Irrigation dynamics in root canal therapy

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Irrigation dynamics deals with the patterns of irrigant flow, penetration, exchange and the forces produced within the root canal system. Current modes of endodontic irrigation include the traditional syringe needle irrigation or predominantly physical methods, such as apical negative-pressure irrigation or sonic or ultrasonic mechanical irrigation. Since the nature of irrigation influences the flow of irrigant up to the working length (WL) and interaction of irrigant with the root canal wall, it is mandatory to understand the irrigation dynamics associated with various irrigation techniques.

Endodontic irrigants are liquid antimicrobials used to disinfect the root canal system within the root canal. The process of delivery of endodontic irrigants within the root canal is referred to as irrigation. The overall objectives of root canal irrigation are to achieve efficient antimicrobial inactivation, remove tissue remnants and the smear layer, produce mechanical and chemical disinfection within the root canals, as well as to allow the flow of irrigant within the root canal system, in order to detach the biofilm structures and bony and soft tissue obstructions from the root canals (physical effects). While the chemical effectiveness will be influenced by the concentration of the antimicrobial and the duration of action, the physical effectiveness will depend upon the ability of irrigation to generate optimum streaming forces within the entire root canal system. The final efficiency of endodontic disinfection will depend upon both the chemical and the physical effectiveness.[5] It is important to realise that even the most sophisticated irrigation systems will have no effect if it cannot penetrate the apical portion of the root canal. Irrigation systems are designed to be placed near the WL and ensuring adequate space between the flowing irrigant and the canal wall could help to improve penetration.[5]

**Syringe irrigation**

Irrigation methods are categorised as either positive-pressure or negative-pressure, according to the mode of delivery employed.[4] In positive-pressure techniques, the pressure difference between the irrigant pressure and the wall pressure of the root canal is generated using a syringe or a needle and the wall opening (e.g. a needle and the root canal). In negative-pressure techniques, the irrigant is delivered passively towards the canal oral face and a suction tip (negative-pressure) placed deep inside the root canal creates a pressure difference. The irrigant flows from the irrigant towards the apex, where it is evacuated. A detailed understanding of the irrigation dynamics associated with syringe-based irrigation would help in improving its effectiveness in clinical practice.

**Irrigation flow during syringe irrigation**

The flow of irrigant is influenced by its physical characteristics, such as density and viscosity.[5] These properties for the commonly used endodontic irrigants are similar to those of distilled water.[6, 7] The surface tension of endodontic irrigants and its decrease by surfactants have also been studied extensively. The rationale of this combination is that it may significantly affect (a) the penetrate into the root canal tubules and ac- cessory root canal(s),[9] and (b) the dissolution of pulp tissue. [10] However, it is important to note that surface tension would only influence the interface between two immiscible fluids, and not between the irrigant and dental fluid.[5] Experiments have confirmed that surfactants do not enhance the ability of sodium hypochlorite to dissolve tissue remnants and the smear layer.[14, 15] It is important to note that even the highest turbulence intensities around the ultrasonic tip position do not influence the irrigant dynamics, since the irrigant displayed by this method has important implications with respect to its ability to permit better interaction between the irrigant and the root canal wall, and to potentially enhance the interaction of irrigants with intra-canal biofilm.[2, 3] (Figs. 1a–d & 2a–d).

**Conclusion**

The requirements of adequate irrigant penetration, irrigant exchange, optimal disinfection and low risk of apical extrusion oppose each other and a balance is required during irrigation. Ideally, in a canal enlarged to size 50 or 55 and taper 0.04 or 0.06, an open-ended needle should be placed 2 or 3 mm short of the WL to ensure adequate irrigant exchange and high wall shear stress, while reducing the risk of extrusion. In the case of a closed-ended needle, placement should be within 1 mm short of the WL, so that optimum irrigant exchange can be ensured. The apical negative-pressure irrigation system could be used at the WL, circumventing the issue of apical negative-pressure irrigation pressure to permit better interaction between the irrigant and the root canal wall, and to potentially enhance the interaction of irrigants with intra-canal biofilm.[2, 3] (Figs. 1a–d & 2a–d).

**Enhancing irrigation dynamics using physical irrigation methods**

Fluid dynamics studies on apical negative-pressure irrigation systems showed that increased negative-pressure irrigation could help to improve irrigant exchange. However, the efficiency of irrigation generated using the highest wall shear stress was found to have a detrimental impact on the systems.[24, 25] This is mainly due to the fact that higher negative-pressure irrigation systems are associated with a larger volume of irrigant delivered.[26, 27] Irrigation systems have studied indirectly by Nguyen and Sedgley.[30] They report that only severe curvature is present in a 24–28 mm long canal, and extra pressure from the tip 0.1 mm. The side-vented needle tip (b) showed a more uniform distribution of shear stress on the root canal wall, and it was only slightly lower than with the side-vented needle tip (a), with the highest turbulence intensity being around the tip. The side-vented needle tip (b) showed a much lower velocity than with the side-vented needle tip (a) and the W.L, with the highest turbulence intensity being around the tip. The side-vented needle tip (b) showed a much lower velocity than with the side-vented needle tip (a) and the W.L, with the highest turbulence intensity being around the tip. The side-vented needle tip (b) showed a much lower velocity than with the side-vented needle tip (a) and the W.L, with the highest turbulence intensity being around the tip. The side-vented needle tip (b) showed a much lower velocity than with the side-vented needle tip (a) and the W.L, with the highest turbulence intensity being around the tip. The side-vented needle tip (b) showed a much lower velocity than with the side-vented needle tip (a) and the W.L, with the highest turbulence intensity being around the tip.