The Effectiveness of Endodontic Irrigating Solutions on Smear Layer Removal from Radicular Dentin
A scanning electron microscopic study

MONICA DANA MONEA1, PETER OLAH2, DIANA CERGHIZAN3*, KAMEL EARAR4, CRISTIAN CONSTANTIN BUDACU5, CRISTINA IOANA BICA6

1 University of Medicine and Pharmacy TirguMures, Faculty of Dental Medicine, Department of Odontology and Oral Pathology, 38 Gh. Marinescu Str., 540139, Tirgu Mures, Romania
2 University of Medicine and Pharmacy TirguMures, Faculty of Medicine, Department of Medical Informatics and Biostatistics, 38 Gh. Marinescu Str., 540139, Tirgu Mures, Romania
3 University of Medicine and Pharmacy TirguMures, Faculty of Dental Medicine, Department of Fixed Prosthodontics, 38 Gh. Marinescu Str., 540139, Tirgu Mures, Romania
4 Dunarea de Jos University of Galati, Faculty of Medicine and Pharmacy, 47, Domneasca Str., 800008, Galati, Romania
5 University of Medicine and Pharmacy Grigore T. Popa Iasi, Faculty of Dental Medicine, Department of Oral and Maxillofacial Surgery, 16 Universitatii Str., 700115, Iasi, Romania
6 University of Medicine and Pharmacy TîrguMures, Faculty of Dental Medicine, Department of Pedodontics, 38 Gh. Marinescu street, 540139, Tîrgu Mures, Romania

The aim of our scanning electron microscopic study was to evaluate the cleaning efficiency of irrigating solutions used in endodontic treatment regarding smear layer removal from the root canal dentin walls. Ethylenediaminetetraacetic acid (EDTA) 17%, citric acid (CA) 10% and chlorohexidine gluconate (CHX) 2% solutions were tested as final irrigants after endodontic treatment. The study was conducted on extracted teeth, divided in four groups according to the irrigation protocol used. The specimens were analyzed by scanning electron microscopy and the amount of smear layer present at apical, middle and coronal level was recorded, based on a scoring system. Data were statistically analyzed using Kruskal-Wallis and Friedman test and the level of significance was set at p<0.05. At the coronal and middle thirds we recorded no statistically significant difference between EDTA and CA regarding the smear layer removing capacity. Final irrigation with 10% CA proved to be more efficient than 17% EDTA in smear layer removal at apical level of the root canal, with p<0.05 (p=0.036), which is an important area for disinfection in endodontic treatment.

Keywords: chelating agents, smear layer, scanning electron microscope, radicular dentin

The long term success of endodontic treatment is based on proper instrumentation, disinfection and three-dimensional filling of the entire root canal system. During this process, a special attention is given to complete removal of organic and inorganic debris formed on the radicular dentin surface as a result of endodontic instrumentation, known as smear layer [1,2]. Most of the irrigating protocols proposed contain sodium hypochlorite (NaOCl) associated with a chelating agent, but the best sequence of solutions is still a matter of debate and controversy in the scientific literature [3]. The combination of NaOCl (table 1) with a chelating agent as EDTA or CA has been proposed as an excellent irrigation method, which effectively removes debris and smear-layer [4].

EDTA is an aminopolycarboxylic acid and a colourless water soluble solid, which has the ability to capture metal ions such as Ca2+ by binding to its two amines and four carboxylates (fig. 1, table 2). It is an artificial aminoacid with a pH 7, biocompatible and with a reduced antibacterial effect, based on the inhibiting effect on bacterial growth by chelating with metallic ions used in their metabolisms [5,6]. At concentrations of 15-17% eliminates calcium from the dentin, leaving an organic matrix. EDTA solutions with the addition of a surfactant loosen up calcifications at the top or inside the root canal, allowing the complete instrumentation of obliterated canals. Citric acid is a weak organic tribasic acid that has been suggested as a chelating

![Fig.1. Chemical structure of EDTA](image)
Fig. 2 Chemical structure of citric acid

<table>
<thead>
<tr>
<th>Study group/ Root area</th>
<th>Coronal third Mean (+/- SD)</th>
<th>Middle third Mean (+/- SD)</th>
<th>Apical third Mean (+/- SD)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (saline)</td>
<td>3.0 +/- 0.0</td>
<td>3.0 +/- 0.0</td>
<td>3.0 +/- 0.0</td>
<td>P=1</td>
</tr>
<tr>
<td>EDTA</td>
<td>1.2 +/- 0.72</td>
<td>1.3 +/- 0.58</td>
<td>2.5 +/- 0.43</td>
<td>P=0.008</td>
</tr>
<tr>
<td>CA</td>
<td>1.1 +/- 0.81</td>
<td>1.2 +/- 0.78</td>
<td>1.75 +/- 0.20</td>
<td>P=0.006</td>
</tr>
<tr>
<td>Chlorhexidine</td>
<td>3.0 +/- 0.0</td>
<td>3.0 +/- 0.0</td>
<td>3.0 +/- 0.0</td>
<td>P=1</td>
</tr>
</tbody>
</table>

Table 3
CHARACTERISTICS OF CITRIC ACID

Table 4
MEAN SCORES OF SMEAR LAYER REMOVAL FROM THE RADICULAR DENTIN WALL

The aim of this SEM in vitro study was to evaluate the cleaning efficiency of EDTA and CA as final irrigating solutions in smear layer removal from root canal dentin walls during different endodontic treatment protocols.

