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RESEARCH ARTICLE

# AN EFFECT OF APICAL PREPARATION ON THE QUALITY OF ENDODONTIC TREATMENT

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**Abstract**

**Relevance:** The apical third of the root canal is difficult to access for high-quality endodontic treatment due to the complex anatomical and morphological structure of this area, which includes anastomoses, extra canals, apical deltas, various shapes of the apical foramen. Based on this, the accomplishment of suitable mechanical preparation of the apical part of the root canal remains one of the most complex and important tasks for successful endodontic treatment.

**Aim:** to evaluate the impact of mechanical preparation of the lower third of the root canal on the quality of endodontic treatment.

**Materials and methods:** 30 extracted teeth (incisors, premolars, molars), which root canals had been mechanical and medicamentous processing, were examined. All teeth were divided into two groups based on the extent of apical preparation: up to №25 and №50 according to ISO. The root canal obturation was done with the technique of vertical condensation of gutta-percha. The X-ray diagnostics was used to control the quality of obturation. Teeth from each group that met the inclusion criteria were placed in a solution of methylene blue. Then, transversal cuts were received with a separation disc. The degree of dye penetration into the dentin of the root canal was recorded on these cuts.

**Results:** The study results demonstrated that the adhesion of the filling material to the walls of the root canal was significantly worse in the first group of teeth (apical enlargement up to 25/04), compared to the second group (apical enlargement to 50/04).

**Conclusion:** The root canal enlargement only to №25 according to ISO is not enough for the complete removal of contaminated dentin and the accomplishment of high-quality obturation. The suitable mechanical preparation of the apical part with large sizes allows do more thorough irrigation of the root canal and subsequent obturation, which is a keystone for successful endodontic treatment.

***Keywords:*** *Endodontic treatment; Apical preparation; Apical size; Vertical condensation of gutta-percha; Quality assessment of obturation.*

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## INTRODUCTION

Despite the advances in modern clinical dentistry, the issue of the apical preparation of the root canal remains one of the most controversial topics in endodontics today. Numerous controversies arise regarding the size of the enlargement of the apical third of the root canal.

The anatomical complexity of the root canal system, particularly its apical third, has been extensively discussed in scientific literature since the beginning of the last century.[5,6] To date, numerous studies have been published describing different variations of the anatomical structure of the root canal system.[3] Lateral canals, apical deltas, the presence of anastomoses and variable shapes of the apical foramen - all these structural features complicate thorough mechanical preparation and removal of pathogenic microflora from the tooth's root canal system.[1]

Unfortunately, the size of the first file used to achieve apical constriction does not reliably determine the appropriate final instrument size required for the entire enlargement of the apical part.[4,9] This is due to the uneven width of the root canal throughout its length. Additionally, a lot of root canals do not only have a circular shape at the apical foramen but also oval, elongated oval or ribbon-like shapes.[6]

From a clinical point of view, this means that a more meticulous approach is needed to choosing the size of instruments during mechanical preparation. Furthermore, it is necessary to consider the largest diameter of the canal and its shape.

In the modern endodontic practice, rotary instruments are widely employed to accomplish high-quality mechanical preparation of the root canal. Most medical practitioners prefer to prepare the root canal three sizes larger than the initial file. However, researches proved that it is necessary to use files larger than those commonly used for the suitable removal of contaminated tissues and the root canal preparation for obturation.[4,9]

Mechanical preparation of the root canal is one of the fundamental factors in successful endodontic treatment. However, it is necessary to do the medicamentous processing is essential to minimize a volume of pathogenic microflora within the root canal system. A facilitation of penetration of irrigating solutions into the apical part are keeping with the sufficient enlargement of the root canal, this is evidence in favor of choosing large endodontic files.[2]

Achieving suitable mechanical preparation, especially of the apical part of the root canal, facilitates complete obturation and sealing of the root canal system, which is an earnest of success of endodontic treatment.

## MATERIALS AND METHODS

The study was conducted on 32 root canals of extracted teeth that had not been exposed to previous endodontic treatment. These included mandibular incisors, maxillary premolars and molars (palatal root canal).

All teeth were divided into two equal groups (16 extracted teeth in each group):

The first group - root canals of extracted teeth were exposed mechanical and medicamentous processing with RACE EVO, the final file was number 25/04 (apical preparation of mandibular incisor, maxillary premolaruand molar (palatal root canal) was accomplished up to size 25/04).

The second group - root canals of extracted mandibular incisors, maxillary premolars and molars (palatal root canal) were exposed mechanical and medicamentous processing with RACE EVO, the final file was number 50/04.

