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RESEARCH ARTICLE

ANALYSIS OF THE ROOT CANAL APICAL THIRD OBTURATION QUALITY DEPENDING ON THE TOOTH ROOT INDIVIDUAL ANATOMY

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Abstract

Background: Up-to-date methods of root canal obturation applying gutta-percha do not provide an accurate and predictable result. The different anatomy of the root canal apical third requires the selection of an optimal method that avoids voids and high sealer content. This study compared standard and modified lateral compaction techniques in root canals with different morphologies using computed tomography.

Objective: To come up with an optimal method for filling the apical third of the root canal, considering its anatomical structure and to evaluate the quality of obturation using the computed tomography method.

Materials and methods: The research was performed on 46 root canals of extracted teeth. All teeth were divided into two groups depending in the obturation technique used. The study included a lateral compaction technique with modification in oval-shaped root canals, followed by control using computed tomography.

Results: Basing on the study, it has been revealed that even at the stage of computed tomography it is possible to plan the most appropriate method of root canal obturation, depending on their shape.

Conclusion: To increase the endodontic treatment efficiency it is necessary to take into account the individual anatomical and morphological structure of the root canals. Root canals that have an oval shape in the apical third may require an obturation technique different from a standard one.

Keywords: *endodontic treatment in genera; cone beam computed tomography; lateral compaction method; apical part of the root canal.*

Introduction

Complicated forms of caries remain a common pathology, its treatment requires the dentist to have certain knowledge, skills and materials. Owing to the variability of morphology and bends of the root canal apical third is the most clinically significant, the errors there are often made during instrumentation that can have a negative impact on the subsequent stage of obturation and the outcome of endodontic treatment in general.[1]

Gutta-percha pins are known to have a circular shape that cannot ensure effective filling of the root canal apical part with a non-standard oval or other shape.

The round cross-section, tapered root canal is believed to be rare. Thus, the prevalence rate of oval or slit-shaped root canals in the apical third amounts to about 25%, and in some groups of teeth that indicator reaches 50%.[1,2]

It is recommended to use solid pins only in root canals that have a certain taper, since when used in root canals of irregular shape, it leads to the formation of voids or large volumes of endodontic sealer tending to dissolve over time.[1,3]

With atypical morphology of the apical third, the difficulty of obturation lies not only in the unsuitable shape of the gutta-percha pin for a given root canal, but also in the difficulty in using the filling method. Thus, another problem that arises during the obturation process is the inability to advance the instrument for compaction to the apical stop, hat may result from the irregular shape and taper of the canal.[1]

The most optimal methods today involve gutta-percha pins for obturation. Each of them has its own advantages and disadvantages. For example, when using the “single pin” method, even when using calibrated conical gutta-percha pins, defects in filling the lumen of the root canals are detected in 67% or more of the analyzed sections.[4] The frequently used lateral compaction method reliably obstructs the root canal and allows the use of less sealer.[5,6]

However, it may require more appointment time compared to other methods. The vertical compaction technique requires the use of special equipment and makes it possible to obtain gutta-percha in the form of a homogeneous and size-stable mass facilitating the penetration of the material into the branches of the root canal system.[7] Even if filling root canals with thermoplastic gutta-percha gives excellent results, it is still a difficult task with oval-shaped canals in the apical zone.

In some researches the hybrid obturation technique (a combination of lateral and vertical compaction) demonstrated the best quality of filling the root canals of “laboratory” teeth: defects in filling the canal were revealed only in 7.5% cases.[8] Some studies found that the total void amount in the group of teeth with oval root canals where the hybrid technique was used was significantly lower than that in the groups where Guttacore and the single post method were used.[9]

Gutta-percha on a carrier is another method of filling root canals (Gutta Core, Thermafil systems). However, if the technique is not followed, the heated rod may “lose” gutta-percha when entering the root canal. Thus, an empty carrier ultimately reaches the apical section, and the root canal itself remains unevenly sealed, and endosealant being removed into the periapical fabrics is highly probable.

