

Smear layer in endodontics: role and management

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The smear layer was first described by McComb and Smith, who demonstrated the presence of an organic layer containing apatite particles on the enamel surface caused by heat generated during cutting [1]. In endodontics, the smear layer term was used to describe the amorphous and irregular particles that resulted from root canal instrumentation and covered all instrumented surfaces of the prepared root canals. The thickness of the smear layer may vary from tooth to tooth according to several factors including: wet or dry cutting of the dentin, size and shape of the root canal, shape and sharpness of instruments, and the type and amount of the irrigating solution [2].

The smear layer consists of both; organic and inorganic components. The organic component is usually a collection of pulpal and bacterial debris whereas the inorganic component is mainly made of dentinal debris. The effect of smear layer on the outcome of root canal therapy (RCT) has been considered a hot topic for long time. Does the presence of the smear layer affect the results of RCT positively or negatively? Should the smear layer be removed, kept, or ignored during RCT? To answer these questions, it is good to consider the following evidences from previous studies.

Dentin permeability

The Effect of smear layer removal on the diffusion permeability of human roots was evaluated by Galvan et al. [3] using tritiated water ($3\text{H}_2\text{O}$) and liquid scintillation assay. The results showed that when the smear layer existed, the diffusion ability of the active water was reduced about 25-49%. This means that it took more time for the water to diffuse into the dentin tubules. Since the most common irrigant, sodium hypochlorite (NaOCl), has bigger and heavier molecule, this will suggest that the smear layer reduces the diffusion ability of the NaOCl more than 50%. In other words, the microbial control will be less if the smear layer is not removed. Similar results were previously found for the effect of smear layer removal on the diffusion of calcium hydroxide through radicular dentin. The *ex-vivo* study on human extracted teeth showed that the smear layer reduced diffusion permeability of dentin, blocked dentin tubules and prevented the alkaline effect of calcium hydroxide to move deeply in the root canal and dentin tubules [4].

Bacteria colonialism

Yang and Bae [5] has compared the ability of black

pigmented bacteria (*Prevotella nigrescens*) to adhere to the dentin of prepared root canals with the presence/absence of the smear layer. It was found that the smear layer could attract the bacteria and provided a good environment for their adhesion and proliferation. In teeth where smear layer was removed, no bacterium was observed. In conclusion, the smear layer may work as a substrate for bacteria growth.

Fluid-tight seal

Some studies reported that the presence or absence of the smear layer had no significant effect on the apical seal [6]. However, Shahravan et al. [7] evaluated all previous articles that had assisted the effect of smear layer on the fluid-Tight seal of canals after obscuration of the root canal system. It was found that the smear layer removal enhances the fluid-tight seal of root canal system.

Taking in consideration all these important results, one can conclude that the removal of the smear layer should be always considered in the daily practice of endodontics.

What is the best technique to remove the smear layer?

It was early discovered that chelating agents such as ethylene diamine tetraacetic acid (EDTA) and citric acid are effective agents in removing the smear layer [1,8]. However, 17% EDTA was considered a better chelating agent than 1% and 5% citric acid [9] but less effective than the 6% [10]. In 1981 and 1982, Goldman et al. [11,12] tested various solutions individually and in combination and reported that chelating agent EDTA and NaOCl was the best to remove the debris when used as a final flush [13]. In another interesting study [14], the demineralizing effect of EDTA at different concentrations and pH levels was evaluated. The results showed that the higher concentrations and lower pH of EDTA resulted in better smear layer removal. Using 17% EDTA with pH=7.5 was considered the best as it could remove the smear layer in all cases significantly when applied in the root canal for only 1 min.

Lui et al. [15] evaluated various protocols to remove the smear layer and found that using EDTA with passive ultrasonic irrigation (PUI) followed by NaOCl resulted in complete removal of the smear layer in 100% of the samples. However, when EDTA and PUI were not combined, the smear layer removal was not complete. More recently, the use of Er:YAG laser to activate 17% EDTA inside root canal was

found promising and resulted in more effective removal of the smear layer when compared to the positive pressure irrigation [16]. But more studies are needed to compare its efficacy with the EDTA/PUI protocol.

Finally, it is worth mentioning that applying 17% EDTA as a final irrigant after 5.25% NaOCl resulted in a clean dentinal surface with very normal and regular dentinal tubules. Whereas when NaOCl was used as final irrigants after demineralized agent, a remarkable erosion of dentin occurred with a view of irregular eroded dentinal tubules [17].

Conclusion

Root canal instrumentation creates a smear layer that covers all canal walls. This smear layer can harbor bacteria and their products, decrease the dentin permeability to irrigants and medical dressing, and compromise the fluid-tight seal of canals after root filling. Thus, it is recommended to remove this smear layer before processing the root canal obturation. This can be ideally achieved using 17% EDTA of pH 7.5, for 1 min with passive ultrasonic activation. It is not recommended to use NaOCl as a final irrigant after EDTA.

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