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Root Canal Irrigants in Pediatric Dentistry – A Narrative Review

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ABSTRACT:

The two main techniques used in endodontic therapy to get rid of all the germs, dead tissue, and microbial by-products from the canal are chemical and mechanical root canal debridement. Surface disinfection is a great use for sodium hypochlorite, a potent organic tissue dissolver with a wide range of antibacterial qualities. Conversely, the inorganic components on the smear layer may be eliminated using chelating agents. The smear layer can be removed with this irrigation technique, although the apical third is where it is least successful. Irrigating solutions must come into direct touch with the entire root canal wall surfaces when employing irrigant activation devices, particularly in the apical regions of small root canals. Irrigants play a crucial role in the canal system since they facilitate the seepage of medications into the system while cleaning the canal. Thus, prior to the obturation process, the canal must be in good health. These days, a lot of irrigants have been researched; as a result, a compilation of the different sources that are available and an examination of their effects in vivo and in vitro are necessary. Since the appropriate activation and features of the root canal system are critical to the effectiveness of endodontic root canal therapy, the relationship between irrigants and canal cleanliness is critical. As a result, the use of modern-day irrigating solutions along with benefits and drawbacks are included in this review.

1. Introduction

Long-term success in root canal therapy is not pertained to a single factor but relates to three aspects of treatment which includes instrumentation, disinfection, and obturation [1]. The use of instruments acts only on the central body of the canal, leaving canal fins, isthmi, and cul de sacs untouched after completion of the preparation [2,3]. These areas might harbour tissue debris, microbes, and their by-products, preventing close adaptation of the obturation material and resulting in persistent periradicular inflammation [2,4]. It has been reported that more than 35% of root canal surfaces remain untouched by the root canal files, regardless of the filing method [5]. So, disinfection is key to augmenting the process because it allows for cleaning beyond what might be achieved by root canal instruments alone [6].

Irrigation supports mechanical instrumentation by reducing friction and removing residuals from the root canal. It is truly said "Instruments shape, Irrigants clean*"* [2,7].

The challenge for successful endodontic treatment always relies on the removal of remnants of the pulp tissue, debris generated during instrumentation, dentine smear layer, micro-organisms, and micro toxins from the root canal system [8,9].

Many irrigating solutions have antimicrobial activity that effectively kills residual microbes in the canal [10]. Irrigants also help to prevent debris accumulation apically in the root canal and into periapical area and exhibit antimicrobial activity by actively killing bacteria and yeast when in direct contact with the microorganisms [11,12].

The most frequently used irrigants in contemporary endodontic treatment are sodium hypochlorite, hydrogen peroxide, chlorhexidine, citric acid, iodine, potassium-iodide, alcohol and EDTA solutions [7]. More recently, several new solutions such as MTAD, Ozone, Light activated disinfection, Lasers, Nanoparticles have been advocated for disinfection [13]. There is also an increased popularity in the usage of herbal or natural products for root canal irrigation for

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their anti-inflammatory and/or antioxidant properties and most of the commercially available irrigants used routinely have cytotoxic reactions. Routine irrigation syringe and needle is unable to eliminate bacteria from dentinal tubules [14,15].

Hence, there is a need for alternate solutions/systems. Amongst the systems a range of lasers are now available for use in dentistry have been proved effective in cleaning and disinfecting the root canal and lateral canals [16]. Photoactivated dye techniques have been used to disinfect the root canals [17].

2. Mechanism of action

1. Irrigants perform physical and biological functions. Dentin shavings get removed from the canals by irrigation so that they do not get packed at the apex of the root canal [18].
2. Instruments do not work properly in dry canals. Their efficiency increases by use in wet canals. Instruments are less likely to break when canal walls are lubricated with irrigation [2,19].
3. Irrigants act as solvent for necrotic tissue, so they loosen debris, pulp tissue and microorganisms from irregular dentinal walls [2,15].
4. Irrigants help in removing the debris from accessory and lateral canals where instruments cannot reach [3,14].
5. Most irrigants are germicidal but they also have antibacterial action [13,19].
6. Irrigants (e.g. NaOcl) also have bleaching action to lighten teeth discoloured by trauma or extensive silver restorations and decrease the chance of postoperative darkening [7,18].
7. Though presence of irrigants in the canal facilitates instrumentation but simultaneous use of some lubricating agents (RC prep, REDTAC, Glyde, etc...) make the instrumentation easier and smoother [2,20].

