

Smear Layer in Endodontics

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Abstract

McComb and Smith (1975) were the first researchers who described the presence of smear layer on surfaces of instrumented root canals in their Scanning Electron Microscopic study. This layer primarily contains ground dentin, remnants of pulp tissue, odontoblastic processes and bacteria.

Key Words Smear Plugs, EDTA, Irrigation, Dentinal Tubules

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I. Introduction

Successful endodontic treatment depends upon thorough cleaning, shaping, disinfecting and obturation of root canals so as to achieve three-dimensional hermetic sealing of the pulp spaces. During mechanical preparation or whenever dentin is cut using hand or rotary instruments, the mineralized tissues are scattered producing considerable amount of debris. The debris so produced in the form of small particles of collagen matrix (composed of organic & inorganic material) is spread as an amorphous, irregular layer over dentinal surface, is known as “smear layer”.

Definition

American Association of Endodontists defined smear layer as a “surface film of debris retained on dentin or other surfaces after instrumentation with either rotary instruments or endodontic files; consists of dentin particles, remnants of vital or necrotic pulp tissue, bacterial components & retained irrigants”

Structure of Smear Layer

The thickness of smear layer depends on the type and sharpness of cutting instrument and also whether the cutting was carried out on dry or wet dentin. The smear layer contents are described in two parts; the superficial smear layer and the smear layer where contents are packed into dentinal tubules. The superficial smear layer is estimated to be 1.0-2.5 μm in thickness; whereas the smear layer contents may get packed into the dentinal tubules to a depth of 40 μm . The penetration of smear layer components into dentinal tubules could be caused by capillary action as a result of adhesive forces between the dentinal tubules and the smear contents, known as “smear plugs”.

Factors Influencing Formation of Smear Layer

The complexity of root canal system usually limits the efficacy of thorough cleaning the pulp spaces. The deviated root canal anatomy may pose difficulties in instrumentation, subsequently leading to unevenly prepared zones on root canal walls. These uneven zones may contribute to produce more of smear layer.

When dentin chips are accumulated in flutes of the instrument, working effect is impaired and friction between instrument and canal walls is increased. The cutting effect is decreased; consequently larger amount of smear layer is formed.

It has been established that the amount of smear layer produced during rotary instrumentation is far greater as compared to hand filling. It is established that sonic and ultrasonic preparation of root canal are the most effective methods leading to only minor formation of smear layer.

Massive irrigation directed towards working part on the instrument facilitates removal of dentin and prevents debris binding on the root canal walls. Vent needles enable detachment of smear layer from root canal walls under pressure thus making debridement more efficient.

Post space preparation results in thicker smear layer and also consists of fragments of sealer and gutta-percha. So when posts are cemented without removal of smear layer it will bond to loosely adherent smear layer and ultimately bond will break.

Management of Smear layer

The management of smear layer in endodontics has always been controversial.

Features warrant the removal of smear layer

- * Unpredictable thickness & volume
- * Mainly contains bacteria, their by-products and necrotic tissue.
- * Acts as a substrate for bacteria and may allow bacteria penetrating deeper in the dentinal tubules.
- * May limit the penetration of disinfecting agents into the dentinal tubules.
- * Act as a barrier between filling materials and the canal wall. The sealers can penetrate dentinal tubules only if the smear layer is removed.
- * Being loosely adherent structure, it is a potential avenue for leakage between root canal obturated material and the dentinal walls

Features warrant the retention of smear layer are:

- * Smear layer block the dentinal tubules, preventing the exchange of bacteria and other irritants by altering their permeability.
- * It acts as a barrier to prevent bacterial migration into dentinal tubules
- * A few authors have observed that bacteria remaining after root canal preparation were sealed into dentinal tubules by smear layer and subsequently filling materials.