The advent of cone-beam computed tomography in endodontics[9] enabled assessment of the complexity of dental anatomy and the quality of their treatment.

The X-ray beam in this study is cone shaped. As the radiation source and receiving sensor rotate, multiple short exposures are performed. The result is a clear spatial image, without overlapping anatomical structures, without object distortion and measurement errors in the vertical and horizontal directions.[10,11]

Thus, the choice of a method for filling the apical third of the root canal remains undefined, and often depends on the anatomical structure, clinical situation, equipment of the dentist and the quality of radiological control.

Objective: to come up with an optimal method for filling the apical third of the root canal, considering its anatomical structure and to evaluate the quality of obturation using the computed tomography method.

Materials and methods

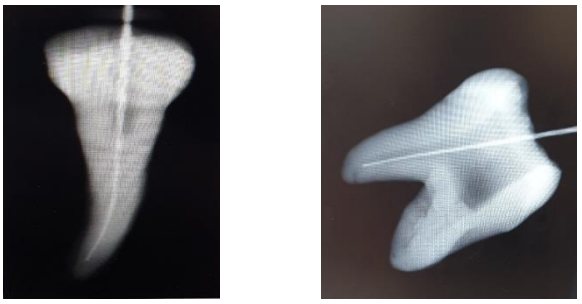
The research was performed on 46 root canals of extracted teeth. The study was performed on extracted teeth of different groups that had been washed with running water, cleared of soft tissue and placed for 3 hours in a 1% sodium hypochlorite solution, followed by the washing with distilled

water.

The preparation technique for 46 root canals that had not previously undergone endodontic treatment included ensuring access to the tooth cavity and measuring the length of each canal by inserting a size 15 K-file (MANI, Japan) so that the tip of the file remained visible in the apical foramen (Figure 1). The working length was set at 1 mm shorter than this point. Mechanical treatment of root canals was performed using steel K- and H-files using the Step-back method. Preparation to working length was completed with a K-file of at least size № 30. The root canals were irrigated with 10 ml of 3% sodium hypochlorite solution after changing each instrument. Then, final irrigation was performed with 3% sodium hypochlorite and distilled water, followed by drying with paper points (Dispodent, USA).

A two-component (paste-paste) Viedent epoxy resin-based sealer (VladMiVa, Russia) was used as an endosealant for filling. Filling was performed by a lateral compaction technique. A gutta-percha master pin (Dispodent, USA), corresponding to the size of the apical ledge, with a small amount of sealer applied to its surface, was inserted into the root canal to its full working length. Then lateral compaction was performed using an endodontic spreader (MANI, Japan), the canals were filled with additional gutta-percha pins sized 15 and 20 (02) tapers. If the apical third of the root canal was oval, then the first additional pin was inserted to the same full working length as the master pin.

Filled teeth were divided into 2 groups. Group No. 1 consisted of teeth with presumably oval-shaped canals in the apical area, in which both the master pin and the first additional pin were installed to their full working length. In group No. 2, the additional pin was inserted at a shorter length than the master pin. Filling continued till the root canal lumen was completely obstructed. The homogeneity of the filling was assessed using x-ray control (Figure 2). If the slip image reveals the heterogeneous obturation, the tooth was not included in the study and was replaced with another one.



a **b**

Figure 1 (a, b). *X-ray control of chemomechanical dental treatment*

a **b**

Figure 2 (a, b). *X-ray control of root canal obturation*

To assess the quality of obturation, the computed tomography method was chosen. X-ray examination of the samples was performed using a VATECH PAX-I3D computed tomograph (South Korea). Both tooth groups were fixed in plasticine in such a way as to fall within the image area, then computed tomography was performed (Figure 3).

a **b** **c** **d**

Figure 3 (a, b, c, d). *Two groups of teeth fixed in plasticine for computed tomography*

