

# Impact of Surface Tension of Endodontic Irrigants on Root Canal Treatment: A Review

Anju Bala<sup>1</sup>, Zara Suharwardy<sup>2</sup>

<sup>1</sup>Post Graduate Student, Department of Conservative Dentistry and Endodontics, PDM Dental College and Research Institute, Bahadurgarh, India

Corresponding Author Email: [dr.anju29\[at\]gmail.com](mailto:dr.anju29[at]gmail.com)

<sup>2</sup>Post Graduate Student, Department of Conservative Dentistry and Endodontics, PDM Dental College and Research Institute, Bahadurgarh, India

**Abstract:** *Endodontic irrigants are chemical solutions used in root canal treatment to clean, disinfect, and shape the inside of the tooth's root canals. The physicochemical properties of these irrigants are essential in determining their effectiveness and safety. Some of the key physicochemical properties of common endodontic irrigants are pH level, solubility, temperature, concentration, temperature, antimicrobial activity, chelating ability, viscosity and least but not last, surface tension. These properties affect how irrigants interact with the tooth structure, bacteria, and debris inside the root canals. This article is aimed to highlight the impact of surface tension of endodontic irrigants in root canal procedures. To trace this relation various search engines like Google Scholar, Pubmed and Research Gate are used by using keywords like Endodontic Irrigants, Surface Tension, Significance of surface tension of root canal irrigants etc. Inclusion criteria is based only those articles (clinical research, basic research and review), are selected which gives direct or indirect relation between surface tension and outcome of endodontic procedures and rests are excluded which do not end on key points. Almost every article concludes that lowering the surface tension of endodontic irrigants effect the outcome of root canal treatment positively. Still the researches are going on and the concrete value of surface tension is awaited.*

**Keywords:** Endodontic irrigants, Surface tension, Factors effecting endodontic irrigants, Significance of surface tension of endodontic irrigants, Physicochemical properties of root canal irrigants.

## 1. Introduction

Endodontic therapy, is a dental procedure performed to save a damaged or infected tooth. It involves removing the pulp (the innermost soft tissue of the tooth), cleaning and disinfecting the inside of the tooth, and then sealing it to prevent further infection. The goal of endodontic treatment is to remove all vital and necrotic tissues, microorganisms, and microbial by-products from the root canal system. This goal can be accomplished by chemical and mechanical cleaning of the root canal system. The anatomy of the root canal system is extremely complex and variable, and effective cleaning and disinfection are not always possible. Root canals are usually shaped under constant irrigation with hand instruments and rotary systems.<sup>1</sup> It is truly said, "Instruments shape, irrigants clean." Every root canal system has spaces that cannot be cleaned mechanically. The bacteria located in areas such as isthmuses, ramifications, deltas<sup>2</sup> irregularities, and dentinal tubules will not be eliminated by mechanical means alone.<sup>3</sup> In a study of micro-CT images obtained before and after root canal shaping, 35% or more of the root canal surface (including the isthmus) was found to be untouched, regardless of the canal preparation technique. Therefore, the importance of irrigation and the complete disinfection of root canals has been emphasized. Literature evidences that the number of infected tubules and depth of penetration of bacteria are highly variable and may range from 150  $\mu$ m to 50 percent of the distance between the main root canal and cemento-dentinal junction.<sup>4</sup>

The irrigation effectiveness depends on the working mechanisms of the irrigants and the ability to bring the irrigants in contact with microorganism and tissue debris in

the root canal.<sup>5,6</sup> The intimacy of this contact is associated to the wettability of the dentin surface where the drop of irrigant is applied. The term "wetting ability" refers to the ability of a liquid to wet a solid surface while the term "wettability" is defined as the ability of the surface of a material to be wet in a uniform and stable way by a liquid substance.<sup>7,8</sup> The wetting ability of a solution influences its penetration ability into the main and lateral canals as well as into the dentinal tubules. It strictly correlated to its surface tension.<sup>9,10</sup> Nowadays, instrumentation is largely considered a means of providing access to the apical anatomy for the irrigants, which are then expected to accomplish most of the cleaning and disinfection.<sup>11</sup> The change of paradigm motivated a renewed interest in root canal irrigation, which is manifested by the large number of studies that have been published within the last 20 years and the upward trend. Irrigation appears to be one of the hot topics in Endodontology with hundreds of new studies being published every year.<sup>12</sup>

However, conflicting findings are often reported and the resultant information overload may confuse clinicians, researchers and decision makers.<sup>13</sup> Therefore, the purpose of this review is to set the relation between surface tension of endodontic irrigants and outcome of root canal therapy and the challenges that need to be tackled, to discuss, to highlight knowledge gaps and to provide directions for future developments in this particular area.

## 2. Material and Method

Database systems Pubmed, Google Scholar and Research Gate were used to extract the articles. In regards to inclusion criteria, only those articles (original research/ basic research/

case studies/ review articles) were selected which shows direct or indirect effect of surface tension on endodontic treatment. Keywords to search the article was “Endodontic irrigants, Surface tension, Factors effecting endodontic irrigants, Significance of surface tension of endodontic irrigants, Physicochemical properties of root canal irrigants”. Exclusion criteria were all other articles which do not end on key point.

