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Review

Narrative Review on Methods of Activating Irrigation Liquids for Root Canal Treatment

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Abstract: As indicated by standards of modern dentistry, the essence of endodontic treatment is chemo-mechanical disinfection of the root canal system. The vital element of this process is the irrigation of canals with designated solutions as well as activating them. This review article summarizes various techniques of activation of irrigants for endodontic treatment such as manual activation, thermal, pressure, sonic, ultrasonic, and laser techniques in order to compare them. Results were gathered using PubMed, Scopus, Web of Science, and Google Scholar databases by searching keywords: activation, irrigation, irrigation protocols, and sodium hypochlorite.

Keywords: activation techniques; endodontics; irrigation; root canals; root canal treatment

Citation: Raducka, M.; Piszko, A.; Piszko, P.J.; Jawor, N.; Dobrzyński, M.; Grzebieluch, W.; Mikulewicz, M.; Skośkiewicz-Malinowska, K. Narrative Review on Methods of Activating Irrigation Liquids for Root Canal Treatment. *Appl. Sci.* **2023**, *13*, 7733. https://doi.org/10.3390/app13137733

Academic Editor: Gianluca Gambarini

Received: 29 May 2023
Revised: 25 June 2023
Accepted: 27 June 2023
Published: 30 June 2023

1. Introduction

Endodontic treatment is concerned with operative dental therapy. It is performed when the irreversible inflammatory process of the dental pulp, its necrosis, or failure of previous root canal treatment occurs. Pulp inflammation may be caused by multiple factors, such as trauma, chronic irritation, and deep caries [1]. Globally, the latter is one of the most common problems. Factors increasing its probability to occur are the presence of cariogenic species of oral bacteria, fermentable carbohydrates, and tooth surface susceptible to acidic attack [2]. Caries lesions may be categorized according to the depth of penetration into the tissue (e.g., enamel, dentin, pulp) [3]. When the process of caries spreads deeply into the tooth tissues and reaches the pulp causing irreversible inflammation, endodontic treatment needs to be performed. This type of dental procedure is gaining popularity due to the desire of patients to preserve their natural teeth and increased awareness of the benefits of maintaining natural dentition. This type of treatment is composed of receiving access to the pulp chamber, chemo-mechanical preparation, and obturation of the root canals. Teeth treated according to this pathway require functional restoration with respect to clinical needs. The elimination of microorganisms, necrotic tissues, and accumulated hard tissue debris is crucial for the success of the treatment. Over 35% of the root canal area remains untrimmed, regardless of the instrumentation technique used. Chemical preparation using disinfectant solutions to irrigate the root canal system is essential [4]. For this purpose, various irrigation liquids were introduced to the clinical procedures. The properties of the sole irrigation solutions are not sufficient to achieve the desired disinfection of the canal. Therefore, some of these liquids could be activated to increase the effect they cause in the whole endodontic treatment process.

Among methods of activation of irrigants utilized during an endodontic treatment we can outline:

- Manual activation;
- Thermal techniques (internal or external to the root);
- Pressure techniques (EndoVac, Kerr Endodontics, Gilbert, AZ, USA; Rinsendo, Dürr Dental, Bietigheim, Germany);
- Sonic/ultrasound techniques (EndoAcivator, Dentsply Maillefer, Ballaigues, Switzerland; EDDY, VDW, München, Germany; Ripsisonic, Medidenta International Inc., Woodside, NY, USA; SAF, ReDent, Ra'anana, Israel);
- Passive Ultrasonic Irrigation (PUI);
- Laser techniques.

The schematic division of irrigant activation techniques is presented in Figure 1.