3. Ideal requirements of irrigants [7,12,18]

1. It must exhibit broad spectrum antimicrobial properties.
2. It must aid in the debridement of the canal system.
3. It must have the ability to dissolve necrotic tissues or debris.
4. It should have a low toxicity level.
5. It should have low surface tension so that it can easily flow into inaccessible areas.

4. Classification

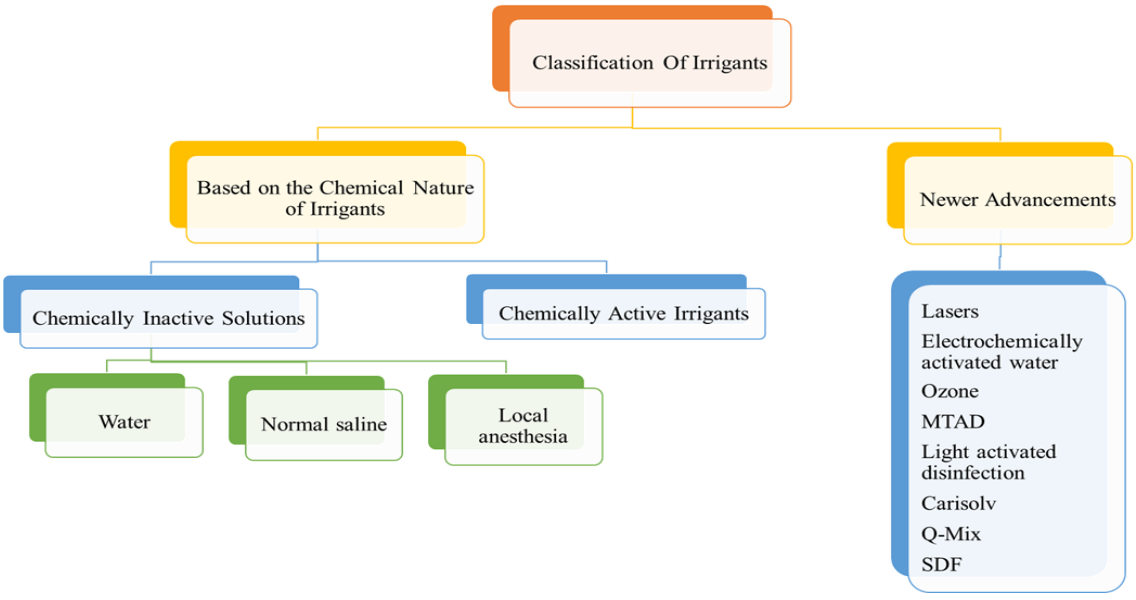

Fig 1: Classification of Irrigants [21]

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6. It should be able to effectively sterilise the root canal (or at least disinfect them).
7. It should be able to prevent formation of a smear layer during instrumentation or dissolve the latter once it is formed.
8. It should inactivate bacterial endotoxin.
9. It should be easily available and should be a good lubricant.
10. It should have low cost
11. It should be convenient to use, have adequate shelf life and ease of storage.
12. If irrigant comes in contact with vital tissues, it should be systemically nontoxic, non-caustic to periodontal tissue and have little potential to cause an anaphylactic reaction.