Research data is displayed in specialized software Ez3D-i V4.3.0 from Vatech. This application visualized measurement of two perpendicular diameters of the obturated root canal at a distance of 1 mm from the sealed area of the apical cross-section. On the sagittal snapshot, a ruler marked 1 mm from the obturated apex, then diameters were measured at this level in the axial cross-section. Two diameters could be equal in length to each other, then the canal was considered to be circular in cross-section. If one diameter was larger than the other, then the canal was considered oval. We studied the correspondence of teeth with an oval root canal shape in the apical area on computed tomography and teeth in which obturation with both the master pin and the first additional pin was performed to the full working length (Figures 4, 5)

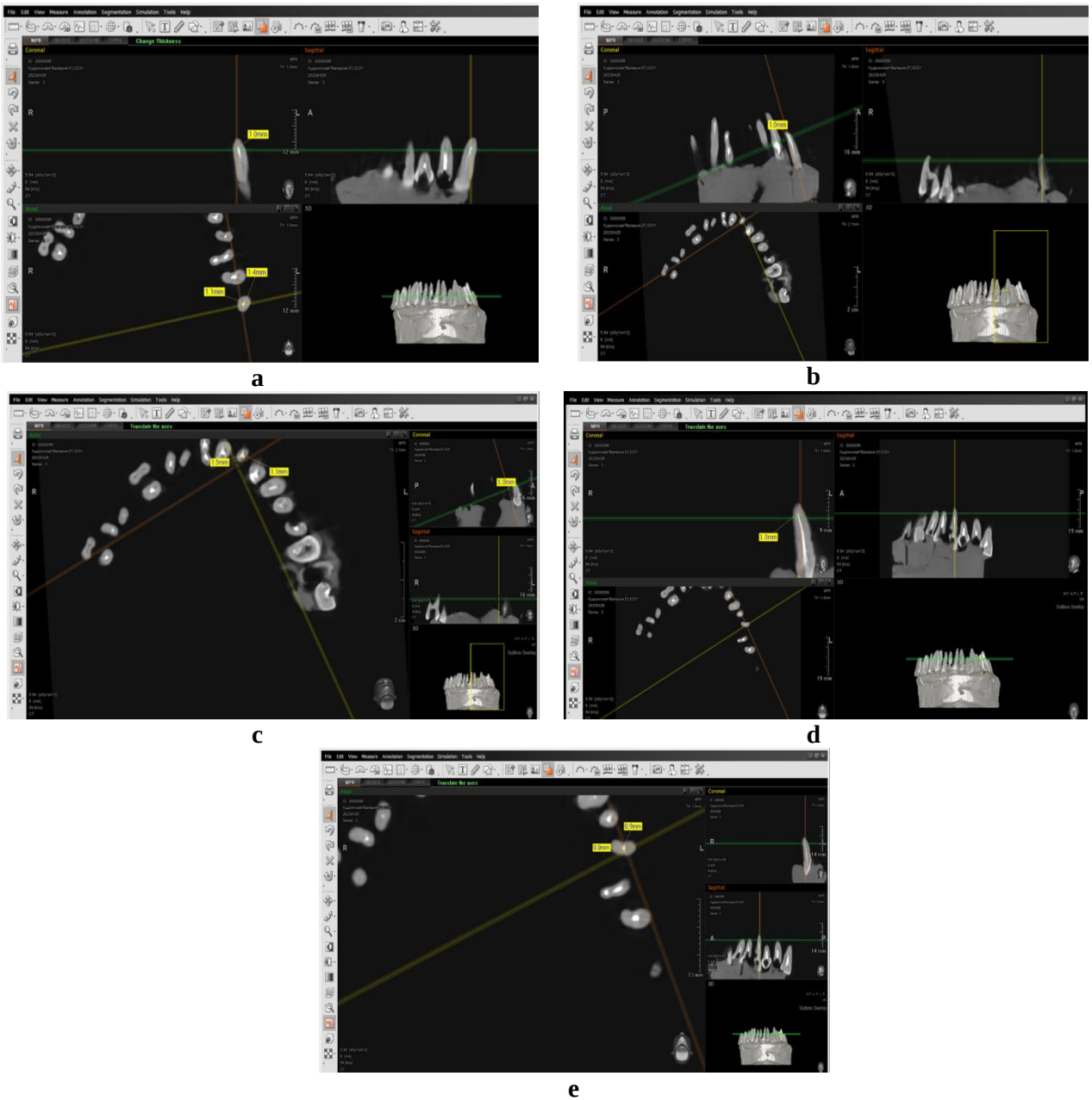
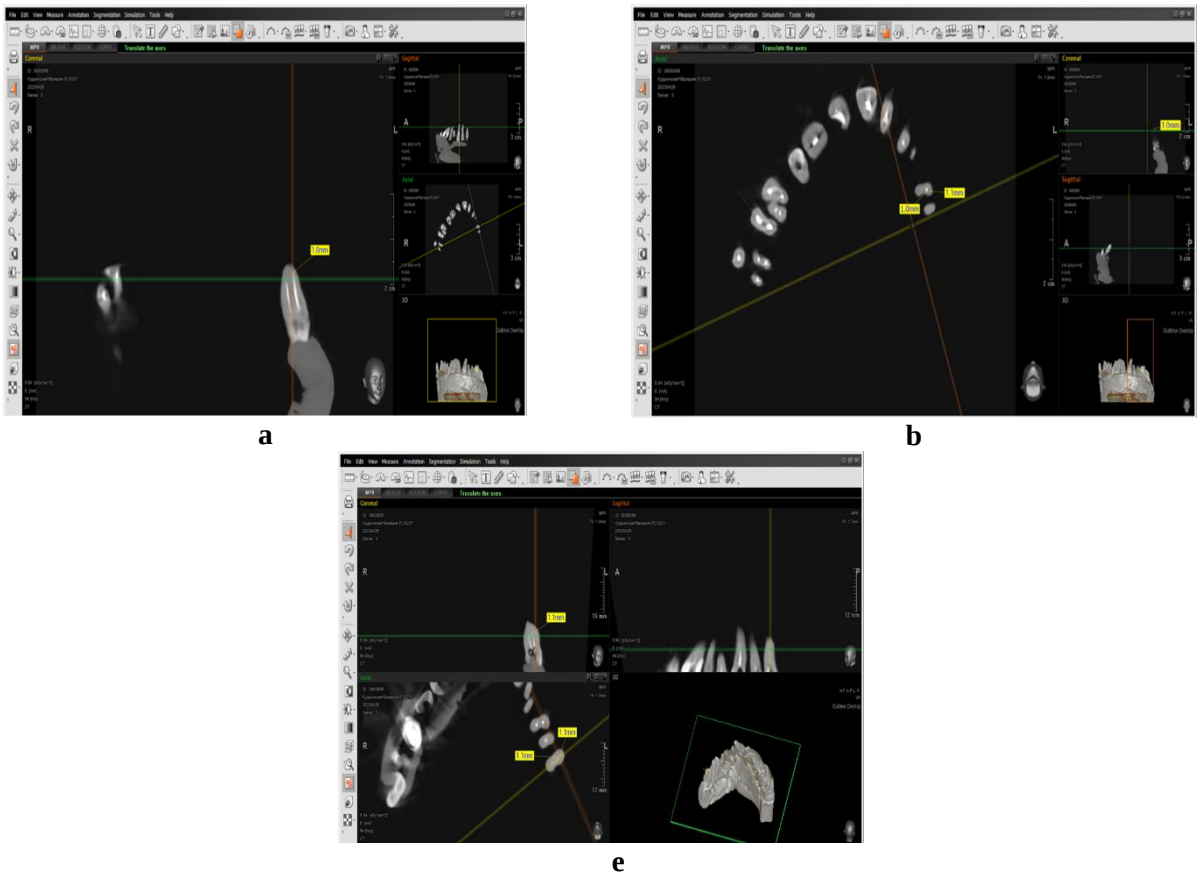


Figure 4 (a, b, c, d, e). *Measurements of a tooth group with two pins at full working length in the Ez3D-i application*



a **b**

e

Figure 5 (a, b, c). *Measurements of a tooth group with one pin at a full working length in the Ez3D-i application*

Statistical analyses were performed using SPSS (SPSS 25.0, IBM). P values < .05 were considered statistically significant. Differences between observation periods were checked using the paired Student test.