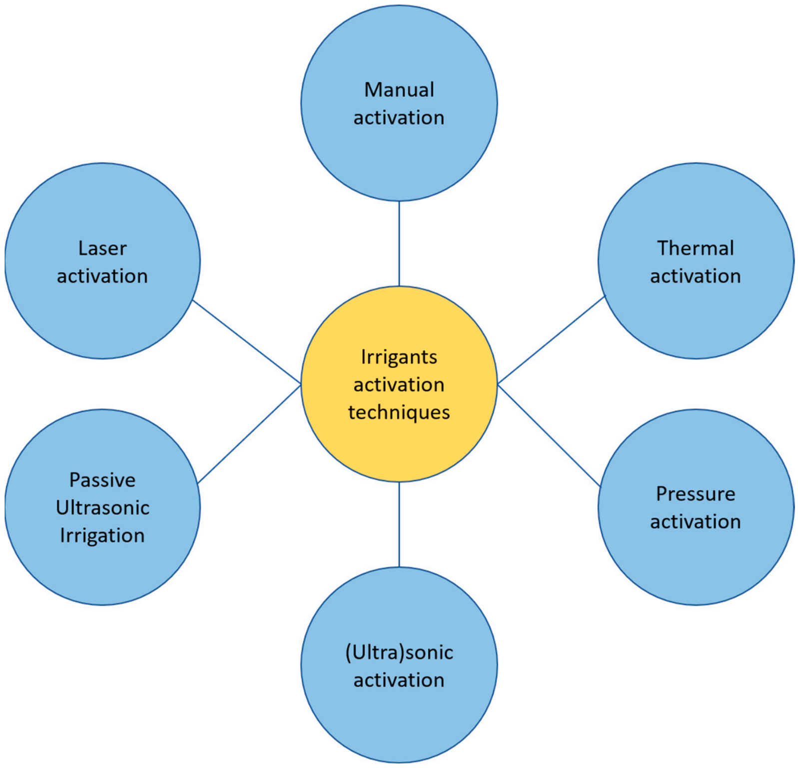

Figure 1. Schematic division of irrigants activation techniques.

2. Materials and Methods

An electronic search of the literature was conducted within PubMed, Scopus, Web of Science, and Google Scholar databases. A combination of free-text words was used: irrigation, activation, sodium hypochlorite, and irrigation protocols. From the search results a group of articles was selected with respect to their significance in the topic. An emphasis was put on clinical application and/or scientific-based research in the scope of activation of irrigants in endodontic treatment.

3. Types of Irrigants and Irrigation Protocols

Root canal irrigation during the endodontic treatment aims for the removal of remaining pulp, bacteria, smear layer, and other contaminations. The literature describes irrigation with sodium hypochlorite (NaOCl) in the concentration of 1–6% as a golden standard in endodontics [5], because of its antimicrobial activity, ability to inactivate intracanal bacterial toxins, and to dissolve the organic component of the smear layer [6]. The advantage of this irrigant is its ability to lubricate the root canal with a quick onset of action [7]. However, one needs to be aware of the cytotoxicity of NaOCl when the solution accidentally penetrates into the periapical area or reaches the soft tissue [8]. To prevent the last complication the procedure must be performed with the help of a rubber dam.

A dried-out canal should not be subjected to mechanical processing [9]. Working in a dry environment may cause the instrument to break or the physiological apex to end up blocked with dentin debris. While using endodontic instruments it is advised to use an aqueous solution of NaOCl, pure distilled water, or designated lubricants with antibacterial properties [10]. According to the literature, aqueous solutions may be used instead of ready-made lubricants. They are decreasing both the torsional loading and the force generated by nickel titanium (NiTi) instruments during operation [9,11]. Between the usage of different tools, it is advised to irrigate the root canal with 2 mL of NaOCl [12]. According to reports, NaOCl does not change the surface structure of NiTi instruments with corrosion and does not increase the risk of fracture [13].

The smear layer is composed of organic and inorganic material and is generated during instrumentation. As substances that remove the smear layer, we may include sodium hypochlorite in concentrations of 1% to 6%, which dissolves only organic material, and chelating agents that remove the inorganic portion of the smear layer (Ethylenediaminetetraacetic acid—EDTA in concentrations of 10% to 19% and citric acid in concentrations of 10% to 50%) [13–15]. Chelating agents are usually advised to be used in the final part of the irrigation protocol [15]. Numerous clinicians identify chlorhexidine (CHX) as an antibacterial agent. Due to the variety of compounds used in endodontic treatment, the procedure must be carried out with the aid of a rubber dam.

Many authors do not recommend chelating compound irrigation during root canal processing. It may result in root dentin erosion [16]. Studies acknowledge the importance of chelating agents but suggest that in order to reduce their destructive effects on dentin, they should be applied in small volumes (1 mL) and for a short period of time (1 min) [17,18]. Using ultrasonic activation (UA) and EDTA irrigation, it is possible to remove the smear layer and contaminations in the apical region of straight root canals in 1 min (lack of difference in comparison with 3 min of activated irrigation) [19]. Irrigation for 10 min with EDTA resulted in excessive peritubular and intratubular dentinal erosion [18].

