Positive versus negative pressure irrigation

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_The endodontic triad_

Long-term endodontic success is not due to a single factor but is dependent upon three critical aspects of treatment called the “endodontic triad” — instrumentation, disinfection and obturation. These three components of the triad are interwoven, and success requires careful attention to all three to provide long term-clinical success.

Teeth have very complex pulpal anatomy, and instrumentation alone cannot adequately prepare the canal system for obturation. The intricacies of the canal anatomy with its fins, lateral canals and apical deltas make it impossible for endodontic instruments to reach all aspects of the anatomy (Fig. 1). Thus irrigation is critical for removal of residual tissue and microbiota that cannot be reached by instrumentation of the main canals.

Regardless of the file system used for instrumentation, files cannot reach all of the pulpal anatomy, and therefore disinfection is key to augmenting the cleaning process prior to obturation. But what is referred to when we mention disinfection of the canal system? Disinfection comprises removal of the residual tissue in the canal system and the associated bacteria through flushing the canal system with irrigating solution. The key being to remove as much residual tissue as possible and the more thorough the irrigation process the lower the remaining bacterial level. The less residual tissue remaining the less bacteria and the more successful the clinical outcome of the endodontic treatment.

_Cleaning the canal_

No matter what obturation material is used, how well the sealer adheres to the canal walls is important. Smear layer can play a factor that may prevent sealer penetration into the dentinal tubules. The frequency of bacterial penetration through teeth obturated with intact smear layer (70 percent) was significantly greater than that of teeth from which the smear layer had been removed (30 percent). Removal of the smear layer enhanced sealability as evidenced by increased resistance to bacterial penetration.¹ The incidence of apical leakage was reduced in the absence of the smear, and the adaptation of gutta-percha was improved no matter what obturation method was used later.² ³ ⁴

What is used to obturate the canals is important; however, the manner in which the canal was...
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prepared prior to obturation also determines how well the canal is sealed. Rotary instrumentation with NiTi files has shown less microleakage than hand-instrumented canals irrespective of what was used to obturate the canal.5 The machining of the canal walls with NiTi rotary instruments provides smoother canal walls and shapes that are easier to obturate when compared to stainless steel hand filing. The better the adaptation of the obturation material to the instrumented dentinal walls, the less leakage is to be expected along the entire root length. The better the canal walls are prepared and cleaned, the more smear layer and organic debris is removed which is beneficial to root canal sealing.

Smear layer removal is best achieved by irrigating the canals with NaOCL (sodium hypochlorite) followed by 17 percent EDTA solution.6 NaOCL dissolves the organic component of the smear layer exposing the dentinal tubules lining the canal walls, whereas EDTA, a chelating agent, dissolves the inorganic portion of the dentin opening the dentinal tubules. Alternating between the two irrigants as the instrumentation is being performed will permit removal of more organic debris further into the tubules, increasing resistance to bacterial penetration once the canal is obturated.7,8

Studies suggest that regular exchange and the use of large amounts of irrigant should maintain the antibacterial effectiveness of the NaOCl solution, compensating for the effects of concentration.9 Volume is more critical to canal disinfection during treatment than the concentration of the irrigant.10 Flushing of the irrigant also serves to remove the debris exposing the dentin around the anatomy in the canal system to further action of the irrigant improving the efficacy of the process.

Positive vs. negative pressure

Irrigation as it relates to endodontic treatment involves placement of an irrigating solution into the canal system and its evacuation from the tooth. Traditionally, this involved placement of the irrigant with an end-port or side-port needle into the apical canal and expressing solution out of the needle to be suctioned coronally. This creates a positive pressure system with force created at the end of the needle, which may lead to solution being forced into the periapical tissues. Positive pressure irrigation has its risks as some irrigating solutions, such as sodium hypochlorite, have the potential to cause tissue injury that may be extensive when encountering the periapical tissue and its communication with tissue spaces (Fig. 2). These NaOCL accidents can lead to permanent physical injury or disability with facial deformation and neurological complications.11,12

Chow was able to show as early as 1983, that positive pressure irrigation has little or no effect apical to the needles orifice.13 This is highlighted in his paradigm on endodontic irrigation, “For the solution to be mechanically effective in removing all the particles, it has to: (a) reach the apex, (b) create a current force and (c) carry the particles away.” We increase the risk of clinical failure due to the inability to eliminate intraradicular microorganisms from the canal system, especially in the apical portion of the root.14

A negative pressure irrigation system on the other hand does not create positive pressure force at the needle’s tip, so potential accidents are essentially eliminated. In a negative pressure irrigation system, the irrigation solution is expressed coronally, and suction at the tip of the irrigation needle at the apex creates a current flow down the canal towards the apex and is drawn up the needle. But true apical negative pressure only occurs when the needle (cannula) is utilized to aspirate irrigants from the apical termination of the root canal. The apical suction pulls irrigating solution down the canal walls toward the apex, creating a rapid turbulent current force towards the terminus of the needle (Fig. 3). Haas and Edson found, “The teeth irrigated with negative apical pressure had no apical leakage. While the teeth irrigated with positive pressure leaked an average of 2.41 mL out of 3 mL.”15 A study by Fukumoto found using negative pressure there was less extrusion of irrigant than when using needle irrigation (positive pressure) when both were placed 2 mm from working length.16

But what other sequela can occur with minute amounts of NaOCL leaking from the apex during the irrigation process? Gondim et al, in a study of post-operative pain when comparing positive a negative
pressure irrigation systems reported, “The outcome of this investigation indicates that the use of a negative pressure irrigation device can result in a significant reduction in postoperative pain levels in comparison to conventional needle irrigation.” So although we may not see NaOCl accidents frequently, it is possible to see the effects of positive pressure irrigation allowing some minute extrusion apically in our normal, day-to-day endodontic treatment. They further stated that “the use of the EndoVac system did not result in apical extrusion of irrigant, hence chemical irritation of the periapical tissues leading to postoperative pain may not be likely.” And they concluded, “It is safe to use a negative pressure irrigation protocol for antimicrobial debridement up to the full working length.”