Methods of statistical processing: statistical processing of data was performed in order to identify the obtained patterns in the research data. The correlation between the studied characteristics was displayed in a form of diagrams, diagrams and statistical tables. To establish a pattern among the results obtained, correlation analysis was used. Resorting to correlation analysis, one can reliably judge the statistical relationships that exist between variables. Multiple linear regression was performed to analyze the correlation between the difference in root canal diameters and the obturation method used.

A general linear regression equation looks like this:

$$У = a0 + a1x1 + \ldots + акхк$$

In this formula, Y means the variable on which the effect of factors is being studied. This study examines a root canal obturation method. The value of x is the various factors that influence the variable. Parameters are regression coefficients; they reflect the significance of a particular factor. The index k denotes the total number of these factors.

Results

The obtained results were entered into calculation tables, and then the data obtained by means of statistical processing - correlation analysis with multiple linear regression is presented in Table 1.

Table 1. *Results of statistical processing*

Regression statistics	
Multiple R	0,855178
R-square	0,731329
Standardized R-square	0,725223
Standard error	0,258655
Observations	46

In given study, the multiple R was equal to

0.855178, indicating a fairly strong linear correlation between the obturation technique performed and the specific root canal shape in the apical third as visualized on CT. The coefficient of determination value is 0.731329, indicating that one can explain 73.13% of the variance in obturation methods by the difference in diameters on the axial computed tomography snapshot. It allows concluding that there is a high degree of correlation. Based on the analysis data, a scatter plot was constructed (Figure 6).

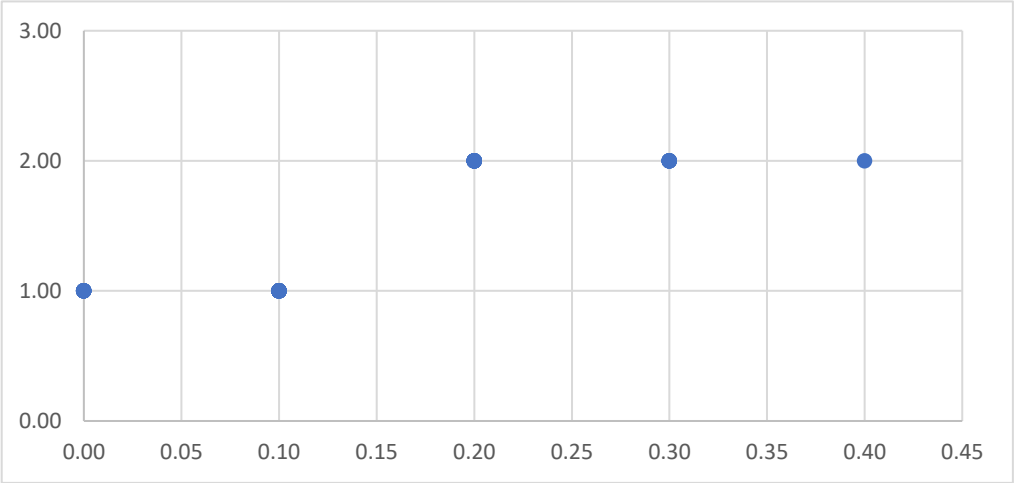


Figure 6. *Correlation between diameter difference and suitable obturation*

One can make a conclusion that if the difference in the diameters of the root canal on the axial cross-section of computed tomography exceeds the first additional pin stands by 0.2 mm at the same length as the master pin. Therefore, one can consider such root canals to be oval.

