Problem statement and analysis of the latest research

Nowadays, the need for endodontic treatment in Ukraine is quite high, but due to a number of factors, the effectiveness of this treatment is still insufficient with a high percentage of complications – from 30 up to 70% [1,2], meanwhile the success rate of endodontic treatment abroad is 85-91.45%, highlighted in foreign sources [3,4].

High-quality endodontic treatment directly depends on proper instrumental and medical processing of the root canal system in accordance with existing modern protocols, as well as the right choice of optimal filling material, taking into account peculiarities of clinical situation [5,6,7].

The success of this treatment also depends on the complexity of the morphological teeth structure, number of roots and roots canals, teeth position in the jaw. It is much more complicated to conduct high-quality endodontic treatment and obturate the multi-rooted teeth with curved root canals compared to single-rooted teeth with a straight canal [8,9,10]. Also, the effectiveness of endodontic treatment can be influenced by the following factors: the absence of periapical changes before the treatment, the level of root canal obturation within 2 mm to the radiographic apex, dense filling of root canal space without visible voids, and satisfactory crown restoration [11,12,13].

For understanding the reasons that could lead to unsuccessful endodontic treatment [14], it is necessary to take into account not only the absence or presence of radiological changes in the apical area, but also to consider additional criteria that can be obtained from X-ray examination, namely apical constriction [15], root canal obturation, sealing condition of the orifice part of the canal [16,17,18], and the periodontal tissue conditions in the area of this tooth [19,20].

The objective of the research was to determine the effectiveness of obturation of the root canals and crown part of the teeth, and to identify the most important factors influencing its results, based on the X-ray examination.

Materials and methods

Determination of the obturation state of root canals and crown part of the teeth, and the state of periodontal tissues was performed on the basis of computed tomography [21,22,23] and digital orthopantomography, obtained using X-ray apparatus with a computed tomography function “Morita Veraviewepocs 3D” (Japan), and digital target radiography by using Heliodent Vario Sirona (intraoral universal sensor 2002), with a parallel stacking technique with dental positioners, followed by analysis in Sidexis 5.5, Sirona, conducted at the Dentistry Center of the University Clinic of Ivano-Frankivsk National Medical University.

140 orthopantomograms, computed tomograms and digital intraoral images of patients at the age of 18-68 were assessed. The endodontic treatment of root canals was the selection principle for further analysis. The radiological picture of 579 teeth and 1120 roots in particular was evaluated.

Computer programs based on Microsoft Excel 2019 were used for statistical processing of the research material.
Results

As a result of evaluation of radiological data, periapical changes were found around 518 (48.25%) roots and were absent around 602 (53.75%) roots. For more detailed study of endodontic treatment effectiveness, the following criteria were taken into account:

- The state of apical constriction on radiological images: opened/closed.
- State of canal obturation: overextension of filling material, material was traced at the level 1 mm to the apex, 2 mm to the apex, 3 mm to the apex, and more than 3 mm to the apex.
- Sealing conditions of entrance part of the canal: tightness was preserved, tightness was disturbed.
- The condition of periodontium around the tooth: the signs of periodontal pathology were present, signs of periodontal pathology were absent.

According to the data presented in Fig. 1, apical construction was destroyed (opened) in 358 roots (32%) and was preserved (closed) in 762 roots (68%).

Radiological changes were found in the apical periodontium in (42.81±1.67) % of roots with closed apical constriction, while the changes were found in (59.07±3.19) % with opened apical constriction, which was significantly higher and indicated the negative impact of opened apical constriction on endodontic treatment. On the other hand, no radiological changes were observed in (57.19±1.67) % with closed constriction and only in (40.93±3.19) % with opened constriction which was a significantly better result and proved the benefits of closed apical constriction (Table 1). Thus, changes in apical periodontium were more common in roots with opened apical constriction than with closed one, namely for 16% on average.

According to the analysis of the obturation level of root canals, the filling material was overextended in 50 roots (4.46%), sealed within 1 mm to the apex in 328 roots (29.29%), sealed within 2 mm to the apex in 295 roots (26.34%), sealed within 3 mm to the apex in 223 roots (19.91%), sealed above 3 mm to the apex in 224 roots (20%) (Fig. 2).