*Inclusion criteria:*

1. Teeth extracted according to orthopedic and parodontal indications (integrity of apical constriction is preserved).

*Exclusion criteria:*

1. Teeth extracted due to chronic periodontitis (disruption of the integrity of the apical constriction);
2. Severely crooked root canals (more than 35°).

The final obturation of the canals was carried out with the vertical condensation of gutta-percha and AH-Plus sealer under X-ray control after final mechanical and medicamentous (medicamental, drug, chemical) preparations druaccording to record (using a 3% sodium hypochlorite solution, 17% EDTA solution, and three cycles of ultrasonic activation lasting 20 seconds each). If signs of imperfect seal were observed on the periapical X-ray, the tooth was excluded from the study and replaced with another one.

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Teeth with satisfactory root canal obturation were kept in an oven at 37°C, then they were coated with a thin layer of wax, leaving uncovered only the apex (1-2 mm), they were dipped in a 2% methylene blue dye solution for 24 hours. Afterward, the teeth were rinsed with distilled water, they were cleaned of wax, and transversal cuts at the level of the apical third of the root were received with a separation disc. Subsequently, the quality of the seal between the filling material and the root canal wall was assessed with a microscope at 40x magnification.

The quality of the marginal seal of the filling material to the walls of the root canal was evaluated according to the following criteria:

**3 points** – the apical part of the root canal in the cross section is homogeneously filled with the filling material;

**2 points** – the apical part of the root canal is non-homogeneously filled with the filling material, there is a gap between the filling material and the root canal wall up to ½ of the diameter;

**1 point** – the apical part of the root canal is non-homogeneously filled with the filling material, there is a gap between the filling material and the root canal wall more than ½ of the diameter.

Methods of statistical processing: statistical processing of data was accomplished to reveal patterns in the research data. The correlations between the studied characteristics were presented in the form of graphs and statistical tables. The correlation analysis, which allows to reliable judge the statistical links between variables, was used to establish patterns between the obtained results.

A general linear regression equation:

$$\mathbf{Y = A_0 + A_1X_1 + ... + A_kX_k + Ɛ}$$

In this formula, Y - the variable on which the effect of factors is being studied,

X - the various that influence the variable,

$A_0$, $A_1$, … $A_k$ – model parameters, which reflect the significance of a particular factor,

k – the total number of these factors.

For accuracy, data calculations were performed with Microsoft Excel + Analyse-it software.

## RESULTS

Significant differences in the quality of root canal obturation between two groups (apical third enlargement with files 50/04 and 25/04) were not observed based on the target X-ray images. The material was homogeneous and dense without voids and pores in the canals in all groups (Figure 1).

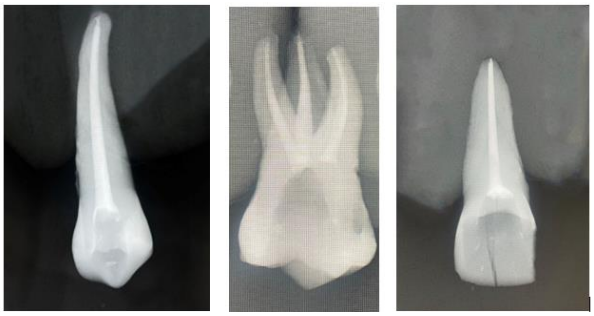

***Figure 1.*** *X-ray images to control the quality of obturation of root canals*

The study and comparison of transversal cuts of extracted teeth after pre-staining with a 2% methylene blue solution revealed that the degree of dye penetration between the tooth wall and the filling material in the first group was significantly higher compared to the second group. The obtained results were combined and presented graphically in the form of diagrams.

A total of 12 mandibular incisor root canals were explored. The firs group (root canal preparation up to size 25/04) consisted of 6 teeth. Voids were visually identified between the root canal wall and the filling material under the microscope at 40x magnification (Figure 2). The second group (root canal preparation up to 50/04) also included 6 teeth. The close adjacency of the filling material to the root canal wall was observed by using the same method (Figure 3). All root canals in the second group were assessed 3 points, which is 100%, while for the first group the result was 33% (Figure 4).