Of the 46 root canals, 18 had an oval shape in the apical area that accounted for 39.1%.

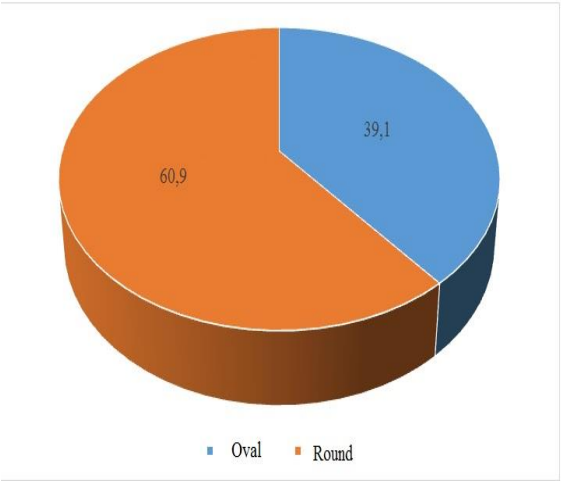


Figure 7. *The ratio of oval and round shapes of root canals in the apical cross-section (%)*

Among the root canals with an oval apical section, 11 canals had a difference in diameters measured in the Ez3D-i application of 0.2 mm, 6 canals had a 0.3 mm difference, and one canal had a 0.4 mm difference (Figure 8).

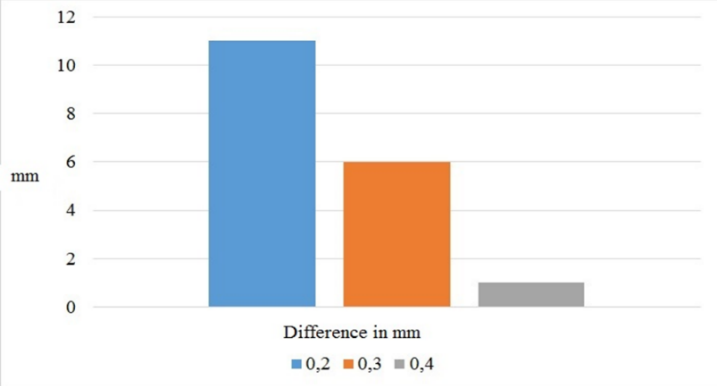


Figure 8*. Distribution of the number of canals depending on the difference in diameters*

Among the 20 studied teeth of the mandible, the oval canal in the apical area was found among 1 incisor (5%), 6 canines (30%), 4 premolars (20%) and 1 molar (5%) (Figure 9).

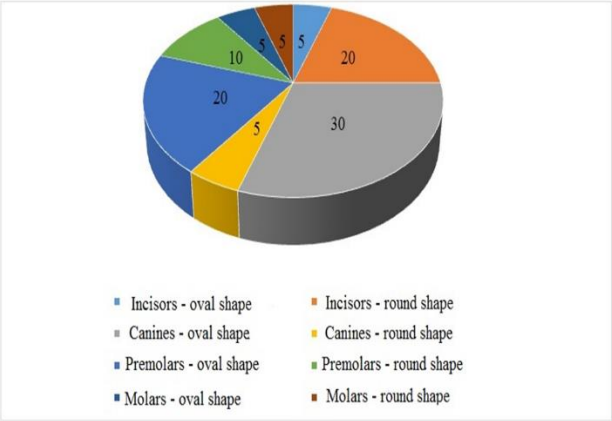


Figure 9. *Correlation of different mandible tooth groups with oval and round canal shapes in the apical area (%)*

Among 10 teeth of the maxilla, an oval shape of the apical area was detected in 1 premolar (10%) and 2 molars (20%) (Fig. 10).

