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QUALITY OF ROOT FILLINGS PERFORMED WITH FOUR ROOT FILLING TECHNIQUES. AN IN VITRO STUDY USING MICRO-CT

ЕВАЛУАЦИЈА НА ЧЕТИРИ ТЕХНИКИ НА ОБТУРАЦИЈА НА КОРЕНСКИТЕ КАНАЛИ НА ЗАБИТЕ СО ПОМОШ НА МИКРО-КОМПЈУТЕР ТОМОГРАФИЈАТА. ИН ВИТРО СТУДИЈА

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Abstract

The main aim of the endodontic therapy consists of the tridimensional obturation of the endodontic space. The efforts for an ideally processed and sterilized root canal are questioned if the same is not obturated completely. The aim of this paper is to evaluate and determine the percentage of the volume of empty spaces and spaces of root canals obturated with different materials for obturation with the help of a microcomputer –tomography. This paper includes 80 frontal human extracted teeth. The teeth were divided in two bigger groups according to the technique of processing of the root canal: The first group consisted of 40 human single root teeth processed according to the standard technique of processing and obturated with gutta-flow and Thermafill. The second group consisted of 40 human single root teeth processed according to the ultrasonic technique of root canals processing and obturated with single cone and lateral compaction technique. Statistically significant differences have been registered between the root canals obturated with Thermafill and the Single cone technique ($p<0.05$). Statistically significant differences have been registered between the root canals obturated with GuttaFlow and the Single cone technique ($p<0.01$) and the Single cone and the technique of lateral condensation ($p<0.01$).
Key words: Root canal obturation, materials, techniques, micro-CT.

Апстракт

Главната цел на ендодонтската терапија се состои во тродимензионална оптурација на ендодонтскиот простор. Напорите за идеално обработен и стерилизиран коренски канал се доведуваат во прашање ако истиот не е комплетно оптуриран. Цел на овој труд е да се оценува и одреди процентот на волуменот на празнини и простори на коренските канали обтурирани со различни материали за обтурација со помош на микрокомпјутер- томографијата. Во овој труд вклучени се 80 фронтални хумани екстрахирани заби. Забите беа поделени во две поголеми групи според техниката на обработка на коренскиот канал. Првата група ја сочинуваа четириесет хумани еднокорени заби обработени според стандардна техника на обработка и оптурирани со Gutta-Flow и Thermafill. Втората група ја сочинуваа четириесет хумани еднокорени заби обработени според ултрасоник техниката за обработка на коренските канали и оптурирани со single cone и техниката на латерална кондензација. Евидентирани се статистички значајни разлики измеѓу коренските канали оптурирани со Thermafill и single cone техниката($p<0,05$). Статистички високо значајани разлики се евидентирани измеѓу коренските канали оптурирани со GuttaFlow и single cone техниката ($p<0,01$) и single cone и техниката на латерална кондензација($p<0,01$). Клучни зборови: канална обтурација,материјали, техники,микро-ЦТ.

Introduction

The success of the endodontic therapy depends on the complete chemical and mechanical processing of the canal system of the root of the tooth, followed by an obturation of the root canal[1,2,3].

The main aim of the endodontic therapy consists of the tridimensional obturation of the endodontic space. The efforts for an ideally processed and sterilized root canal are questioned if the same is not obturated completely[26,85].

An ideal obturation would be considered as such if the canal obturation manages to close the side openings of the dentin canals, foramen apical and the entrance of the root canal, i.e. the root canals obturated with a thick filling which reaches 2 mm to the x-ray tip of the root.

The empty places which would remain between the canal filling and the wall of the canal, as well as the air

bubbles inside the material for obturation, may contain these bacteria or create a path which will enable the bacteria or their products to break through to the paradontal tissue and reactivate the inflammatory processes.

The ideal obturation has to prevent their entering in the periapical tissue i.e. disable the conditions for their further development[4,3].

The materials used for obturating the endodontic space do not satisfy their aim according to their characteristics. This is confirmed by the fact that although there are numerous materials for obturation of the root canals further efforts are made to discover material with better performaces[5,1,6].

Thermafill is a method for obturation of the root canals by using warm gutta-percha. Even before 1883 the author Perry used spiked golden wires covered in soft gutta-percha for root canals obturation.

Single cone - technique was developed in 1960 by standardizing the endodontic instruments. The aim of this method is after preparing the apical part of the root canal to be covered with a thin layer of cement and gutta-percha, silver or titanium cone is placed in the tooth canal.

The method for canal obturation called lateral condensation is considered to be safe, cheap and suitable to work.