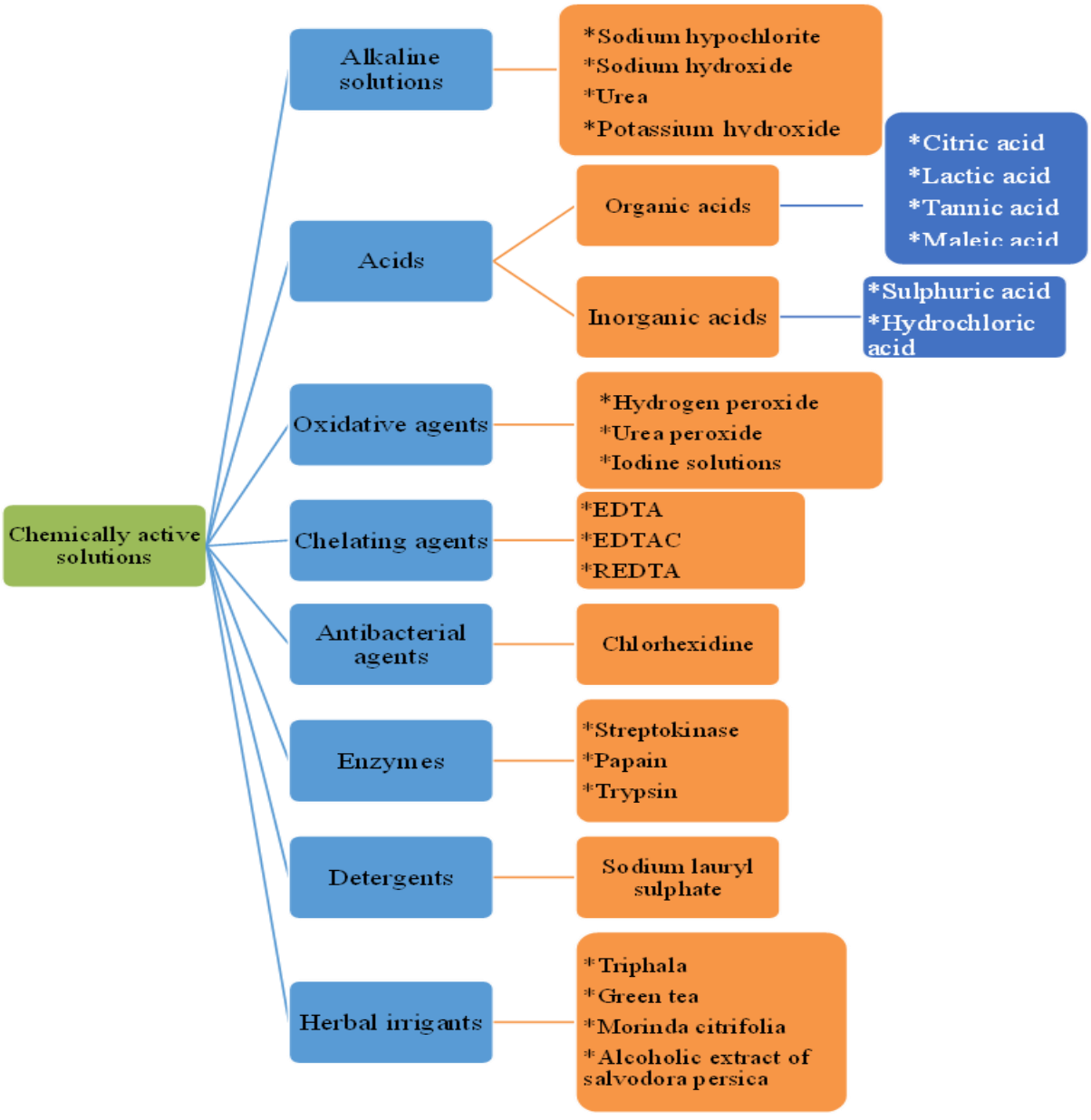

Fig 2: Chemically Active Irrigants [21]

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5. Chemically Inactive Solutions Water

Use of tap and distilled water appears in the literature and used as a bland solution useful for its flushing action [22]. Distilled water does not have antibacterial effect and is also ineffective in removing both smear layer and superficial debris from the canal [23]. Ingle and Zeldow shown that distilled water might only temporarily reduce the number of micro-organisms in the canal [12,24].

Some of the literature suggests the final irrigation with sterile water to prevent any precipitate formation following use of saline, NaOcl, EDTA or citric acid as well as to terminate any solvent action of irrigants previously used [25].

Local anaesthetics

Although there appears to be no published research on the efficacy of local anaesthetic agents as an irrigant, there has been reference to it as a bland, sterile flushing agent [26]. Mayne (1959) recommended sterile isotonic solution, such as local anaesthetic warmed in hot water, as an irrigant during the removal of vital pulps. It was speculated that a non- isotonic solution could cause the rupture of the red blood cells, thereby allowing the breakdown products of haemoglobin to enter the dentinal tubules and results in subsequent tooth discoloration

Saline

According to dental literature saline has been mostly employed as a negative control irrigant in many studies [27,28] Saline has no action on smear layer, nor it is effective tissue solvent neither do they provide chelation action [2,15]. It is mainly used as a final flush to reduce irritation from other irrigants [18].

6. Chemically Active Irrigants Hydrogen peroxide

It is widely used biocide for disinfection and sterilization [29]. It is clear, odourless liquid that is used in dentistry mainly in 3% concentration as an irrigating solution [30]. It is a strong oxidizing agent which rapidly degrades into water and nascent oxygen. While in contact with tissue enzymes catalases and peroxidases, the liberated [O] has bactericidal effect but this effect is transient and diminishes in presence of organic debris [31].