***Figure 2.*** *Transversal cuts of root canal of tooth 3.2 (the apical third). The preparation up to №25 according to ISO*

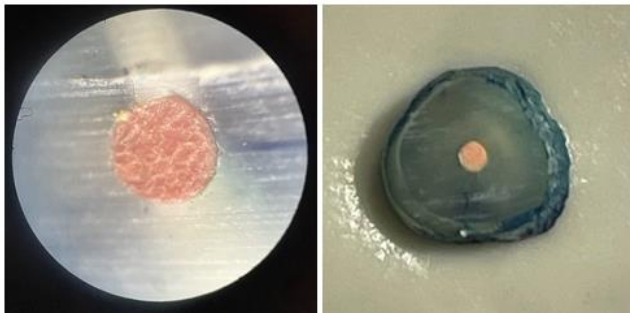

***Figure 3.*** *2. Transversal cuts of root canal of tooth 3.2 (the apical third). The preparation up to №50 according to ISO*

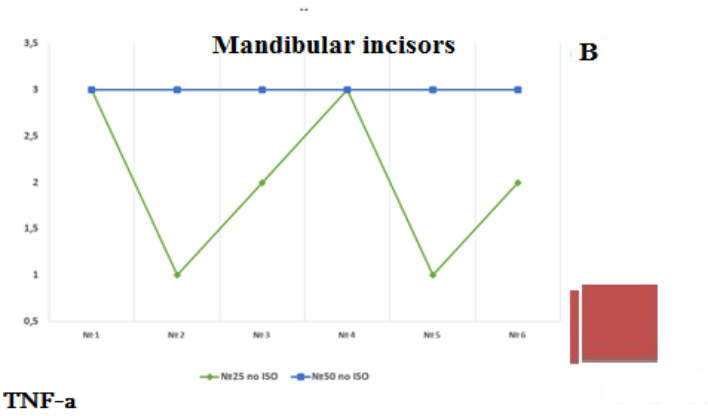


***Figure 4****. The assessment of quality of adjacency of the filling material to the root canal wall of mandibular incisors*

Additionally, 10 maxillary premolars with a single root canal were included in the study, it was consisting of 5 teeth per group: root canal preparation up to sizes 25/04 and 50/04. Voids were visually identified between the root canal wall and the filling material in the first group of teeth under a microscope at 40x magnification (Figure 5). In the second group the root canals were homogeneously filled with the filling material (Figure 6), which is 100%. For the first group the result was 40%.

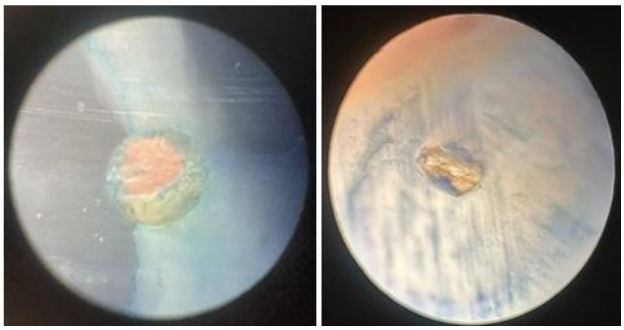

***Figure 5.*** *Transversal cuts of root canal of tooth 2.5 (the apical third). The preparation up to №25 according to ISO*

***Figure 6.*** *Transversal cuts of root canal of tooth 2.5 (the apical third). The preparation up to №50 according to ISO*

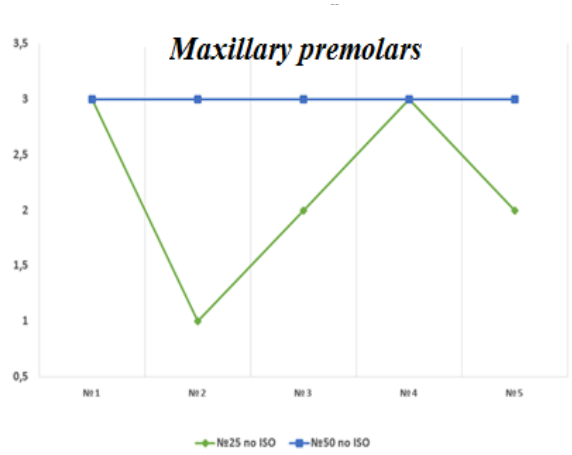


***Figure 7.*** *The assessment of quality of adjacency of the filling material to the root canal wall of maxillary premolars*

10 teeth were selected among molars after X-ray diagnostics. The study considered the outcomes of mechanical preparation and obturation only for palatal root canals. The first group (preparation of the root canal up to 25/04) included 5 teeth. Additionally, voids were identified between the root canal wall and the filling material in almost all teeth using a microscope at 40x magnification (Figure 8). The second group (preparation of the root canal up to 50/04) also included 5 teeth. The close adjacency of the filling material to the root canal wall was observed by using the same method (Figure 9). However, in this case, homogeneous filling with the sealing material was not observed in all teeth but rather in 80%. The results in the first group were better compared to those from another group, it was 60%.

