STATISTICAL ANALYSIS OF METHODS AND MEASURES USED FOR IRRIGATING ROOT CANAL

Keywords: rinsing, disinfection, sodium hypochlorite, ultrasounds, root canal treatment

1. INTRODUCTION

Endodontic therapy is a treatment of irreversible inflammation of the tooth pulp, which contains large nerve trunks and blood vessels. The major objective in endodontic therapy is to disinfect the entire root canal system. Thanks to this therapy, the tooth without pulp should stay in oral cavity for a longer period of time without causing harm to the patient’s health. The primary cause of the pulp disease are bacteria that get inside of the tooth through cavity, the gap between the filling and the tooth or by the crack. Pulp tissue infected by the bacteria dies, and bacteria that penetrated beyond an apex of the dental root can cause inflammation of the bones around it. Treatment can be divided into three stages: mechanical instrumentation, chemical irrigation and filling.

It is known that a thin layer of impurities is created as a result of mechanical instrumentation. This is called a smear layer and it is formed during cleaning and shaping that covers the instrumented root canal walls. The smear layer contains organic and inorganic substances as well as necrotic debris, fragments of odontoblastic processes and microorganisms that block the access to dentinal tubule [13]. Also, the anatomical shape of the teeth can prevent dental tools from reaching all places in the canal. Therefore, the toxic microorganisms may still be present in the recess of root canal system, additional canals or in the tooth delta. After some period of time these bacteria can lead to inflammation of the periapical tissues. Furthermore, smear layer has a negative impact on the filing strength and tightness.

The chemical preparation is important because it is used in removal of the smear layer. Studies shown that around 20-30% of the root canal wall surface was still unpurified after the mechanical preparation. Heavy rinsing of root canal decreases danger of damaging or breaking endodontic tools. It also facilitates the work in a moist environment of the tooth. In order to reduce or eliminate bacteria from the root canal system, various irrigants have been used during a treatment.

Contemporary dentistry uses many irrigants, but none of them are ideal [3]. To disinfect and clean the root canal system effectively, an irrigant should have the following features (currently, there are no irrigants available on the market that meet all the criteria):
• antimicrobial activity,
• biocompatibility,
• lack of toxicity,
• ability to remove smear layer,
• ability to dissolve pulp tissue,
• dentin conditioning properties
• positive effect on root canal seal,
• noncarcinogenic,
• easy to use,
• ability to inactivate endotoxins.

In addition, it should have no adverse effect on the sealing ability of filling materials, be safe for dentin and relatively inexpensive [16, 17]. The irrigants which are currently used during cleaning and shaping can be divided into antibacterial and decalcifying agents or their combinations. They include acids (citric), oxidative agents (hydrogen peroxide), chelating agents (ethylenediaminotetraacetic acid [EDTA]), alkaline solutions (sodium hypochlorite) and CHX (chlorhexidine) [8].

Fig. 1. Irrigants classification

All of the irrigants which are used nowadays have their share of limitations that cause a continuous search for an ideal root canal irrigant.

It is difficult for the irrigant to reach the whole apical region. Therefore, the modern endodontics promotes the use of ultrasonic devices, which is more effective than syringe-needle irrigation [10]. In endodontics, they were first introduced by Richman (1957) for root canal therapy. Currently, these devices are used in root canal irrigation.

Studies show that the use of ultrasonic devices has enhanced the action of irrigant and today they are used by many endodontics specialists [7, 14]. The ultrasounds devices are more effective than syringes when used during removal of pulp tissue remnants and dentin
Tab. 1. Advantages and disadvantages of selected currently used intracanal irrigants

<table>
<thead>
<tr>
<th>Irrigant</th>
<th>Antimicrobial activity</th>
<th>Ability to remove smear layer</th>
<th>Biocompatibility</th>
<th>Ability to dissolve pulp tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaOCl</td>
<td>+</td>
<td>−</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>CHX</td>
<td>+</td>
<td>−</td>
<td>+</td>
<td>−</td>
</tr>
<tr>
<td>EDTA</td>
<td>−</td>
<td>+</td>
<td>+</td>
<td>+/−</td>
</tr>
<tr>
<td>Citric Acid</td>
<td>−</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

debris [10]. This is due to the much higher velocity and volume of irrigant flow. Ultrasounds activate irrigant in the canal and produce at least 2 helpful effects [8, 14]:

a) cavitation, defined as formation of thousands bubbles which rapidly implode removal of biofilm.

b) acoustic streaming which produces shear forces that help extricate debris from instrumented canals.