It causes the oxidation of bacterial sulfhydryl group of enzymes and thus interferes with bacterial metabolism.

Urea peroxide (Endo- PTC or Glyoxide)

It is white crystalline powder with slight odour. It is soluble in water, alcohol, and glycerine. It is another widely used solution to aid instrumentation [32]. It is an anhydrous glycerol based irrigant. It presents the properties that are not irritating to the periapical tissues and non-allergic. Its action combines the effect of urea and hydrogen peroxide.

Urea peroxide → Urea + Hydrogen peroxide

Iodine solution

Iodine in potassium iodide solution has been recommended as a potential root canal irrigant because E. faecalis is sensitive to it. In practice, a solution of 5% potassium iodide or Churchill's solution can be used.

It is a powerful oxidizing agent that disrupt bacterial cellular enzyme systems and inactivate them. Concentration commonly used is 2-10%.

EDTA

Nygaard Ostby was the first who suggested the use of 17% EDTA for cleaning and widening of root canals. It dissolves the inorganic portion of smear layer thereby softening dentin and facilitates degradation of calcifications obliterating the root canals. It functions by forming a calcium chelate solution with calcium ion of dentin, because of which dentin becomes more fragile and easier to instrument. EDTA is used during cleaning and shaping of root canal and is effective for achieving canal patency, enlargement, debridement, and disinfection.

Citric acid

In endodontic research, citric acid can be used as a substitute for EDTA [33]. Many different concentrations of citric acid have been used, with varying degree of success. 10%, 20%, 25%, 50% solutions are used successfully for irrigation

Chlorhexidine

Chlorhexidine was developed in the late 1940s in the research laboratories of imperial chemical industries ltd. (macclesfield, england). Chlorhexidine is a strong base and is most stable in the form of its salts.

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Morinda Citrifolia

Morinda Citrifolia commercially known as Noni is indigenous to tropical countries and is considered as an important folk medicine. It is also called as Indian Mulberry, Nono or Nonu, Cheese fruit and Nhan in various cultures throughout the world. Its juice has a broad range of therapeutic effects including antibacterial, anti-inflammatory, antiviral, antitumor, anthelminthic, analgesic, hypotensive, anti-inflammatory, and immune enhancing effects [34]. Its antibacterial property is attributed to the presence of L-asperuloside and alizarin. It also has several phytochemicals including lignans, oligopolysaccharides, flavonoids and catechins.

Triphala and Green tea polyphenols (GTP)

Triphala is one of the well-known Indian Ayurvedic herbal formulations consisting of dried and powdered fruits of three medicinal plants namely *Terminalia Bellirica*, *Terminalia Chebula* and *Emblica Officinalis*. It is rich in citric acid, which may aid in removal of smear layer thereby acting as chelating agent and also found to be alternative to sodium hypochlorite for root canal irrigation. Green tea is made solely from the leaves of *Camellia sinensis*. The antimicrobial activity is due to inhibition of bacterial enzyme gyrase by binding to ATP B sub unit [35]. Green tea polyphenols have significant antioxidant, anticariogenic, anti-inflammatory, thermogenic, probiotic, and antimicrobial properties in numerous human, animal and in vitro studies. Triphala and GTPs are proven to be safe, containing active constituents that have beneficial physiologic effect apart from its curative property.

Propolis

This is prepared from resins collected by bees from trees of poplars and conifers or from flowers of genera clusia. The most important pharmacologically active constituents in propolis are flavonoids, phenolics and aromatics. It is believed that flavonoids account for much of the biologic activity in propolis. Propolis exhibits a wide range of biologic activities, including antimicrobial, anti-inflammatory, antioxidant, anaesthetic and cytotoxic properties. The anti-inflammatory property of propolis is due to the presence of caffeic acid and phenethyl ester (CAPE) in propolis and effective against *Streptococcus sobrinus* and *Streptococcus mutans*. Ethanol extract of propolis presents good properties for endodontic use, such as promoting bone regeneration and inducing hard tissue bridge formation in pulpotomies or pulp capping. Propolis is dispensed in various forms which serve as a better intracanal irrigant and intracanal medicament.

Azadirachta Indica (Neem)

Commonly known as Neem is used as traditional medicine for household remedy against various human ailments, since antiquity. Nimbidin, a major crude bitter principle extracted from the oil of seed kernels of A. indica demonstrated several biological activities. Few tetranortriterpenes including nimbin, nimbinin, nimbidinin, nimbolide and nimbidic acid have been isolated. Neem leaves, seeds and bark possesses a wide spectrum of antibacterial action including M. tuberculosis and streptomycin resistant strains.