Removal of the Smear layer

The smear layer can be removed using mechanical, chemical, ultrasonic and by means of laser.

a. Mechanical Removal

The mechanical removal of smear layer includes:

i. Microbrush (Canal brush): A microbrush has been specifically fabricated for root canal cleaning. The brush is available in three sizes, small, medium and large, corresponding to apical diameter of 25, 30 & 40 respectively. The brush is used along with the irrigating solution, being evolved at a slow speed.

ii. XP-endo finisher: XP-endo finisher is a modified Ni-Ti file without taper and of small diameter (25/.00). Due to its specific design, it can reach the inaccessible areas of the canal wall and efficiently remove the smear layer. The file has added advantage of changing the shape during rotation in the root canal, which effectively remove dentin debris and smear layer.

b. Chemical Removal

The solutions commonly used to remove smear Layer are:

i. Sodium hypochlorite:

Sodium hypochlorite is known for its potential to dissolve organic tissues; however, it cannot effectively remove smear layer from the instrumented root canal walls. Alternating use of sodium hypochlorite with EDTA was effective in smear layer removal.

ii. EDTA:

The alternate use of 17% EDTA & 5.25% sodium hypochlorite removes smear layer completely from coronal & middle thirds, however, less effective in apical third areas. (EDTA removes the inorganic component & sodium hypochlorite removes the organic part). A quaternary ammonium bromide (cetavlon) has been added to EDTA solutions to reduce surface tension and increase penetrability of the solution. This solution is called EDTAC. Optimal working time for EDTAC in root canal is 15 Minutes.

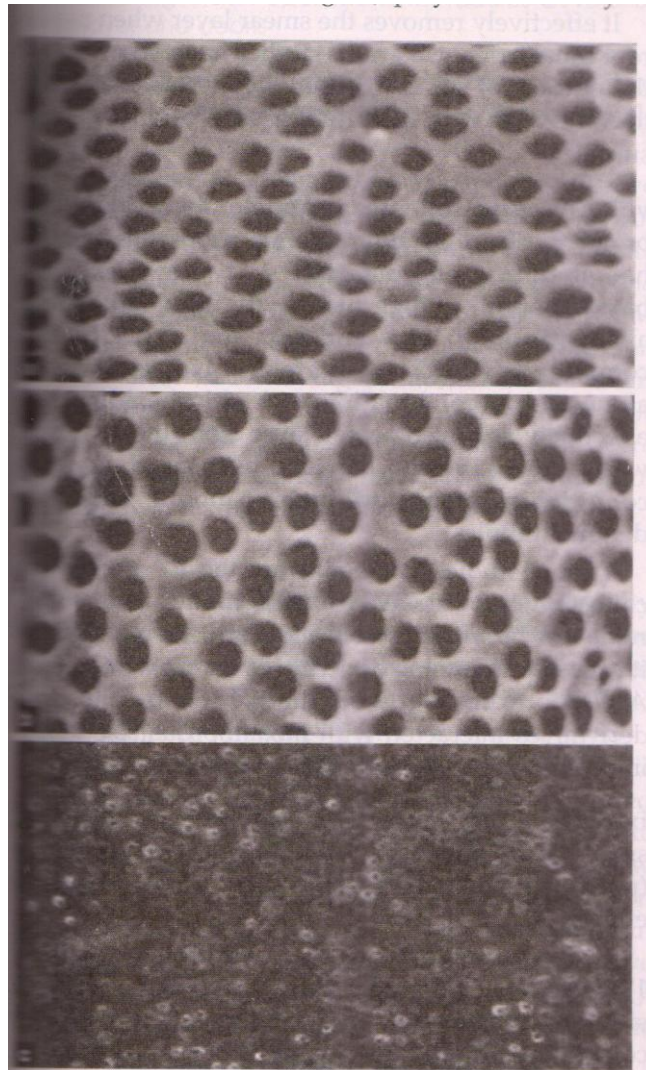


Fig 1. (a). Absence of Smear layer in coronal third after using EDTA. (b). Absence of Smear layer in middle third after using EDTA. (c). Presence of Smear layer in apical third after using EDTA.

iii. Tetracyclines: Tetracyclines including doxycycline and minocyclines are effective against a wide range of microorganisms. They have low pH in concentrated solution & act as calcium chelator; may cause root surface demineralization. They are effective in removing smear layer from the surface of instrumented canals & root-end cavity preparations.

iv. MTAD: MTAD, an irrigating solution, containing a mixture of tetracyclines, a detergent and an acid (3.0% doxycycline hyclate, 4.25% citric acid and .5% polysorbate detergent) was developed having potential of removing smear layer and also disinfecting root canals.

v. QMix: QMix 2 in 1 is a new irrigating solution that facilitates smear layer removal and also provides disinfection. The solution contains a mixture of bisguanide (antimicrobial agent), polyaminocarboxylic acid (a calcium chelating agent) and a surfactant. Various studies have confirmed the superior effect of QMix as compared to 17% EDTA.