The main purpose of this study was to identify which irrigant is the most commonly used for irrigation of the root canal. It was also reviewed which measures and methods are the most commonly used in chemical preparation of the root canal treatment. In addition, this research also focused on dentists’ willingness to use novel techniques such as ultrasounds in endodontics.

2. MATERIAL

The survey was conducted among the group of 29 dentists from Sub-Carpathian Region (Podkarpacie). There were questions about demographic data and specialized questions about endodontic treatment. Three demographic questions included information about gender, years in practice and area of work (private, public or both of them). Specialized questions included information about using irrigants (multiple choice) and if NaOCl was used what was the concentration of it generally used. Other specialized question was about the use of ultrasounds in rinsing the root canal and the type of needle used during irrigation. The data was collected and analyzed in Microsoft Excel.

3. METHODS

One of the main interests of industrial informatics is the statistical analysis of data. In this case, the analyzed data are related to irrigating root canal. Collected data was saved in Microsoft Excel, which has a number built-in mathematical functions. This computer program was used for analyzed of data and visualization of results. Analysis of data was carried out using the following method.

To initially formulate results of survey the A matrix has been created.
Construction of matrix $\mathbf{A} = [a_{ij}]$

- $i$ – the answer $i = 1, \ldots, 45$;
- $j$ – number of respondent $j = 1, \ldots, 29$;
- $a_{ij} = 1$ when respondent number $j$ signed the answer number $i$,
- $a_{ij} = 0$ in other case.

It can be noted that

$\sum_{j=1}^{29} a_{ij}$ – the number of positive replies to question number $i$,

$\sum_{i=12}^{21} a_{ij}$ – the variety of imparted replies by respondent number $j$.

The $\mathbf{B}$ matrix has been created to further analysis $\mathbf{B} = [b_{ij}]$.

$$B = \mathbf{A}\mathbf{A}^T,$$

$b_{ij}$ – the number of respondents who positively replied to both questions $i$ and $j$.

Particularly cells located at diagonal - $b_{ii}$ determine the number of respondents who positively reply to question $i$. The charts and conclusions were made on the base of $\mathbf{B}$ matrix.

Submatrix’s analysis shows the frequency of responses at demographic group or subjects between various responses. For example, using ultrasound is more popular at group of dentists under 15 years of seniority. In our opinion, the most interesting results have been presented below in section 4.

4. RESULTS AND DISCUSSION

The study was conducted on 29 subjects including 12 men and 17 women: 19 of the respondents worked only in the private practices which represents 65.5% of all respondents. Ten dentists worked within the NFZ (National Health Fund)* and privately (34.5%), but none of the respondents worked only at the NFZ.

The study involved the largest number of dentists with six to ten years of service. Percentage breakdown based on dentists’ length of service and seniority is shown in Figure 4.

Currently, there are no irrigants available on the market which meet all necessary criteria. Therefore, the optimal solution is to use a combination of a few irrigants at the same time. As an example, the combination of NaOCl and EDTA is used by many specialists for antisepsis of root canal systems around the whole world. The questionnaire included information about the most commonly used irrigants. The respondents could choose more than one answer. The 100% of respondents chose NaOCl as one of the irrigants that they use personally.

Sodium hypochlorite (NaOCl) is the primary antiseptic liquid used in endodontics [11]. This is caused by the fact that it can dissolve protein structures and also it is antiseptic and inexpensive. NaOCl has been used in dilutions ranging from 0.5% to 5.25%. Alternatively, NaOCl is toxic, but by decreasing the concentration of the solution its toxicity can be reduced. However, doing so one also reduces the ability of NaOCl solution to dissolve tissues and its antibacterial properties

*The NFZ is a state institution that finances health care benefits from contributions paid by people insured in the NFZ (the insured individuals pay contributions to the NFZ, and in return for that they are entitled to free healthcare).