Carvacrol

Carvacrol is present in the essential oils of origanum vulgare, oil of thyme, pepperwort, bergamot and satureja khuzistanica jamsizad oil (SKJ oil) Carvacrol has inhibitory action on *E-coli* and *P-aeruginosa*. The cause of antimicrobial property is attributed to action on several targets in bacterial cell and disruption of bacterial cell membrane. It also helps in repair of periapical tissues. This property is due to the presence of phenolic component which stimulates pulpal fibres, phenomena known as hormesis.

Salvadora Persica Solution (Miswak-Siwak)

Its chewing sticks contain trimethyl amine, salvadorime chloride and fluoride in large amounts. 15% alcoholic extracts of it have maximum antimicrobial action. It can be used as a substitute for sodium hypochlorite and chlorhexidine as root canal irrigant. Various concentration of salvadora persica solution have been used (1%, 5%, 10%, 15%, 20%). But high antimicrobial activity of Salvadora Persica extract against aerobic and anaerobic microorganisms is demonstrated at 15% concentration which statistically has no significant difference from 5.25% sodium hypochlorite and 0.2% chlorhexidine.

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German Chamomile

It is used for removal of smear layer and found to be more effective than NaOcl. An SEM study had concluded using two medicinal plants i.e. German chamomile extract and tea tree oil might disinfect the root canal system with less toxicity when used as irrigants [36]. It was concluded that the efficacy of chamomile to remove smear layer was superior to NaOcl alone but less than NaOcl combined with EDTA.

Tea Tree Oil

This is a native Australian plant with terpenin-4-ol as a major component, responsible for antibacterial and anti-fungal properties. It is used as root canal irrigant, but less effective compared to EDTA and NaOCl.

Garlic (Allium sativum)

The main active component of garlic is allicin. It is antibacterial and has immune regulatory functions. Allicin destroys cell wall and cell membrane of root canal bacteria. This is used as irrigant alternative to NaOcl.

Jieeryin Solution

This is a pure Chinese herbal compound and has heat clearing, detoxifying, antibacterial and anti-inflammatory effects. It is used for root canal irrigation with ultrasonics and is found to be effective against anaerobic bacteria. 30% concentration of this has similar effect to that of NaOcl.

Aloe Vera Gel

Aloe leaves contain clear gel and green part of the leaf that surrounds the gel is used to produce juice or dried substance. It contains alloins and barbadoins as main chemical constituents. Aloe Vera possesses good anti-bacterial and anti-fungal activity. *Streptococcus pyogenes* and *Streptococcus faecalis* are two microorganisms that have been inhibited by aloe vera gel. The antimicrobial effect of water, alcohol, chloroform extracts of Aloe Vera gel were investigated on different strains of bacteria and yeasts and concluded that chloroform extract of Aloe vera Showed significant Zone of Inhibition against *E. faecalis.* hence, Aloe vera has shown antimicrobial effect against resistant microorganisms found in pulp space [37,38].

Curcuma longa (Turmeric)

Curcumin is the principle curcuminoid of the popular Indian spice turmeric, which is a member of the ginger family (*Zingiberaceae*). The active constituents of turmeric are the flavonoid curcumin (diferuloylmethane) and various volatile oils, including tumerone, atlantone, and zingiberone. It possess good antioxidant, hepatoprotective, antimicrobial and anti-cancer activity [39].

An in vitro study to evaluate the antimicrobial efficacy of curcumin against E. faecalis revealed that curcumin had significant antibacterial activity against E. faecalis and concluded that the antibacterial activity of curcumin was similar to sodium hypochlorite and thus herbal medicine can be used in endodontics for root canal failure.

Acacia nilotica

It is species of Indian and Africans sub-continent. Antimicrobial function is believed to be due to tannins, phenolics compounds, essential oil and flavonoids and is effective against E-faecalis [40].

7. Newer Advancements

Lasers

The potential use of lasers in eradicating the root canal microbes has been the focus of interest for many years. With regards to laser application to endodontics, laser systems such as Neodymium: Yttrium-aluminium-garnet (Nd: YAG), diode and carbon dioxide (CO2) lasers have proved effective in cleaning and disinfecting the root canal and lateral dentinal tubules.