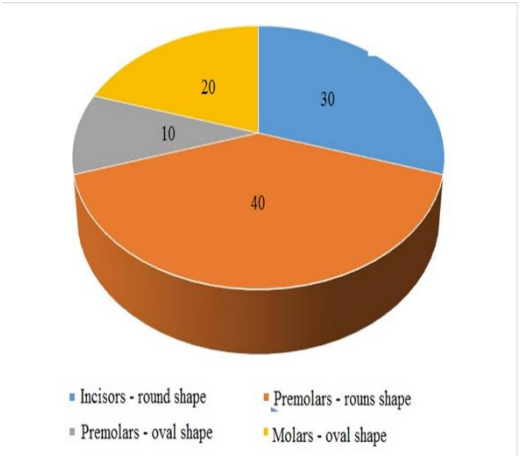


Figure 10. *Correlation of teeth in different groups of the maxilla with oval and round canal shapes in the apical area (%)*

Discussion

The hermeticity of the obturation is the key to successful endodontic treatment. A high degree of hermeticity helps to prevent re-infection of root canals and avoid the need for re-treatment of the tooth. To increase the efficiency of endodontic treatment, it is necessary to consider the anatomical and morphological features of the root canal structure.[12] Canals that are oval in the apical third may require an obturation technique different from a standard one. When filling a tooth root canal using gutta-percha pins, the lateral compaction method is one of the most preferred. An important feature of this method is the ability to perform high-quality filling of root canals of various morphologies.[13]

The work involved obturation of 46 tooth root canals using the lateral compaction method. With measuring the root canal in an axial area, the study involving computed tomography has revealed a difference in two perpendicular diameters affecting the shape of the root canal in the apical area, and reliably predicted the optimal obturation technique. Statistical processing using correlation analysis with multiple linear regression revealed a high degree of correlation between the obturation technique performed and the specific shape of the root canal in the apical third. If the difference in the diameters of the root canal on the axial section of computed tomography amounts to more than 0.2 mm, the first additional pin stands at the same length as the master pin. One can consider such root canals to be oval and it is recommended to use a modified lateral compaction technique. Thus, when performing a computed tomography scan, measurements of the apical area on an axial section can help make a choice in favor of this obturation technique when identifying an oval tooth canal shape. We should not forget that the outcome of endodontic treatment also depends on the use of an effective irrigation protocol and high-quality instrumentation.

A computed tomography-based comparative analysis of the root canal obturation quality using the lateral compaction method confirms that in oval-shaped canals in the apical cross-section, one has to insert a spreader to the entire working length near the master pin, and an additional pin to the same length. Round-shaped canals are filled using standard methods.

A computed tomography-based study with measuring the root canal in an axial cross-section has revealed a difference in two perpendicular diameters, which can affect the shape of the root canal in the apical area and reliably predicted the optimal obturation technique.

Computed tomography of axial cross-sections of the apical third of root canals allows visualizing complex morphology and helps the dentist to obstruct anatomically complex canals in a simple and accessible way as ergonomically and efficiently as possible.

Conclusions

To increase the endodontic treatment efficiency, it is necessary to take into account the individual anatomical and morphological structure of the root canals. Root canals that have an oval shape in the apical third may require an obturation technique different from a standard one.

Declarations

Conflicts of interest and financial disclosures

The author declares that he has no conflict percent and there was no external source of funding for the research in question.

Ethical approval

The study was approved by the University ethics committee and was conducted in accordance with the Declaration of the World Medical Association.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Source of funding

The work was not funded.

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Կուդրինսկայա Վալերիա Ռուսլանովնա[5]

1. Բժշկական գիտությունների դոկտոր, պրոֆեսոր, Սանկտ Պետերբուրգի պետական համալսարանի թերապևտիկ ստոմատոլոգիայի ամբիոնի վարիչ, Սանկտ Պետերբուրգ, ՌԴ
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5. Դաշնային պետական բյուջետային ուսումնական հաստատության Սանկտ Պետերբուրգի պետական համալսարանի ստոմատոլոգիայի ամբիոնի օրդինատոր, Սանկտ Պետերբուրգ, ՌԴ