EndoVac endodontic irrigation system

Designed by Dr. G. John Schoeffel with more than a decade of research, the EndoVac irrigation system (SybronEndo, Orange, Calif.) was developed as a means to irrigate and remove debris to the apical constriction without forcing solution out the apex into the periapical tissue. The system utilizes negative pressure through the office’s high volume evacuation system permitting thorough irrigation with high volumes of irrigation solution.

The EndoVac system consists of Multi-Port Adapter (MPA) assembly that connects to the high volume evacuation hose in the dental operatory (Figs. 4, 5). To this, connects the Master Delivery Tip (irrigation and suction together) with a disposable syringe filled with irrigation solution (Figs. 6, 7). Either a MacroCannula (Fig. 8) or MicroCannula (Fig. 9) is attached and used simultaneously with the Master Delivery Tip during treatment. The plastic MacroCannula is placed on a handpiece that is attached to tubing that connects to the MPA via a separate line. This is used for coarse debris removal. The MicroCannula is a metal suction tip available in either 21, 25 or 31 mm lengths with 12 micro holes in the terminal 0.7mm of the tip, permitting removal of particles that are 100 microns or smaller to the apical constriction. This tip fits into a metal fingerpiece and is connected to the Multi-Port Adapter (Fig. 5) in the HVE via tubing. The turbulent current forces developed by the MicroCannula rapidly flows to the micro holes at the terminus, which can reach within 0.2 mm of full working length. Quite simply, the vacuum formed at the tip of the MicroCannula is able to achieve each of Chow’s objectives in his irrigation paradigm.
Nielsen and Baumgartner found the volume of irrigant delivered with the EndoVac system was significantly more than the volume delivered with needle irrigation over the same amount of time. Furthermore, they reported significantly better debridement 1 mm from working length for the EndoVac system compared with needle irrigation.

Since one of the laws of physics states, "only one object can occupy a space at a time," if the tissue remnants can be removed from the lateral canals, apical deltas and fins within the canal system, these areas can be filled with obturation material providing a better seal and inhibiting bacteria in or out of the canal system. The EndoVac irrigation system, as Nielsen and Baumgartner demonstrated, is able to better clean at the apex where other irrigation methods and systems have not been able to do as thorough a job (Figs. 10–12).

EndoVac technique

Following removal of the chamber roof and exposure of the pulp, the Master Delivery Tip is used to provide frequent and abundant irrigation as the orifices are identified and explored. The Master Delivery Tip may be used to deliver irrigant into the pulp chamber while also suctioning debris brought coronally during the instrumentation process. Be careful to deliver the irrigant passively into the pulp chamber; avoid delivering irrigant directly into the orifice as this will create positive apical pressure (Fig. 13). The benefit of the Master Delivery Tip is that with a single tip at the tooth’s access, visibility is not blocked and large volumes of irrigation solution can be utilized. As the canals are being instrumented to a size 30 with a 0.04 taper, the MacroCannula is introduced between changes in file size as the canal is shaped. The MacroCannula is utilized to remove coarse debris during instrumentation and is used in combination with the Master Delivery Tip, which delivers the irrigating solution. Negative pressure is created as irrigating solution is drawn down the canal towards the apex as it is expressed from the Master Delivery Tip and then is drawn up the MacroCannula (Fig. 14). It is sug-
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suggested that the MacroCannula be used with a slight pumping motion as each canal is flushed. Irrigation should continue with the MacroCannula until clear fluid is observed being withdrawn through the tubing connected to the handpiece before proceeding to the next file.

When the canal has been enlarged to the desired size, the MacroCannula is again used until clear solution is observed in the tubing. This will ensure that all coarse debris has been removed from the canal. Next, the metal MicroCannula is placed on the Fingerpiece and attached to the MPA connector line (white connection) and used at the completion of canal instrumentation to remove fine debris to the apical constriction under negative pressure when the canal has been instrumented to a size 35 with a 0.04 taper or greater (Fig. 15). To prevent plugging of the fine holes in the apical terminus do not use the MicroCannula until thorough irrigation has been accomplished with the MacroCannula and all instrumentation has been completed.

**Conclusion**

Instrumentation, disinfection and obturation are important aspects of rendering quality endodontic care. Yet, the instruments we use to prepare the canal, whether hand or mechanized are unable to reach all aspects of the canal system. Irrigation is key to cleaning and disinfecting those areas that cannot be reached by instrumentation alone.

The EndoVac irrigation system with its negative pressure is able to more much larger volumes of irrigant through the canal system, safely, resulting in more thorough removal of the micro debris at the apical constrictor, thereby providing a better environment for sealing. Accordingly, negative pressure irrigation not only greatly improves both the flow and safety of irrigation with NaOCl but has also been shown to minimize postoperative sensitivity following treatment compared to traditional positive pressure irrigation protocols.

A complete list of references is available from the publisher, feedback@dental-tribune.com.

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**Fig. 13** Master Delivery Tip being used to provide constant irrigation as the canal is instrumented.

**Fig. 14** Use of the EndoVac MacroCannula and Master Delivery Tip.

**Fig. 15** Use of the MicroCannula of the EndoVac system showing placement of the tip in the apical root end.

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