Experimental part
Materials and methods
Ethical approval was taken before starting this study in which we used forty human freshly extracted teeth. The selection was based on the relative dimension, similar morphology and absence of root curvatures, in order to standardize the endodontic preparation. All teeth were stored in saline solution for 1-2 days and instrumented according to the step-back technique using K-files (Dentsply-Maillefer, Ballaigues, Switzerland) up to # 40, with NaOCl 5.25% irrigation after each file, followed by 5 mL of saline solution. The teeth were divided in 4 study groups according to the final irrigating protocol used (Group I - NaOCl 5.25% + saline solution + EDTA 17%, Group II - NaOCl 5.25% + saline solution + citric acid 10%, Group III - NaOCl 5.25% + saline solution + CHX 2% and Group IV - control, irrigation with saline solution). In each group the samples were irrigated for 1 min with 5 mL of each solution which were freshly prepared and standardized. For the SEM evaluation, longitudinal grooves were made on the buccal and oral surfaces of the roots using a diamond disk at low speed, without penetrating the canal. The roots were split in half with a sharp blade and were coded according to the protocol used. The specimens were dehydrated with increasing concentrations of ethyl alcohol, mounted on coded stubs and sputter-coated with 300 Angstrom gold layer. The specimens were examined using a SEM (Cam scan MV 2300, Oxford Instrument, UK) at x1000 and x750 magnification at the coronal, middle and apical thirds, based on a graded scale from 1-3 (1 - complete smear layer removal, open dentin tubules, 2 - moderate smear layer, partially opened tubules, 3 - dentin surface completely covered with smear layer) in order to assess the quality of smear layer removal. Photomicrographs of the examined areas were taken and evaluated by two independent observers in a double-blind manner. Statistical analysis was carried out with the Statistical Package for Social Sciences (SPSS) version 16.0 for Windows. Non parametric data of smear layer scores were presented as a percentage distribution and the mean ranks were calculated for each root section. The Kruskal-Wallis test was used to compare between final irrigation solutions at each section between study groups and Friedman test was used to compare between root canal thirds at each group. The level of significance was set at p<0.05.

Results and discussions
According to Kruskal-Wallis test there were no statistically significant differences between EDTA and CA except for the apical thirds of the root canal, where CA proved to be more efficient in smear layer removing ability with p<0.05 (p=0.037). The photomicrographs obtained after SEM evaluation are presented in figure 3 and 4. The mean scores of smear layer removal for the control and study groups are listed in table 4 that shows the ability of CA and EDTA to remove debris efficiently in the coronal and middle thirds of the root canal.

In the apical part, CA proved to have better cleaning properties compared to EDTA and CHX. The Friedman test had shown statistically significant differences within EDTA and CA groups regarding the degree of smear layer removal from canal sections, with a p<0.05 (p=0.008 and p=0.006 respectively). We recorded also a significant erosion of dentine dissolution.
dentinal tubules in samples irrigated with EDTA, disclosing an important decalciﬁcation effect of this solution.

Root canal instrumentation produces a layer of organic and inorganic material called smear layer that may contain bacteria and their by-products. In endodontic treatment it has many disadvantages as it prevents the penetration of endodontic medicaments into dentinal tubules and disrupts the seal between the dentin walls and root ﬁlling, conditions that may lead to treatment failure [2, 7]. Cleaning of endodontic system is extremely important and NaOCl 5.25% solution is considered to be the gold standard in endodontic irrigating protocols due to its very good tissue dissolving effect; at the same time, it has been suggested to degrade micromechanical characteristics of dentin. Furthermore, it is toxic to apical tissue and has no effect on the inorganic component of the smear- layer. NaOCl 5.25% solution promotes the formation of smear layer during instrumentation and the use of a chelating agent facilitates the smear layer removal [8]. Another important endodontic irrigant is CHX, a cationic polybisguanide which can be used due to its antimicrobial activity and its unique property called substantivity. Until now, using chelating agents was done mostly by irrigation with EDTA, which has been tested in different concentrations and for different time periods [9-11]. The disadvantages noticed were lack efﬁciency in the apical area and dentinal erosion in the middle and coronal part of the root. Previous studies had shown that there is no significant difference between CA and EDTA regarding the capacity of smear layer removal, but both disclosed a limited antibacterial effect [12-14]. Spano et al [15] examined smear layer removal with different solutions and found that EDTA and CA had comparable effectiveness. Our results showed that 5.25% NaOCl and 2% CHX did not promote an adequate cleaning of radicular dentin, with a great amount of smear layer present. Previous studies had demonstrated that CHX 2% solution could be an effective endodontic irrigant; it could maintain the canal free of microorganisms but few studied had shown its cleaning capacity. The present study was carried out on extracted teeth and therefore the results do not allow a deﬁnite conclusion regarding the effects of chelating solutions used in situ. The presence of blood and tissue fragments, together with other variables may inﬂuence the action of these chemical agents under use in the root canal system. Therefore, more long term clinical studies are necessary in order to conﬁrm these results and to evaluate their relevance to dental endodontic practice.

Conclusions
The apical part of root canal imposes a special attention during irrigation as the borderline between safety and effectiveness is particularly important in this area. Final irrigation of the root canal with 10% CA is more efﬁcient than 17% EDTA in smear layer removal at apical level, which represents the most important area for disinfection. The chelating agents used, especially EDTA, exhibited an important decalciﬁcation effect, therefore the risk of dentin erosion should be taken into consideration.

References