The method consists of laying the inner walls of the root canals with cement by using a lentulo spiral, thin needle or an ultrasonic system and master cone gutta-percha placed on the determined root length.

GuttaFlow®2 and GuttaFlow®2FAST is a liquid cold system for canal obturation which combines cement and gutta-percha in one unique product. The system consists of matrix of polydimethylsiloxane filled with small gutta-percha.

The aim of this paper is to evaluate and determine the percentage of the volume of empty spaces and spaces of root canals obturated with different materials for obturation with the help of a microcomputer - tomography.

Material and method

This paper includes 80 frontal human extracted teeth which have curves on the root canal smaller than 10 (degrees) selected according to the technique Schnider.

The experiment does not include teeth with underdeveloped roots, with obturated root canals and caries on the root of the tooth.

After the extraction, the teeth were rinsed with saline to remove the blood and were kept in artificial saliva. The teeth are de-crowned with a diamond borer 1 mm above the enamel-cement border to achieve the length of the root of 12 mm.

Determining the length of the root canals of the teeth has been made using an instrument no.10 placed in the root until you see the tip of the instrument in the apex of the root canal.

As exact length the length 1mm smaller than the length determined by the instrument is taken.

The teeth were divided in two bigger groups according the technique of the processing of the root canal:

1. The first group consisted of 14 human single root teeth processed according to the standard technique of processing.
2. The second group consisted of 14 human single root teeth processed according to the ultrasonic technique of root canals processing.

First group - After determining the exact length of the root canals the teeth from this group were processed according the technique described by Ingle (1961). The canals were irrigated with 2ml NaOCL 5% (Produites Dentares SA, Vevey, Switzerland) and dried with paper pins (PRESIDENT DENTAL, Duisburg,Germany).

This procedure is performed until the root canal gets the determined form and has no smell and leftovers of the pulp tissue.

The root canals from the first group are divided in two subgroups according to the obturation technique.

For the obturation of the root canals from the first subgroup we used the material GuttaFlow®2 (Coltene/Whaledent GMBh+Co.KG, Langenau, Germany).

The root canal in the second subgroup is laid with AH-Plus ®JET™ paste (Densplay De Trey GmbH, Kostanz, Germany) and obturated with Thermafill system (Densplay DeTrey GmbH, Konstanz, Germany).

The second group - the root canals from this group were processed using ultrasonic crown-down technique according to Greka et al. (2007). We started the instrumenting with a hand widener size 40 K-file adjusted to the ultrasonic device (Zhengzhou Smile Dental Equipment Co, Ltd. China) in the period of 1 min. During every change of instrument, we rinsed the root canals with a 5% NaOCL and dried them with paper pins. The root canals were divided in two subgroups. The root canal from the third subgroup was obturated with a paste AH-Plus® JETTM (Densplay De Tray GmbH, Kostanz, Germany) with the help of a lentulo spiral, and the root canal was set with only one gutta-percha (Coltene/Whaledent GmbH+Co.KG).

The root canals of the teeth in the fourth subgroup were obturated with the technique of lateral condensation. The walls of the root canals were laid with AH-Plus® JETTM paste (Densplay De Trey GmbH, Kostanz, Germany) with the help of a lentulo spiral.

Micro-computer tomographic method

The samples were measured in a commercially available cabinet for cone beam micro-CT, (μCT 35, SCANCO Medical AG, Brüttisellen, Switzerland).

The examination samples were wrapped in a piece of sponge 2 x 3 cm and placed in special test tubes with artificial saliva. The test tubes were then placed in a scanning machine and the machine was started. We placed five samples at a time.

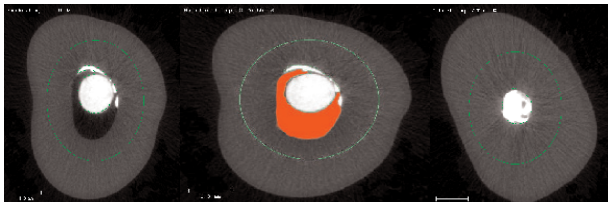
The machine works with a cone beam starting from 7 μм from the point of the x-ray tube. The photons are detected with a CCD-based space detector and the projection data is reconstructed by a computer in a 900 x 900 matrix picture.

The chosen size of the voxel is 20 μм in all three space dimensions.

