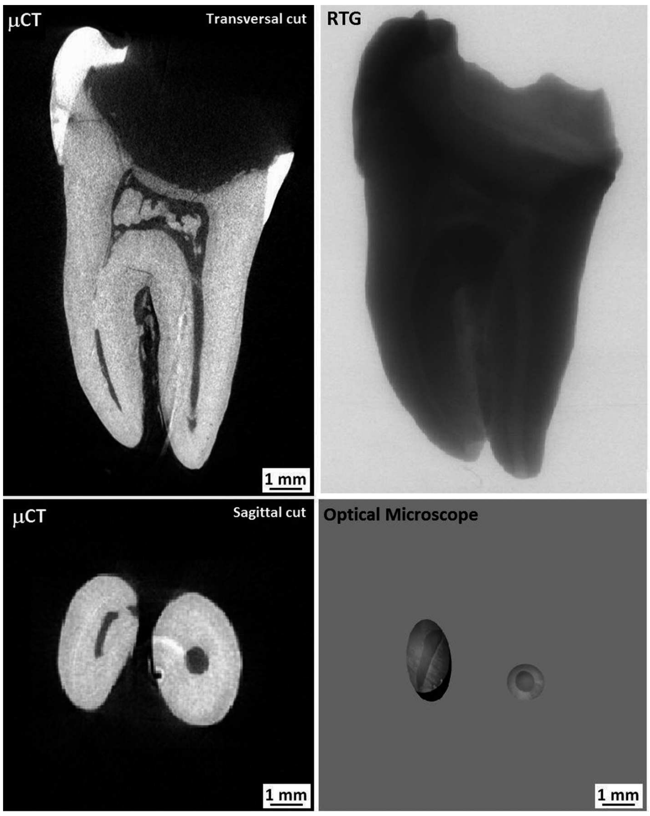

Fig. 4. The images of canal system of first mandibular molar observed by X-ray image, microtomography) and optical microscope

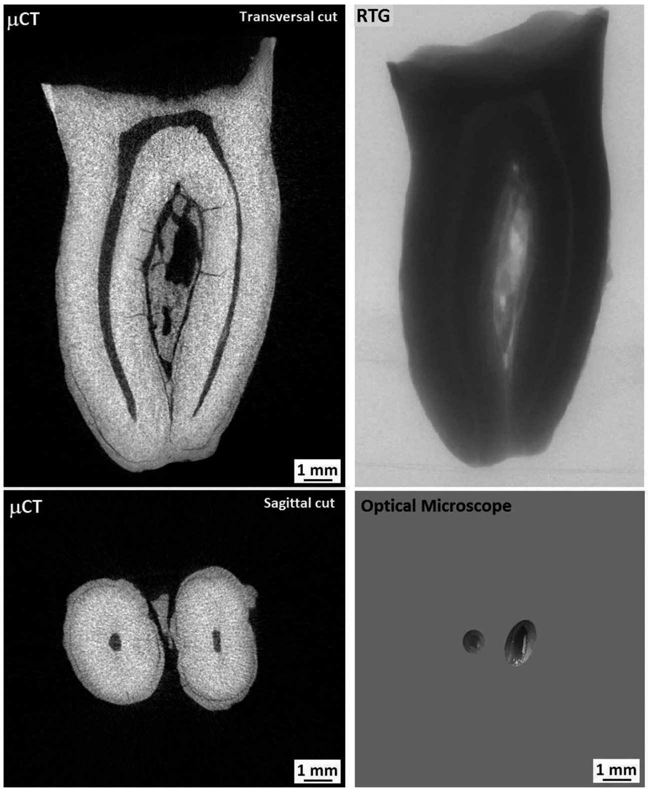

Fig. 6. The images of canal system of first mandibular molar observed by X-ray image, microtomography optical microscope

In Fig. 5, the two canals are visible: one in mesial root and one in distal. The mesial root canal delta is visible in periapical area.

In Fig. 7, the two canals are visible: one in mesial and one in distal root. The presence of canal delta in both canals has also been observed.

Fig. 7. The 3D model of the root canal system of the sample presented in Fig. 6

Anatomical anomalies such as presence of lateral canals, canal delta, intercanal connections are more often seen in first lower molars (TABLE 1). This complicates the measurement of working length and forces to use the thermal methods of obturation. Due to TABLE 1 presence of lateral canals in upper molars is higher than in lower molars (upper molars 45%, lower molars 56%). Additional canals is higher in upper molars (upper molars 50%, lower molars 45%). Canal delta is also higher in first lower molars (upper molars 25%, lower molars 80%) and intercanal connections is higher in lower molars (lower molars 46%, upper molars 35%). Presence of these anatomical anomalies complicates treatment due to problems with their debridement and if they are left untreated leads to inflammatory process.

TABLE 1

Anatomical anomalies detected by μCT

Anatomical anomalies	First upper molars	First lower molars
Presence of lateral canals	45%	56%
Presence of additional canals	50%	45%
Presence of canal delta	25%	80%
Presence of intercanal connections	35%	46%

The observation of anatomical anomalies using different methods shows that no canal delta neither intercanal connections are visible on X-ray image (TABLE 2). Also the percentage of additional and lateral canals, observed by means of μCT, is more significant. The detection capability of additional canals and lateral canals is higher on μCT then on tradional X-ray image. Presence of canal delta and intercanal connections was revealed only by μCT and three dimensional imaging.

TABLE 2

Percentage comparison of anatomical anomalies detected by X-ray images and μCT

Anatomical anomalies	X-ray	μCT
Additional canals	5%	70%
Lateral canals	2%	75%
Canal delta	-	65%
Intercanal connections	-	50%

4. Conclusions

In this study the use of micro-CT was introduced as innovative method to describe a configuration of root canal system in the non-endodontical treated first human molar teeth. This initial study of 3D teeth geometry has proven that micro-CT is a valid tool to investigate the root canal system. Considering the limitations of the present study, although micro-CT analysis is more precise in reproduction of root canal geometry than traditional X-ray images which results in finding more additional, lateral canals and canal delta, it cannot be used in examination of patients.

However the micro-CT might be useful during development of new generation of endodontic files and filling materials as well as treatment methods.

For instance, result of this study shows that the complex structure of root canal system indicated on its superficial debridement forces to use the rinsing solutions (1-5,25% NaOCl(sodium hypochlorite), 3%H_2O_2, CHX(chlorhexidine)).

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