After removing the smear layer with the aforementioned solutions, the exposed root canal wall is repeatedly rinsed with NaOCl or CHX to induce bactericidal activity [20]. There is no consensus among researchers regarding the optimal concentration of NaOCl solutions for irrigation. Some studies suggest that a concentration of 5.25% is superior to the eradication of *E.faecalis* from infected root canals in comparison to 2.5 and 0.5% concentrations (without activation) [21]. On the contrary, another research indicates that there are no significant differences between concentrations. As antibacterial factors, it rather suggests frequent delivery of new liquid and use of relatively large volumes of the solution by the operator [22].

For the final irrigation protocol, some clinicians add CHX solution. Chlorhexidine has antibacterial properties while causing less tissue irritation than NaOCl [23]. Some experiments showed that a 2% solution of CHX exceeds the 5.25% solution of NaOCl in eliminating *E. faecalis* [24]. On the contrary, there are results showcasing sodium hypochlorite as superior in terms of bactericidal properties [25,26]. There are also studies demonstrating that NaOCl and CHX have comparable antimicrobial efficacy but that their operation mechanisms are distinct [27]. Moreover, the literature indicates that CHX does not induce dentin erosion in the same way that NaOCl does when used as a subsequent irrigant after EDTA [28]. Although NaOCl, in the concentration of 1–6%, remains a golden standard in endodontics, it is noticed that none of the currently used irrigants are completely satisfactory in all respects.

4. Irrigants Activation Techniques

Using a conventional syringe for irrigation is the most prevalent method used for clinical practice. It implies a variety of problems including the vapor lock effect [29] and a lower disinfection level of up to one-third of the apical portion of the root canal [30].

The shape of the needle used with a syringe in irrigation may also modulate the flow of the irrigant within a canal, thereby influencing the efficacy of the process. In general, needles can be classified as closed-ended or open-ended. The latter is described as more effective but increases the danger of irrigant extrusion through the apical foramen [31]. The computational fluid dynamics may differ based on the type of needle. It may be validated using micro-particle image velocimetry measurements [32]. The literature reports that activation of irrigants led to more efficient smear layer cleansing in comparison with the same liquids without activation [33]. Moreover, it was reported that activation of sodium hypochlorite improves its capability of dissolving organic tissue [34]. Irrigants need to have direct contact with the root canal's wall in order to act effectively. During conventional irrigation with a needle, the exchange of fluids occurs only in very close proximity around the needle's tip (approximately 1.00–1.15 mm according to the studies) [35]. This is a reason why syringe irrigation should only be used when it can be inserted within 1 mm of the working length. It is not always possible due to the complicated morphology of root canals and the danger of forcing the solution through the tissues [35,36]. The velocity of liquid administration is a factor directly influencing flow outside of the needle. Between operators, a broad distribution of the aforementioned parameter was observed. It makes the syringe irrigation challenging to standardize and control [37].

4.1. Manual Activation

Manual dynamic activation (MDA) is an activation using a gutta percha cone inserted 1 mm before the working length. A moderate pumping motion is introduced into the irrigant-filled root canal. It is comprised of brief vertical strokes (2 mm amplitude at 100 strokes per minute). Dynamic movements generate increased intracanal pressure, which disrupts the vapor lock effect and significantly enhances irrigant replacement. This enables the use of fresh portions of the solution and their positive effect on a larger portion of the root canal system. Activation (either NaOCl or EDTA solutions) is recommended following root canal preparation [38]. Activating EDTA or citric acid solutions with MDA increases their affinity for removing the smear layer and debris [17]. Especially in one-third of the root canal apex in comparison to irrigating with EDTA without activation [39,40]. MDS demonstrated a superior ability to remove organic tissue from the apical region than conventional irrigation. However, none of these techniques achievedcomplete decontamination [41].