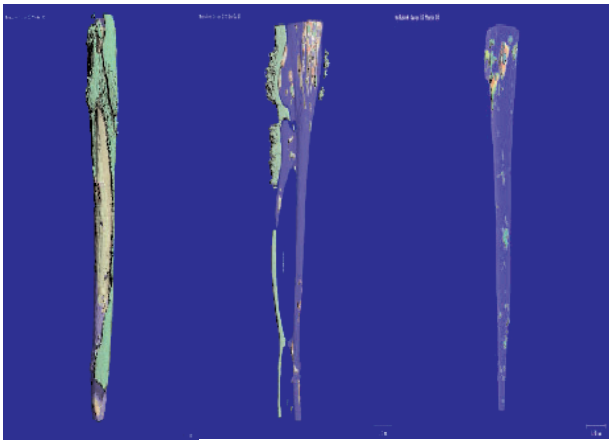
The x-ray voltage is 70kVp, intensity 114.

The empty space in the second evaluation is automatically segmented, based on the grey scale of the values in the CT-layers.

The region of interest (the filling and the empty space) is marked by contours. The script for doing the analyses started by one click on the SCANCO Evaluation program. (picture 20)



Picture 1. *Grey scale of the values of three different teeth. It shows the contours used for the second evaluation to calculate the empty space between the filling and the tooth. The inner contours exclude the volume of the filling.*



Picture 2. *3D-renders on segmented volumes of interest showing the empty space around the filling (seen colored in green)*

In the statistical analyses of the received results from the clinical study we used methods for descriptive and analytical statistical analyses.

For testing the zero hypothesis and reaching valid conclusions we used the following methods of analytics and statistics-

Statistical tests:

- Single factor ANOVA for numeric markings and observation.
- LSD- test-test of the quadrotor of the smallest differences
- Kruskal-Wallis' test
- Mann-Whitney's U test of inversion

Results

Chart 1. The percentual presentation of the empty spaces in the inner side of the canal obturation.

The chart shows the percentage of detected empty spaces in relation to the complete filling.

The statistical analyses showed: ANOVA for numeric markings of observation- F=6,725; DF=3; p<0.1 i.e. there is a statistically significant difference in the percentage of empty space between the researched groups. The smallest percentage of empty space is in 2.1 group, and the biggest in 1.1 group.

The between groups differences with the LSD-test, showed that 1.1 differs statistically significant with 1.2 and 2.1, and does not differ with 2.2.

Group 1.2 differs with 1.1 and with 2.2 and does not differ with 2.1;

Group 2.1 differs with 1.1 and with 2.1 and does not differ with 1.2;

Group 2.2 differs with 2.1 and 1.2 and does not differ with 1.1

The following chart shows the values from the complete percentage of empty spaces and spaces. Chart 2

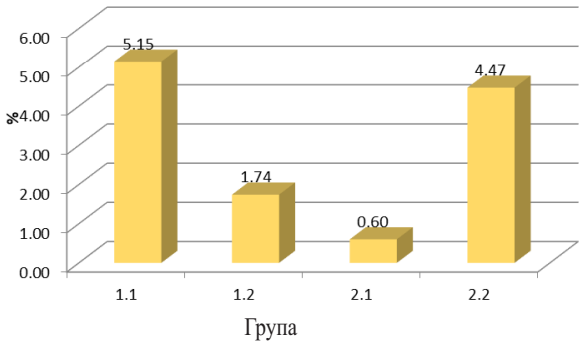


Chart 1. *The percentual presentation of the empty spaces inside the material for obturation compared to the complete filling.*

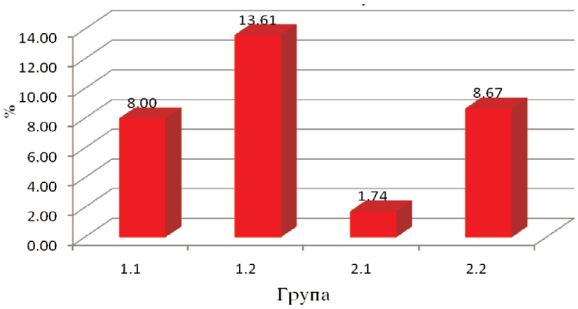


Chart 2. *The percentage presentation of empty spaces inside the material for obturation and the empty spaces in the root canal compared to the complete filling.*

The data analyses showed that a bigger percentage of empty spaces was registered in the root canals obturated with the Thermafill technique (13,61%), while a smaller percentage of empty spaces was registered in the root canals obturated with the Single cone technique.

The single factor ANOVA for numeric markings of observation showed: $F=17.8$; $DF=3$; $p<0.01$

The results show that there is a statistically significant difference in the total percentage of empty spaces in the researched groups:

LSD-tests showed that there was no statistical difference between the root canals obturated with GuttaFlow and Thermafill technique ($p>0.05$), GuttaFlow and the technique of lateral condensation ($p>0.05$) and Thermafill and the technique of lateral condensation.