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Endodontic infections are characterized in line with the fact that they are caused by multi-species colonies that form biofilms. Bacteria that are concentrated as biofilms are, in most cases, resistant to antiseptics. However, concentrated sodium hypochlorite (concentration from 5%) disinfects and also dissolves biofilm. This feature makes sodium hypochlorite the most effective formulation used for the decontamination of the endodontic system. Unfortunately, NaOCl is unable to remove the inorganic components of the smear layer.

The questionnaire also included information about which NaOCl concentration is the most frequently used. Based on the obtained results, it was found that the concentration of 5.25% is mostly preferred. It can also be noted that higher concentrations are used more frequently. The 0.5% NaOCl was selected by only 7% of the subjects. This is probably due
to the fact that high concentrations of hypochlorite dissolve the biofilm.

Unfortunately, due to its toxicity, sodium hypochlorite can cause potential complications when used in clinical practice. If NaOCl has reached beyond the canal system it may result in extensive soft tissue or nerve damage and it can even compromise the airway. The risks of a root canal rinse are insignificant when done by an experienced dentist. Nevertheless, complications may occur in individual cases, possibly requiring additional measures. There are documented cases of allergy, which is revealed by swelling and difficulty in breathing. The patient required hospitalization in the intensive care unit. However, allergy to sodium hypochlorite is rare [11].

**Chlorhexidine (CHX)** was the second commonly chosen irrigant in the questionnaire. It is not a toxic fluid as opposed to sodium hypochlorite. This antiseptic does not have any chelating properties, so it does not remove the smear layer or biofilm. Chlorhexidine should be used normally after removal of the smear layer and after NaOCl rinsing. In that case, NaOCl should be reduced, for instance by addition of citric acid [15].

Occasionally, root canal infections are positive for presence of fungi. Because of that, antimicrobial effect of the irrigant should also work against fungi. CHX has a wide-spectrum of antimicrobial activity at low concentration. It is effective especially against fungi. Furthermore, it might be that CHX inhibit the accumulation and biofilm formation of yeasts and other microorganisms [9].

**Citric Acid** was the third commonly chosen irrigant, according to this research. Citric Acid is a chelating compound which means that it removes inorganic components of the smear layer. In addition, it has antibacterial effect as well [16].
It is recommended to use 40% citric acid for removal of the smear layer and revealing the dentinal tubuli orifices in the root canal rinsing process. Studies showed that the use of citric acid is safe in terms of fracture resistance [2].

Based on the collected data, distribution of popularity of irrigants between work sectors was also analyzed.

Isopropyl alcohol was not chosen by any dentist working privately and in a public sector. Based on the collected data, it is difficult to say which sector is more diverse in choice of liquids for the chemical preparation. Further research should be conducted amongst dentists working only privately and at NFZ. The survey did not include the answer “saline”. Saline was classified as ‘other’ in the questionnaire.

The questionnaire also contained information about the use of ultrasounds. Ultrasound is used in endodontics at various stages of treatment. Ultrasonic devices use bats with a frequency of 25 thousands $s^{-1}$ and the generated energy is sent to the aqueous environment in the channel. This contributes to the increase in the activity of rinsing agents [12]. They are useful in the development of dental feces, as well as their enlargement or cleansing. They are also used to remove broken instruments and silver beads from the dental roots light and to fill them in as well [6].

![Fig. 5. Diagram of the Ultrasonic Piezom® Scaler: 1 - piezoelectric handpiece, 2 - touch control panel and power control, 3 - work tip, 4 - fluid bottle [1]](image)

There are number of methods currently used for the smear layer removal. Among all of these methods ultrasonic devices were proven to be the most effective [5]. Numerous studies have shown that in combination with rinsing agents the rinsing efficiency has significantly increased. This is because high frequency vibrations cause the solution to move around the apex of the channel and also because the fluid is mixed better and slightly heated.
Two types of ultrasonic irrigation are currently available: active ultrasonic irrigation (AUI) and passive ultrasonic irrigation (PUI). AUI is less effective in removing pulp tissue or smear layer from the root canal wall than PUI [14].