The study suggested that manual activation causes a risk of post-treatment pain, occurring 24 h after the procedure. MDA was compared to irrigation with a needle without any activation and passive ultrasonic irrigation. The pain was evaluated after endodontic treatment of teeth with irreversible pulp inflammation [42]. Additionally, the penetration depth of irrigants into root canal dentin is lower with MDA compared to sonic, ultrasonic, and laser-induced activation techniques [39,40].

4.2. Thermal Techniques

The boiling point of sodium hypochlorite is between 96 and 120 °C [43]. The potential of a heated NaOCl solution to dissolve pulp and cleanse a root canal is greater than that of a solution at ambient temperature [44]. Additional heating of sodium hypochlorite enhances its ability to dissolve necrotic pulp tissue as well as improves its efficiency against *E. faecalis*. However, heated solutions remove the organic part of dentine shavings more effectively than non-heated equivalents. High temperature raises the rate of the NaOCl reaction positively influencing its antibacterial properties as well as capability of dissolving organic residues. There is evidence that heating to 50–60 °C is the optimal temperature range [45] and frequent replacement of the irrigant in the root canal system is required due to the solution's rapid temperature decrease. It has been demonstrated that irrigants injected into the root canal at 66 °C reach 41 °C within 15 s and 36 °C within 4 min [46]. Low-concentration NaOCl at 45 °C has the same tissue-dissolving ability as a 5.25 percent solution at 20 °C [7].

Increasing the temperature of NaOCl improves its tissue-dissolution capacity, but on the other hand, enhances toxicity and tissue irritation [47]. From the electrochemical point of view, elevated temperature increases the oxidation-reduction potential of NaOCl making it a more potent agent [48]. Furthermore, electrical activation of NaOCl prior to application resulted in superior bovine muscle dissolution in comparison to inactivated one [49].

There are two ways to increase the temperature of irrigating solution: extracanal (heating of the solution before injection to the root canal) and intracanal (heating directly inside the root canal with heat carriers). According to research, intracanal heating of NaOCl is more efficacious than extracanal heating [50]. The former technique caused much better cleansing of the walls of the root canal from debris in comparison to the latter [51]. It occurs most probably due to the rapid heat exchange between the tissue and environment in in vivo conditions. It results in less effective extracanal heating of the solution than was demonstrated in experiments [52].

Heat carriers (System-B—Endodontic Heat Source, Kerr Endodontics, Gilbert, AZ, USA, or similar) are utilized for intracanal heating. The maximum temperature of the device is between 150 and 180 degrees Celsius, and the measurement of the tip is 30/04. Before introducing the heat carrier, processing of the root canal is necessary. The root canal is filled with sodium hypochlorite with an endodontic needle. The heat carrier is inserted at room temperature up to 3 mm from the end of the working length and subsequently activated. Each activation cycle of the heat carrier lasts 5 s with another 5 s of pause. During the process, carriers make short upward and downward movements with a few mm of amplitude in order to mix the NaOCl solution. After each of the aforementioned cycles, the irrigation solution is replaced with a fresh one [43,53]. Clinicians recommend intracanal UA of heated NaOCl because it results in superior penetration into dentin tubules and canal purity compared to syringe activation or UA alone [52]. While combining thermal activation and UA, better pulp dissolution was obtained in the side dentin tubules that remained contaminated after using either UA or thermal activation alone [53].

4.3. Ultrasound Techniques

The application of ultrasounds during and after root canal preparation is a crucial step in enhancing disinfection. The frequencies utilized in dental ultrasound equipment range from 25 to 40 kHz. Disinfection properties of ultrasound are based on the phenomena of cavitation and acoustic stream. Cavitation is minimized and limited to the tip [54]. When energy is applied to the tip of the instrument, pressure drops, and small air bubbles are formed which create a high-energy shock wave during their explosion. The bursting of bubbles causes microshocks and rapid fluid movement, which can disrupt the biofilm [55]. UA of NaOCl considerably enhances the efficiency of purifying the root canal area [56] including the best lateral canal penetration [57], antibacterial properties [58], boosting the dissolution of necrotic tissues [59] as well as the organic part of smear layer [60]. UA of NaOCl in 3 cycles from 10 to 20 s for each root canal (with irrigant renewal after each cycle) is considered as a sufficient time to achieve cleansed canals. Ultrasounds seem much less efficient in enhancing the activity of EDTA. Nevertheless, they might contribute to better removal of the smear layer as mentioned before [54]. When utilizing UA, the operator must insert the instrument point 1 mm prior to the working length [58]. Ultrasound activation is also beneficial for endodontic treatment conducted during multiple visits, giving the possibility to get rid of $Ca(OH)_2$ from the walls of root canals more efficiently in comparison to the manual syringe [61]. Using tips for UA increases the risk of instrument fracture within the root canal or escape of irrigant outside of the apical foramen [62]. The operators must be careful not to touch the canal walls with a tip, as this could result in a dampening effect or alter the canal wall′s structure [56].