Ամփոփում

Արմատախողովակի լոցնման ժամանակակից մեթոդները գուտա-պերչայի օգտագործմամբ ճշգրիտ և կանխատեսելի արդյունք չեն տալիս: Արմատախողովակի գագաթային երրորդի տարբեր անատոմիան պահանջում է օպտիմալ մեթոդի ընտրություն, որը խուսափում է դատարկություններից և սիլերների բարձր պարունակությունից: Այս ուսումնասիրությունը համեմատել է ստանդարտ և փոփոխված կողային սեղմման տեխնիկական արմատային խողովակիներում տարբեր մորֆոլոգիաներով՝ օգտագործելով համակարգչային տոմոգրաֆիա:

Նպատակը. առաջարկել արմատատախողովակի գագաթային երրորդի լցավորման օպտիմալ մեթոդ՝ հաշվի առնելով դրա անատոմիական կառուցվածքը և գնահատել լցավորման որակը՝ օգտագործելով համակարգչային տոմոգրաֆիա:

Նյութեր և մեթոդներ. Ուսումնասիրությունն իրականացվել է հեռացված 46 ատամների արմատախողովակների վրա: Բոլոր ատամները բաժանվել են երկու խմբի՝ ըստ օգտագործվող լցավորման տեխնիկայի: Հետազոտությունը ներառում էր կողային սեղմման տեխնիկա՝ օվալաձեւ արմատախողովակների փոփոխությամբ, որին հաջորդում էր հսկողությունը՝ օգտագործելով համակարգչային տոմոգրաֆիա:

Ստացված արդյունքներ. ուսումնասիրության շնորհիվ պարզվել է, որ նույնիսկ համակարգչային տոմոգրաֆիայի փուլում հնարավոր է պլանավորել արմատախողովակների լցավորման ամենահարմար մեթոդը՝ կախված դրանց ձևից:

Եզրակացություն. էնդոդոնտիկ բուժման արդյունավետությունը բարձրացնելու համար անհրաժեշտ է իմանալ և հաշվի առնել ատամների արմատային խողովակների կառուցվածքի անատոմիական և մորֆոլոգիական առանձնահատկությունները: Արմատախողովակները, որոնք օվալ են գագաթային երրորդում, կարող են պահանջել այլ լցավորման տեխնիկա, քան ստանդարտը:

АНАЛИЗ КАЧЕСТВА ОБТУРАЦИИ АПИКАЛЬНОЙ ТРЕТИ КОРНЕВОГО КАНАЛА В ЗАВИСИМОСТИ ОТ АНАТОМИИ КОРНЯ ЗУБА

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Абстракт

Актуальность: современные методики обтурации корневого канала с использованием гуттаперчи не дают точного и прогнозируемого результата. Различная анатомия апикальной трети корневого канала предполагает выбор оптимального метода, который позволяет избежать пустот и большого содержания силера. В данном исследовании с помощью компьютерной томографии было проведено сравнение стандартной и модифицированной методики латеральной компакции в корневых каналах с различной морфологией.

Цель: предложить оптимальную методику пломбирования апикальной трети корневого канала с учетом его анатомического строения и оценить качество обтурации с помощью метода компьютерной томографии.

Материалы и методы: исследование проводилось на 46-ти корневых каналах удаленных зубов. Все зубы были разделены на две группы в соответствии с применяемой техникой обтурации. Исследование включало в себя технику латеральной компакции с модификацией в корневых каналах овальной формы с последующим контролем с помощью компьютерной томографии.

Полученные результаты: благодаря исследованию было выявлено, что еще на этапе компьютерной томографии возможно спланировать наиболее подходящую методику обтурации корневых каналов в зависимости от их формы.

Заключение: для повышения эффективности эндодонтического лечения необходимо знать и учитывать анатомо-морфологические особенности строения корневых каналов зубов. Корневые каналы, имеющие в апикальной трети овальную форму, могут потребовать использования отличной от стандартной техники обтурации.