Ultrasonic devices have some limitations. The use of ultrasound is limited by the size of the mouth canal, the short tip of the scalar and the depth at which they are required to work. In order to penetrate along the entire length of the root canal for the rinse preparation, there must be no present obstructions. Therefore, ultrasound flushing during the development of the canal is not beneficial in this case. Using them during the final rinse improves the effectiveness of the activated solution [4]. The use of ultrasound also reduces the possibility of hypochlorous bleeding. Except for many benefits that we can achieve with ultrasonic devices, there are also some disadvantages. The use of ultrasonic instruments near the root apex increases the risk of perforation or root fracture [5].

The ultrasound is used by 55% of professionals who participated in this research study. However, this is not a satisfactory result when considering the positive effects which the ultrasound has on the channel flushing. The obtained data was analyzed in three ways:

a) Ultrasounds use based on seniority.

![Fig. 6. Percentage distribution of using ultrasonic devices in irrigation based on seniority](image)

The highest number of dentists using ultrasound is in the group within 11- to 15-years of practice. The least number is among those with a work experience of more than 15 years (no dentist using ultrasound 20 or more years of service). This is common because dentists with many years of practice have their own habits and are not prone to any changes. However, younger dentists, who are just starting their career work according to the patterns of this study. The ultrasound devices are definitely used more often in a private practice than at the NFZ, mainly because of the lack of funding.

b) It was examined whether gender affects the use of ultrasonic devices.

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The chart show that higher percentage of women use ultrasonic devices in root canal treatment.

c) It was examined whether sector of work affects the use of ultrasonic devices.

Ultimately, ultrasound is used more often in the private sector. Probably this is because the National Health Fund is insufficiently funded.

Despite the significant benefits achieved with ultrasound devices, they are not commonly used for dental flushing. Around 55% of ultrasound tests are good, but not satisfactory.

5. CONCLUSION

Many disinfecting fluids are used in the endodontic treatment, because there is no ideal fluid that would have all desired features. There are liquids that dissolve only organic or only inorganic components of the smear layer. For this reason, more than one irrigant is used in rinsing of canal root. Because of this, there is no single fluid type used during channel rinsing procedure. The combination of rinsing solution is being used instead, to reach a desired dissolving effect. However, there is no one commonly used scheme. It depends on dentist’s choice.

The most commonly used solution was sodium hypochlorite at a concentration of 5.25%. This is probably due to the fact that sodium hypochlorite concentrations above 5% have the ability to dissolve the biofilm.
Ultrasounds are used only by half of the examined dentists. Taking into account the benefits that can be achieved by this method, this is an unsatisfactory result. Probably, a low percentage of the ultrasound use is affected by the high cost of the equipment and the need to learn how to operate it.

Generally, women are more open to novelties and use more diverse methods in specialized dentistry. They use an average of 3.76 different rinsing irrigants in comparison with men who use only 3.17. They also prefer to use ultrasounds more often than men.

REFERENCES


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ABSTRACT

The study included a questionnaire conducted on a group of dentists from Podkarpacie. The statistical distribution of methods and measures was used during the development of root canals in endodontic treatment. The aim of the work was to determine which of the irrigating solutions is most commonly used for rinsing of the dental canal. Based on the obtained results, it was concluded, that dentists have already dismissed the use of obsolete remedies at their work place. They are more open to incorporate new methods such as the use of ultrasound during irrigation. The most commonly used solution will be used in the further study discussing pressure in the dental canal during irrigation.

ANALIZA STATYSTYCZNA METOD I ŚRODKÓW STOSOWANYCH W IRYGACJI KANAŁU ZĘBOWEGO

STRESZCZENIE

W pracy zostało zawarte opracowanie badania ankietowego na grupie stomatologów z Podkarpacia. Przedstawiono rozkład statystyczny metod i środków stosowanych podczas opracowania kanałów korzeniowych w leczeniu endodontycznym. Celem pracy było m.in. wykazanie, które z płynów są najczęściej stosowane przy płukaniu kanału zębowego. Na podstawie uzyskanych wyników zostały wyciągnięte wnioski czy stomatolodzy w swojej pracy odeszli już od używania środków przestarzałych, a także czy są otwarci na nowe metody takie jak używanie ultradźwięków przy irygacji. Najczęściej wybierany płyn zostanie wykorzystany w toku dalszych badań nad ciśnieniem panującym w kanałach zębowych podczas irygacji.