4.4. Laser Activation Techniques

Lasers utilized for activation of irrigants include diode laser, neodymium-doped yttrium aluminum garnet (ND:YAG) laser, erbium-doped yttrium aluminum garnet (Er:YAG) laser and erbium, chromium-doped yttrium, scandium, gallium, and garnet (Er,Cr:YSGG) laser. We can divide laser activation techniques based on the tip placement: Laser-Activated Irrigation (LAI in which the laser tip is positioned inside the root canal and Photon-Induced Photoacoustic Streaming (PIPS) in which the laser tip is positioned within the pulp chamber. For the latter technique, Er:YAG laser is mainly used. Moreover, lasers might be used for disinfection of the root canal walls without using irrigants. Yet again, pairing two techniques gives a superior result. Using a laser in the canal filled with NaOCl has a significantly greater antibacterial effect than using a laser [63,64].

The LAI cleansing mechanism relies on cavitation in the solution [65,66]. The tip inserted in a root canal should be composed of glass fiber with a diameter between 200 and 400 m, regardless of the laser used [66]. The root canal shall be processed until at least ISO 30 with a tool expansion of 02. The depth of tip insertion should be 1 mm less than the functional length of the canal [67]. After positioning the tip at the desired depth, the laser must be activated and 1 mm/s of fiber must be removed from the root canal [68]. In the case of broad canals during the removal of the fiber, the operator needs to make sideway, sweeping movements. It is crucial to activate the laser only during the removal from the canal and not while inserting the fiber toward the canal. This allows us to avoid the danger of processing the canal with the laser. Keeping the glass fiber in constant motion in the root canal is equally important and prevents local temperature spikes [69].

PIPS is an activation technique in which a special Er:YAG laser tip is placed within the pulp chamber and induces cavitation within the irrigant (there is no need to position the instrument at the end of the canal to achieve the disinfecting effect [70]). High-velocity irrigating streams are created at a further distance from the source of activation in comparison with UA [71]. A movement of created follicles in the whole internal part of the multi-root tooth is visible with the laser tip placed just in the pulp chamber [66]. During canal processing, minimal instrumentation is sufficient for effective PIPS activation. It results in ISO 20/25 apical preparation without a specific taper designation, whereas EndoVac requires a minimum of 35/0.04 apical preparation. Despite this, the PIPS results in a more significant potential of pushing NaOCl through the apical foramen than EndoVac [72].

LAI is more efficient in cleansing the root canals, especially from intracanal bacteria than conventional or UA irrigation [65,73]. Using this type of activation allows for achieving a smoother surface of the root canal than while using UA. It translates into the creation of stronger bonding between dentin and root canal filler [74]. What is more, PIPS seems to be more effective than UA irrigation in the removal of apically located dentin residue [70]. Satisfactory removal of the smear layer by PIPS was also reported [75,76] with a high quality of open tubules in the root canal dentin [75]. PIPS appears to be more effective than conventional or sonic activation techniques in killing the bacteria deep in the dentinal tubules [77]. No advantage in terms of disinfection was demonstrated for either LAI or PIPS [66].

4.5. Other Activation Systems

On the market, there are special devices available, designated for the activation of irrigants. Among them, we can enlist pressure systems (EndoVac, Kerr Endodontics, Gilbert, AZ, USA; Rinsendo, Dürr Dental, Bietigheim, Germany) or sound-wave-based system (EndoAcivator, Dentsply Maillefer, Ballaigues, Switzerland; EDDY, VDW, München, Germany; Ripsisonic, Medidenta International Inc., Woodside, NY, USA; SAF, ReDent, Ra'anana, Israel).