Table 1. State of apical periodontium around the teeth roots depending on the state of apical constriction

<table>
<thead>
<tr>
<th>State of apical periodontium</th>
<th>State of apical constriction:</th>
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<tbody>
<tr>
<td></td>
<td>Opened, n=237</td>
</tr>
<tr>
<td></td>
<td>Closed, n =883</td>
</tr>
<tr>
<td>Amount</td>
<td>%</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>with radiological changes, n=518</td>
<td>140 59.07±3.19* ! 378 42.81±1.67</td>
</tr>
<tr>
<td>without radiological changes, n=602</td>
<td>97 40.93±3.19 505 57.19±1.67</td>
</tr>
</tbody>
</table>

Note: * statically significant difference relative to indicators (p<0.05) without radiological changes ! statically significant difference relative to indicators (p<0.05) with opened constriction

Table 2 showed the relationship between the obturation level of filling material in the root canal and the state of apical periodontium. Having analyzed the relationship between the obturation level of filling material and the state of apical periodontium, we found that statically significant changes occurred in the root canal with overextension of filling material, and where the obturation level was over 2 mm to the apex as well. Significantly rare periapical changes were noted when filling material was sealed within 1-2 mm to the apex: the changes were absent in (81.10±2.16)% of roots with the obturation level within 1mm to the apex and in (71.86±2.62)% of roots with obturation within 2 mm

Figure 1. State of apical constriction

Figure 2. State of root canals obturation
While determining the condition of the apical periodontium, the preserved sealing of the entrance was noted in 685 roots constituting 61.16% of cases, and the coronal leakage was present in 435 roots amounting 38.84% (Fig. 3).

Structural changes in the apical periodontium were observed only in (27.30±1.7)% in case of reliable sealing in the coronal part. However, if the coronal leakage was present, periapical changes were detected in (76.90±2.05)% that was significantly higher and indicated an essential impact of coronal leakage on the state of the apical periodontium (Table 3).

The condition of periodontal tissue was also taken into account during the analysis of X-ray images. According to the Table 4, radiological signs of periodontal pathology were present in 74.55% of cases (835 roots), while no signs of periodontal pathology were observed in about 25.45% of cases (285 roots).

Periapical changes were less common in case of the absence of periodontal tissue changes, namely in (21.40±2.43)% of cases. In case of periodontal pathology observed on X-ray image, periapical changes occurred significantly more often, namely in (54.73±1.72)% of cases (Fig. 4).

Conclusions
The relationship between the state of apical constriction and the periapical changes was found. Particularly, changes in the apical part of the roots were significantly more common when apical constriction was disturbed.

The obturation level of root canal affected the state of apical periodontium (periapical changes were found in 518 (46.25%) roots, filling material was traced over 3 mm to the apex in (37.84±2.13)% of cases and within 3 mm to the apex in (25.10±1.90)% of cases. The periapical changes were absent in 602 roots, the obturation level was within 1 mm to the apex in (44.19±2.02)% of cases, and within 2 mm to the apex in (35.22±1.95)% of cases.

The coronal leakage was established to correlate with the higher rate of periapical changes.

The relation between the periapical changes and X-ray changes in periodontal tissue was proven.

Ethical standards (See Statement of Human and Animal Rights):

Conflict of interest: The authors report no conflicts of interest.
Table 3. State of apical periodontium depending on the state of coronal seal

<table>
<thead>
<tr>
<th>State of apical periodontium:</th>
<th>State of coronal seal</th>
<th>State of coronal seal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Presence of coronal seal, n=685</td>
<td>Absence of coronal seal, n=435</td>
</tr>
<tr>
<td></td>
<td>Number of roots</td>
<td>%</td>
</tr>
<tr>
<td>with present radiological changes, n=518</td>
<td>187</td>
<td>27.30±1.7*</td>
</tr>
<tr>
<td>without radiological changes, n=602</td>
<td>498</td>
<td>72.70±1.7</td>
</tr>
</tbody>
</table>

Note: *p<0.05 - statically significant difference relative to indicators without radiological changes

Table 4. State of apical periodontium depending on the state periodontal tissue

<table>
<thead>
<tr>
<th>State of apical periodontium:</th>
<th>State of periodontal tissue</th>
<th>State of periodontal tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present signs of periodontal tissue pathology, n=285</td>
<td>Absent signs of periodontal tissue pathology, n=835</td>
</tr>
<tr>
<td></td>
<td>number</td>
<td>%</td>
</tr>
<tr>
<td>with present radiological changes, n=518</td>
<td>61</td>
<td>21.40±2.43*</td>
</tr>
<tr>
<td>without radiological changes, n=602</td>
<td>224</td>
<td>78.60±2.43</td>
</tr>
</tbody>
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Note:*p<0.05 - statically significant difference relative to indicators without radiological changes

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References

Figure 4. Relationship between changes in apical periodontium and in periodontal tissues


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