At the same time hard tissue lasers like Er: YAG and Er: YSGG underwent further development resulting in delivery systems also usable for root canal application [41]. Recently, laser therapy has shown great promise in endodontics, especially in removal of the smear layer that remains on the instrumented root canal wall.

Electrochemically Activated Water

There is a need for an irrigant with equivalent antibacterial properties that is milder in its action on vital tissue but while ably debriding the dentine surface does not weaken its structure in the manner of sodium hypochlorite. Such an irrigant has reputedly been found and is known as Electrochemically activated water. The

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ECA technology represents a new scientific paradigm developed by Russian scientists at the All-Russian Institute for Medical Engineering (Moscow, Russia, CIS) [42].

Ozone

Ozonated water is newer irrigant solution which is shown to be powerful antimicrobial agent against bacteria, fungi, protozoa, and viruses. Ozone has been proposed as an alternative oral antiseptic in dentistry, due to its antimicrobial power reported for gaseous and aqueous forms, the latter showing a high compatibility with human cells [43].

Light Activated Disinfection /Photo Activated Disinfection

The introduction of antimicrobial light activated therapy (LAT) for the elimination of biofilm mediated microbial infections is revolutionizing current concepts of disinfection

LAD involves the photoactivation of a photosensitizer (a light sensitive compound) with low-energy coherent or non-coherent light, in the presence of oxygen to produce reactive oxygen species, such as hydroxyl radicals, superoxide and singlet oxygen. These reactive oxygen species act on multiple targets in a bacterial cell, resulting in instantaneous killing.

The concept is internationally called PACT (Photodynamic Antimicrobial Chemotherapy), LAD (Light Activated Disinfection) or PAD (Photo Activated Disinfection) [44].

MTAD

Recently, MTAD has been introduced as a final rinse for disinfection of root canal system. Since its introduction, MTAD has been the focus of attention as an alternative root canal irrigant. MTAD was introduced by Torabinejad and Johnson at the Loma Linda University in 2003.

Composition of MTAD

- 3% doxycycline, a broad-spectrum antibiotic
- 4.25% citric acid, a demineralizing agent
- 0.5% polysorbate 80 detergent (Tween 80) [45].

Nanoparticles

Various nanoparticles have gained popularity as antimicrobial agents because of their broad spectrum of activity and biocompatibility. Recent studies have focused on using nanoparticulate materials to disinfect root canals.

Nanoparticles exhibit higher antibacterial activity because of their polycationic / polyanionic nature with higher surface area and charge density, resulting in greater degree of interaction with the bacterial cell. It has been observed that the size of nanoparticles plays an important role in their antibacterial activity, with smaller particles showing higher antibacterial activity than the macro scaled ones [46].

Sonic Irrigation

Tronstad et al were the first to report the use of a sonic instrument for endodontics in 1985.

The EndoActivator System (Dentsply Tulsa Dental Specialties, Tulsa, OK) is a more recently introduced sonically driven canal irrigation system.

The EndoActivator System effectively cleans debris from lateral canals, remove the smear layer, and dislodge clumps of simulated biofilm within the curved canals [47].

Ultra Sonic Irrigation

Ultrasonic devices were 1st introduced into the field of periodontics in the 1950s. The use of ultra sonic in the field of endodontics was 1st suggested in 1957 by Richman as a means of canal debridement. In 1980, an ultrasonic unit designed by Martin et al became commercially available for endodontic use [47].

8. Conclusion

Famous endodontic maxim that postulates “It does not matter what you put in root canal; it is more important what you take out”. Every root-canal system has spaces that cannot be cleaned mechanically. The only way we can clean webs, fins, and anastomoses is through the effective use of an irrigant. Irrigation protocol also play a key role in disinfecting root canal system. The irrigants that are most used during cleaning and shaping include NaOcl, CHX, EDTA and MTAD. Although hypochlorite is the most important irrigating solution no single irrigant has all characteristics of an ideal irrigant.

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Detailed understanding of the mode of action of various solutions is important for optimal irrigation.

Optimal irrigation is based on the combined use of two or several irrigating solutions, in a specific sequence, to predictably obtain the goals of safe and effective irrigation. Many new materials and methods have recently been introduced to improve root canal debridement and to achieve root canal sterilization. New developments such as CFD and mechanical devices will help to advance safe and effective irrigation.

Sonic and ultrasonic vibrations alone or in combination with antibacterial irrigants as well as application of negative pressure have been used to increase the efficacy of these irrigants. Thus, from the above it can be concluded that irrigation has a key role in successful endodontic treatment

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