EndoVac uses negative irrigation pressure. It results in the canceling of the vapor lock effect and provides better cleaning at a depth of 1 mm from the working length in comparison to irrigation with a syringe and needle [78]. The apical negative pressure irrigation technique was shown to be the most effective in delivering the irrigant up to the working length in mature permanent teeth [79]. After irrigation with the EndoVac system patients less frequently complained about post-treatment pain, compared to the irrigation with a needle [80]. It might be linked to the fact that using EndoVac limits the occurrence of pushing the irrigant through the canal to the tissues surrounding the apex, in juxtaposition with Manual Dynamic Agitation (MDA) or UA [81,82]. Moreover, EndoVac is more effective in the removal of the smear layer than MDA. It is mainly because it removes the vapor lock effect more efficiently and better cleansing of the apical area [61]. The efficiency of root canal processing is greater with using UA, but EndoVac is much safer in terms of the potential pushing of irrigants through the apex to apical tissues [83]. This system requires minimal apical preparation measuring 35/0.04 [72].

RinsEndo (Dürr Dental, Bietigheim, Germany) is a hydrodynamic irrigation system that utilizes pressure-sucking technology [82]. It is characterized by greater penetration depth of the irrigants in comparison with using a syringe and needle. However, it bears a greater risk of pushing the irrigant through the apical foramen [84]. The efficiency of cleansing root canals is better with RinsEndo in comparison with using a syringe and needle but worse when compared to MDA [62]. There are studies regarding the presence of broken tools inside the root canal which is unremovable. In that scope, pressure instruments were proven to be the best choice for irrigation. They possessed better permeability of NaOCl than UD or EndoActivator. It may ensure better microbiological control despite the difficulty of tool breakage [85].

The endoActivator system (Dentsply Maillefer, Ballaigues, Switzerland) is a soundwave-based system equipped with a non-cutting tip from synthetic material for activation of the irrigant. The tip does not cause shaving of the dentin which prevents further widening of the canals. It is possible to use many types of tips depending on the size of the root canal. They must be adjusted in the way that the tip moves freely in the canal up to 2 mm before the working length [86]. EndoActivator might be utilized to activate the solution of EDTA [87].

EDDY (VDW, München, Germany) is a tip made of elastic polyamide fiber activated with the air ultrasonic tip, designated to work in a frequency range of 5000–6000 Hz. A flexible working tip is safe for root canal walls and causes no damage to dentin compared to UA sharp tips [88]. Sonic activation (with EDDY of EndoActivator) and PUI are better choices for removing debris than irrigation without activation with a syringe in straight root canals. Moreover, EDDY and PUI removed the smear layer more efficiently than manual activation [89]. The study shows that EDDY can be also more effective than PUI at removing antibiotic pastes from the root canal [90]. One must bear in mind, that patients subjected to irrigation with EDDY complained about post-treatment pain more frequently than a group of patients treated with MDA. It might be related to the much more frequent pushing of irrigants through the apical foramen caused by using EDDY [50].

5. Efficacy of Activation Systems in Curved Canals

The curvature of the canals may affect how effectively the activation system works. Studies on curved root canal models' shapes are uncommon. The majority uses models with straight canals [91]. Increasing the apical size above 40 may enhance disinfection when treating severely curved canals; however, this is not always achievable [92]. The adverse impacts of increased canal curvature were most obvious for the sonic techniques, but this was not noticeable for PUI. The latter may have an enhanced PUI influence due to ultrasonic file pre-bending [91].

According to multiple research, sonic agitation (Endo Activator and EDDY) performed significantly better than syringe irrigation but comparable to PUI [93]. The smear layer was much more susceptible to all activation methods than syringe irrigation. Nevertheless, several studies have found a substantial difference in cleaning abilities between sonic and ultrasonic activations. While activation with PUI produced the best results for clearing debris from uneven canal surfaces, EDDY outperformed PUI significantly in terms of antibacterial activity. EDDY and syringe irrigation eliminated the smear layer from the coronal region substantially more effectively than from the apical region. In contrast, PUI did not show any appreciable enhancement in terms of smear layer removal. The increased streaming velocity of ultrasonic devices, which is often unaffected by the curvature of the root canal, may help to explain this finding.