***Figure 8.*** *Transversal cuts of the apical third of palatal root canals (teeth 2.7). The preparation up to №25 according to ISO*

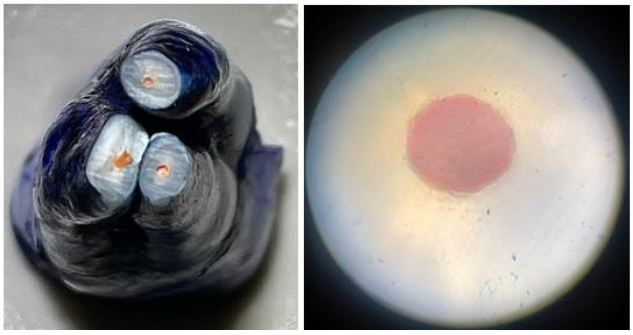

***Figure 9.*** *The transversal cut of the apical third of root canal of the tooth 2.7 (the palatal root canal). The preparation up to №50 according to ISO*

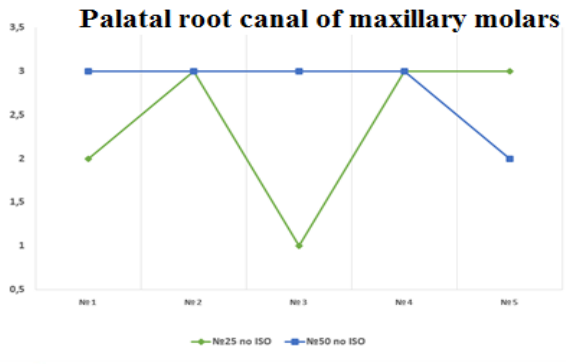


***Figure 10.*** *The assessment of quality of adjacency of the filling material to the palatal root canal wall of maxillary molars*

Despite the fact that significant difference was not observed during the X-ray between the first and second groups, when comparing the depth of dye penetration, preparation of the apical third of the root canal up to 25/04 is not enough, and it confirmed by numerous pores and voids between the tooth wall and the filling material.

The results obtained by correlation analysis with multiple linear regression are presented in Table 1.

***Table 1.*** *The results of statistical processing*

| **Regression statistics** | |
|---|---|
| Multiple R | 0,930528778 |
| R-square | 0,865883807 |
| Standardized R-square | 0,856634414 |
| Standard error | 0,272020479 |
| Observations | 32 |

In this study, the coefficient R was equal to 0.93053, which indicates a fairly strong linear correlation between the quality of root canal obturation and the size of apical preparation. The coefficient of determination (R-squared) is 0.86588, indicating that 86.59% of the variations are due to differences in the size of voids between the filling material and the root canal wall. It allows concluding that there is a high degree of correlation.

## DISCUSSION

The study involved mechanical preparation and obturation of root canals of 30 teeth using the technique of vertical condensation of gutta-percha. The preparation of root canals of the first group of teeth was performed up to size 25/04.

Numerous gaps and voids were observed on the transversal cuts after staining under a microscope at 40x magnification. Similar investigations were conducted for the second group of teeth, whose root canals were mechanical prepared up to 50/04. However, the quality of obturation proved to be significantly better in this case.

Authors' opinions among regarding the issue of apical third enlargement of the root canal are divided. In a study by Joe Vaughn, direct correlation was not found between the size of apical preparation and results of X-ray (images).[11] Dr. Sharanappa Kambale and colleagues concluded that the enlargement of the apical part of root canal beyond file size №30 leads to a higher frequency of mistakes, particularly in crooked root canals.[2] However, it should be noted that manual stainless-steel files were used in this study, which may

explain the results obtained. Other studies have demonstrated that larger apical preparations improve removal of contaminated dentin and disinfection of the root canal.[4,8,10]

In this study, the correlation was identified between the preparation with rotary files and obturation, and the results demonstrated the advantage of choosing larger in size and taper endodontic instruments. High-quality instrumental preparation significantly facilitates the filling process, ensures satisfactory result of the treatment and reduces the risk of requiring endodontic retreatment in the long term.

## CONCLUSION

Transversal cuts of extracted teeth at the level of the apical part of the root canal revealed that voids and gaps between the root canal wall and the filling material are most frequently detected (33% in incisors, 40% in premolars, and 60% in molars) when preparation was up to 25/04. Disruption of the seal between the root canal wall and the filling material is almost nonexistent (100% in both incisors and premolars and 80% in molars) when preparation was up to 50/04.

Mechanical preparation of the apical part to larger sizes allows to make more effective obturation of the root canal. However, not every root canal can be enlarging up to №50 according to ISO, because it is necessary to consider the anatomical structure, degree of crookedness of the root canals, as well as the dentist's experience and the clinic's equipment.

## 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 Institutional 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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