### 3. Review

#### *Origin of Surface Tension*<sup>14</sup>

Liquids consist of molecules, each of which is surrounded by other molecules with a distance close to the molecule diameter. Strong, short-ranged and attractive cohesive forces (van Der Waals forces) act between the molecules. To remove a molecule from the other molecules, work against these forces has to occur. In the bulk of a liquid (with distance to the surface), the force of cohesion between the molecules is the same in all directions. This is not the case for molecules on the surface. These molecules experience a net force of attraction that pulls them back into the body of the liquid. This is due to the fact that there are more molecules below than above and outside the surface. It can be defined as The force between molecules which produces a tendency for the surface area of a liquid to decrease.

#### *Factors influencing the surface tension*

Surface Roughness<sup>14</sup>, pH<sup>15-19</sup>, Temperature<sup>20</sup> and addition of surfactants<sup>21</sup> influence the surface tension of an irrigant.

#### *Role of surface tension in Root Canal Treatment*

**Lubrication and wetting:** Root canal irrigants with lower surface tension can more effectively wet and penetrate the complex root canal anatomy. This allows for better lubrication and flow of the irrigant within the canal, facilitating its access to areas that are difficult to reach, such as lateral canals, isthmuses, and fins. Improved wetting helps in effective removal of debris, biofilms, and residual pulp tissue. These findings are supported by Abou-Rass and Patonai<sup>22</sup> and concluded that the addition of polysorbate 80 to distilled water, alcohol, sodium hypochlorite, and EDTA produced the following effects: (1) It reduced the surface tension of these solutions 15 and 20 percent. (2) It increased the flow of these solutions into the root canal after a 5-minute application, whereas there was no significant increased flow at 7 days. Again findings were supported by Yılmaz et al.<sup>23</sup> and stated that the addition of surfactant to the EDTA solution significantly decreased the surface tension of EDTA solution and increased the wettability of root canal dentin surfaces.

**Enhanced Penetration:** Lower surface tension enables the irrigant to penetrate into dentinal tubules, microscopic irregularities, and accessory canals. This is important for thorough disinfection, as it allows the irrigant to reach areas where bacteria and their byproducts may reside, preventing reinfection. Findings were supported by Luciano Giardino<sup>24-25</sup>, Generali, L.26 and Peters OA<sup>27</sup>.

**Debris Removal:** Low surface tension irrigants are more likely to dislodge and carry away debris, bacteria, and pulp remnants from the root canal system. This action contributes

to the removal of microbial biofilms and the elimination of potential sources of infection. Same thing is supported by Mohammadi Z and Abbott PV.<sup>28</sup>

**Smear Layer Removal:** The low surface tension of irrigants aids in the removal of the smear layer that forms during instrumentation. This layer, composed of organic and inorganic debris, can harbor bacteria and hinder the effectiveness of disinfection. This finding is supported by Torabinejad M, Handysides R, Khademi AA, Bakland LK<sup>29</sup>.

**Improved Disinfection:** Irrigants with low surface tension can access dentinal tubules more effectively, increasing the potential for reaching bacteria residing within these microstructures. This results in improved disinfection of the root canal system. Same thing is supported by Mohammadi Z, Shalavi S, Jafarzadeh H and Abbott PV<sup>30</sup>.

**Minimised Extrusion Risk:** Low surface tension irrigants are less likely to create excessive pressure within the root canal system, reducing the risk of irrigant extrusion beyond the apex, which could cause discomfort or complications. It is supported by Al-Jadaa A, Paqué F, Attin T and Zehnder M<sup>31</sup>.

Modern root canal therapy consists in the cleaning, shaping and 3-dimensional filling of root canal system, followed by the immediate coronal sealing using resin-based materials.<sup>32-</sup>

<sup>33</sup> During the cleaning and shaping procedure, substances are used concomitantly mechanical instrumentation to promote antimicrobial activity and tissue dissolution. Substances commonly used during this phase are sodium hypochlorite (NaOCl) and chlorhexidine.<sup>34, 35-37</sup> After preparation, other substances as citric acid, EDTA and phosphoric acid (in different ranges) are proposed for smear layer removal.<sup>34, 37-</sup>

<sup>41</sup> Finally, before coronal sealing, antioxidant solutions, as sodium thiosulfate and sodium ascorbate, and chlorhexidine have been proposed to recover the bond strength of NaOCl treated dentin.<sup>32, 42-47</sup> To exert its function, the irrigating substances must be brought into contact with the dentin wall. The intimacy of this contact depends on the substances surface tension, which is defined as the force between molecules that produces a tendency for the surface area of a liquid to decrease. This force tends to inhibit the spread of a liquid over a surface or to limit its ability to penetrate a capillary tube. The efficiency of an endodontic irrigant depends on its lower surface tension.<sup>48</sup> Low surface tension enables the irrigant to penetrate deeply into the canal system and dentinal tubules, while low viscosity ensures that the irrigant flows smoothly through these spaces. This combination reduces the chances of residual infection and increases the likelihood of a successful outcome of the root canal treatment. By effectively disrupting biofilms and removing debris, the risk of persistent or recurrent infections is minimized, leading to better healing and improved prognosis.

In short, it can be summarised as low surface tension enhance the efficiency of root canal shaping and cleaning. It's important for clinicians to select endodontic irrigants with optimal surface tension based on the specific clinical scenario. Tailoring the choice of irrigants and irrigation techniques can significantly contribute to the success of root

canal shaping, cleaning, and overall treatment outcomes. Selecting endodontic irrigants with optimal surface tension and is essential for achieving favourable treatment outcomes and improving the prognosis of root canal treatments. However, it's important to note that other factors, such as the choice of instrumentation, sealers, and the overall treatment approach, also contribute to the prognosis of root canal treatment.

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