6. Discussion

The state of knowledge about techniques and biomaterials used in modern medicine changes rapidly nowadays. It is one of the clinicians' tasks to constantly educate and search for the best possible solutions for their patients. To gain the latest and most reliable knowledge about clinical procedures, also in the field of endodontic treatment, clinicians may follow instructions provided by leading endodontic associations. They offer verified and actual knowledge presented in the formula of guidelines.

In 2006 European Society of Endodontology presented a guideline about endodontic treatment [94]. The authors enumerate the following aims of the irrigation—elimination of microorganisms, flushing out debris, lubrication of root canal instruments, and dissolution of the organic debris. Attention is paid to not irritating the periradicular tissues by using a suitable syringe and the exact amount of the irrigant. No specific data is given. The possibility of using ultrasonic or sonic systems is also outlined.

British Endodontic Society remarks that the success of the endodontic treatment depends on accurate diagnosis and completion of each stage of treatment to a high standard [95]. In the guide presented in 2022, it is noticed that the primary objective of endodontic treatment is the elimination of microorganisms from the root canal system and preventing reinfection. The aims of the irrigation are defined as antibacterial action, tissue dissolving capabilities, reduction of the friction between the instrument and dentine, improving the cutting effectiveness of the files, lowering the operation field's temperature, and a washing effect to flush out debris. Most importantly, irrigation is the only way to impact areas of the root canal wall untouched by mechanical instrumentation. Irrigants recommended by the British Endodontic Society include sodium hypochlorite solution (0.5% to 5.25%), EDTA (17%), and Chlorhexidine (2%). Activation of irrigants is also recommended. They can be enhanced using dynamic agitation, ultrasonic activation, negative pressure irrigation, or with heat.

Considering modern studies, we may conclude that sodium hypochlorite is the primary irrigant of choice. Usage of the chelator is also necessary in order to dissolve hard-tissue debris created during instrumentation or the inorganic components of the smear layer [31]. The same study concludes that there is no evidence, that long-term clinical success of endodontic treatment can be improved by irrigants' activation. However, it is noted that delivering NaOCl and EDTA by a syringe and ultrasonic activation is the most popular and efficient protocol of irrigation during root canal treatment. Such an approach is promoted in the review from 2012. The paper, based on many in vitro studies, emphasizes the role of ultrasonic irrigation as having a positive effect on chemical, biological, and physical debridement of the root canal system [96]. The study, which analyzed articles available on MEDLINE and Cochrane bases, concludes that to fully compare different methods of activation, there is a need for protocols' standardization and further tests are necessary to obtain a complete state-of-the-art. Another review on the effectiveness of ultrasonically activated irrigation from 2018 comparing 15 studies came to a similar conclusion as presented above [97]. Authors notice that ultrasonic irrigant activation is more efficient in microorganism reduction compared to other irrigant activation techniques.

7. Final Remarks

The contemporary state of dental knowledge does not indicate one optimal root canal irrigation protocol leading to clinical success of the endodontic treatment. There are many irrigants, including NaOCl, EDTA, CHX, citric acid, distilled water, saline, and many techniques for their activation. Among them, we can outline manual activation, thermal techniques (extra- and intracanal), pressure techniques, sonic/ultrasonic techniques, PUI, and laser techniques. Activation methods such as EDDY, PUI or UA allow for much more efficient removal of a smear layer.

Some activation techniques, like EDDY or manual activation with gutta-percha, might contribute to post-treatment pain. Literature indicates a superior advantage of the activation of irrigants in comparison to its absence. However, one effective way of activation cannot be indicated. It is very much dependent on specific patients' root canal anatomy and predisposition.

Author Contributions: Conceptualization, M.R. and K.S.-M.; methodology, A.P.; validation, M.D., P.J.P. and K.S.-M.; formal analysis, M.D., K.S.-M., W.G. and M.M.; investigation, M.R., A.P. and N.J.; resources, P.J.P.; writing—original draft preparation, M.R. and A.P.; writing—review and editing, P.J.P. and N.J.; visualization, P.J.P.; supervision, K.S.-M., M.D., W.G. and M.M.. All authors have read and agreed to the published version of the manuscript.

Funding: This article was co-financed by a subsidy from Wroclaw Medical University, number SUBZ.B180.23.054 and SUBZ.B010.23.057.

Data Availability Statement: The data presented in this study are available in the article.

Conflicts of Interest: The authors declare no conflict of interest.

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