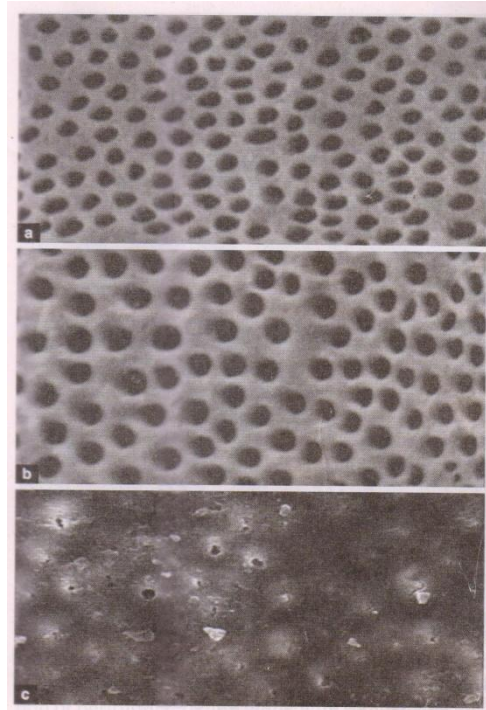


Fig 2. (a) Absence of smear layer in coronal third after using QMix. (b) Absence of smear layer in middle third after using QMix. (c) Presence of smear layer in apical third after using QMix.

vi. Organic acids: The effectiveness of mild acids as a root canal irrigant has been demonstrated. Citric acid, Polyacrylic acid, lactic acid, tannic acid and phosphoric acid are being used to remove the smear layer. Citric acid is considered better than the other acids used.

vii. Super-oxide water (oxum). It is a powerful antimicrobial agent against bacteria, fungi & viruses. It is rich in reactive oxygen & has neutral ph. Super-oxidised water, commercially available as oxum, is stable & has longer shelf life.

viii. Chitosan: Chitosan, a natural polysaccharide, has broad-spectrum of antimicrobial properties & also has chelating characteristics. Various studies have confirmed the use of 0.2 to 0.6% chitosan when irrigated for three minutes, adequately removed the smear layer.

ix. Smear clear: A recently introduced chelating agent smear clear contains 17% EDTA and two surfactants (polyoxyethylene and isobutyl cyclohexyl phthalate ether). Smear clear has low surface tension and improved dentin-wettability facilitating easy flow into narrow canals. This property may be the probable reason for better removal of smear layer from the apical third of root canal.

c. Ultrasonic

Sodium hypochlorite activated by the ultrasonic delivery system when used as an irrigant provided smear-free root canal surfaces. Varying concentration of sodium hypochlorite (1.0-5.0%) when used with ultrasonic energy has been effective in removing smear layer. It is advised to use EDTA/EDTAC with sodium hypochlorite using ultrasonic streaming to achieve desired results.

d. Lasers

Lasers are being used to vaporize necrotic tissues and debris in the root canals. The most commonly used lasers in endodontics is Neodim:Yttrium-Aluminium-Garnet (Nd:YAG) having wave length of 1064nm, Erbium-Yttrium-Aluminium-Garnet (Er:YAG) having wave length of 2940 nm is used for cleaning and shaping of root canals. The main difficulty with laser is the access to small root canal areas.

II. Conclusion

Problems of smear layer is still a controversy. However, growing evidence supports its removal. Sealers with bonding ability like AH Plus show greater bond strength when smear layer has been removed. With the advent of adhesive dentistry for endodontics use of medicated & resin based sealers & obturating materials like Resilon & Active Gutta percha definitely mandates the removal of smear layer for producing secondary & tertiary monoblocks for adequate bonding & to obtain optimal bond strength for a fluid tight seal.

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