Statistically significant differences have been registered between the root canals obturated with Thermafill and the Single cone technique ($p<0.05$).

Statistically significant differences have been registered between the root canals obturated with GuttaFlow and the Single cone technique ($p<0.01$) and the Single cone and the technique of lateral condensation ($p<0.01$).

Discussion

A great number of factors might influence the success of the endodontic therapy. After the efforts made to control infections, an adequately processed and obturated root canal should mean success of the endodontic treatment[21].

A well-known fact is that the hermetically sealed root canals of the tooth would mean smaller chances for postoperative complications. The empty spaces in the obturation of the root canals, in theory, might compromise the outcome of the treatment, knowing the possibilities of microorganisms staying in which may find a way to reproduce and penetrate towards the periapical tissue. All techniques, unfortunately, have a lot of registered failures because of the fact that a chemical binding of the material for obturation with the inner walls of the root canals is not achieved. All authors consider the main goal of endodontic obturation to be the prevention of micro-permeability of oral fluids which contain bacteria and their products to move from the coronary towards the periapical part and obstruct the progress of microorganisms towards the periapical space which were resistant to canal disinfection and instrumentation[22,11,5].

The empty spaces may be captured during the canal obturation. The empty spaces which do not communicate with the inner wall of the root canal named as inner empty spaces are considered as non-risk for the prognosis of the endodontic therapy because the bacteria in these empty spaces do not find suitable conditions to survive and reproduce. These empty spaces may communicate with each other and create a path to the inner wall or the periapical tissue.

The production of new materials in endodoncy is connected to technical innovations of finding techniques and materials which will contribute to bigger clinical successes i.e. satisfying all needs of the endodontic materials where the main accent will be given to the hermetic sealing of the root canal.

These new materials should be evaluated carefully[23].

The x-rays made after the treatment are a benchmark for the quality of the canal obturation and the only method to clinically evaluate the homogeneity of the obturation and the presence of empty spaces in the material for obturation[24].

Jung et al. 2005[24] evaluated the potential of the accuracy of micro-CT for the evaluation of canal obturation. The authors confirmed that micro-CT can clearly emphases the wall of the root canal.

According to the findings of all authors, there is no obturated root canal that does not have empty spaces. (Eplay 2006, Gulsahi 2007, James 2007.)[25].

This information rejects the zero hypotheses.

Our research, with the help of micro-CT scanner analyzed the presence of empty spaces in the inner space of the canal obturation. The empty spaces which started from the inside of the material and continued to the outer wall are marked as limited empty spaces.

According to the statistics data a larger percentage of empty spaces are registered in the root canals obturated with GuttaFlow 5.15%, the root canals obturated with lateral condensation 4.47%, Thermafill 1.74% and the single cone technique 0.60%.

When analyzing the total percentage of empty spaces in the material for obturation and the empty spaces between the inner wall of the root canal and the material for obturation, the larger values are from the root canals obturated with Thermafiil system, followed by the root canals obturated with Gutta-Flow and lateral condensation.

While the root canals obturated with the single cone technique gave smaller percentage values, and highly significant statistical values have been achieved.

The authors Peters (2010)[26] and Anbu (2010)[27] confirmed that the obturation of root canals obturated with the technique of lateral condensation is not homogenous and may show more empty spaces between the gutta-percha spikes. The authors state that during the lateral condensation with a widener the air may infiltrate between the spikes which creates empty spaces.

The authors also determined that the obturation with long gutta-percha where the gutta-percha is heated may more easily adapt in all irregularities of the root canal, but these techniques have also their floes. The gutta-percha when heated expands, but when it is getting cold it contracts 1-2% giving bigger empty spaces in the canal.

This finding may explain the highest percentage of empty spaces (13.6) in the root canals obturated with the Thermafill system.

The author Wu M.K. (2009)[28] explains with data the quality of the single cone technique depending on the cement amount placed in the root canal. If during the placement of the cement we use lentulo spiral, the space between the wall of the root canal and the gutta-percha pin is filled. If the obturation is made with a gutta-percha pin only laid with cement, bigger empty spaces may appear and the possibilities of fluid infiltration are bigger.

Angerame (2012)[29] by using the micro-CT system in the root canals obturated with the single cone technique concluded that the root canals obturated with the single cone technique the percentage of inner and outer empty spaces is 0.522±0896%.

The authors favor the single cone technique because of the faster way of processing it and because it can be used in different protocols when processing the canal.

The cements used during this technique and their physical properties act on the sealing possibility. AH-Plus cements have shown to be stable in dimensions and their use is recommended.

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