

# Smear layer: a brief review of general concepts. Part I. Characteristics, compounds, structure, bacteria and sealing

**Smear layer, uma breve revisão de conceitos gerais. Parte I. Características, componentes, estrutura, bactérias e selamento**

Paula Dechichi\*

Camilla Christian Gomes Moura\*\*

## Abstract

*Smear layer interference on endodontic therapy success is not completely clear. The wide and controversial literature about this issue has motivated this present review. The first part of this study purposed to briefly review general concepts concerning the smear layer: its structure and composition, the relation between bacteria and smear layer, effects of smear layer on penetration of sealer into dentinal tubules and the microleakage of root canal fillings with and without smear layer. Although smear layer construction during canal prepare is proved, the advantages and disadvantages of smear layer presence, and whether it should be removed or not from root canals, are still a question in endodontics.*

**Key words:** smear layer, sealing, bacteria, microleakage, and structure.

## Introduction

Endodontic smear layer has been reported as being a layer of material which covers the prepared canal walls. It is always produced when dentine surface is cut or drilled<sup>1</sup>. According to Madder et al.<sup>2</sup> (1984) and Shaffer and Zapke<sup>3</sup> (2000), smear layer is found only on instrumented portion of canal walls, being absent in dentin walls that have not been instrumented. Bacteria might remain, multiply and grow up in smear layer<sup>4-5</sup>. Afterwards, this layer prevents penetration of root canal filling materials into dentinal tubules<sup>6-9</sup> and might affect the microleakage<sup>6,10-12</sup>.

The aim of this study was to briefly review general concepts con-

cerning the smear layer: its structure and composition, the relation between bacteria and smear layer, effects of smear layer on penetration of sealer into dentinal tubules and the microleakage of root canal fillings with and without smear layer. Characteristics: compounds and structure

The exact composition of smear layer has not been determined. It is believed to contain thin particles of inorganic material and organic elements such as pulp tissue debris, odontoblastic processes, bacteria and blood cell<sup>1,13-14</sup>. According to Cameron<sup>15</sup> (1987) the organic content of the smear layer is relatively high in the early stages of instrumentation due to the presence of viable pulp tissue in the

\* Doutora em Reabilitação Oral pela Faculdade de Odontologia de Ribeirão Preto - USP; professora Adjunta do Instituto de Ciências Biomédicas da UFU-MG. Professora orientadora do Programa de Mestrado em Odontologia da Faculdade de Odontologia da UFU-MG.

\*\* Mestre em Reabilitação Oral pela Faculdade de Odontologia da UFU-MG. Professora do Instituto de Ciências Biomédicas da UFU-MG.

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root canal. The smear layer was not only found in the canal wall, but was also seen packed into some dentinal tubules<sup>2,16-17</sup>.

Cameron<sup>16</sup> (1983) and Madder et al.<sup>2</sup> (1984) described the formation of two kinds of smear layer: the first one consisted of a superficial layer loosely attached to the dentinal walls and the second one of a smear material packed in the dentinal tubule openings. The depth to which this material was packed into tubules varied. In some places, it appeared densely packed up to 40 µm into the tubules<sup>2</sup>. According to the hypothesis proposed by Cengiz et al.<sup>18</sup> (1990), penetration of smear material into dentinal tubules might be caused by capillary action as a result of adhesives forces between tubules and smear material. Typically the texture of the smear material in the tubules is granular or particulate<sup>1-2</sup>.

None of the instrumentation techniques achieved total debridement of root canal<sup>17,19</sup>. Both manual and mechanical shaping produced smear layer and debris<sup>3,19-21</sup>. According to Ahlquist et al.<sup>21</sup> (2001), manually filled canals had less debris than those using a rotary technique. On the other hand, Bertrand et al.<sup>22</sup> (1999) found that the Quantec<sup>TM</sup> rotary system produced cleaner canal walls than conventional manual instrumentation. This finding may imply that stresses applied on the cutting region of Quantec<sup>TM</sup> instruments minimize smear layer accumulation<sup>22</sup>. The design of a cutting blade rotary instrument may affect root canal cleanliness in straight root canals<sup>23</sup>. Nickel-titanium rotary instrument systems may pack debris further into dentinal tubules, thus making its removal under irrigation more difficult. It may be necessary to irrigate with higher final volumes or to allow irrigants to remain in the canal for longer periods of time<sup>24</sup>.

## Bacterial presence and its relation to smear layer

Bacteria infecting root canal system are known to colonize the denti-

nal surface in a complex biofilm<sup>25-26</sup>. When root canal becomes heavily infected, bacteria may be found deep within dentinal tubules<sup>27-29</sup>. Even after chemomechanical instrumentation, they could remain in the smear layer, multiply and grow up within dentinal tubules<sup>4-5</sup>.

Perez et al.<sup>30</sup> (1996) evaluated whether the smear layer formed during root canal instrumentation modifies or not bacterial migration into the root dentinal tubules. In this study, areas with an intact smear layer revealed absence of streptococcus sanguis migration in 88% of the cases. It is plausible that smear layer on canal walls limits bacterial penetration<sup>31</sup>. Some authors believed that smear layer might decrease dentin permeability and prevent bacterial penetration into dentinal tubules<sup>29,31</sup>. In contrast, other investigators believed that smear layer may contain bacteria and may prevent antimicrobial agents from having access to contaminated tubules<sup>1,4</sup>.

There is no scientific consensus regarding the efficacy of smear layer removal in the root canal treatment<sup>1,6</sup>. However, currently, the consensus is toward a smear layer removal in order to reduce the microflora and bacterial endotoxins<sup>32</sup>. Then is it important that the root canal preparation in infected root canals not only clean and remove the smear layer but also have an antibacterial effect<sup>28,33-34</sup>.

## Effects of Smear layer on sealing and microlleakage

Adequate sealing is considered to be one of the main goals of the root canal treatment. The smear layer constitutes a negative influence on sealing ability of filled canals, since it is a porous and weakly adherent interface between filling material and dentine wall<sup>6</sup>. The presence of this layer prevents the penetration of root canal filling materials into dentinal tubules<sup>7-9</sup>. Its removal might conceivably improve the sealing of root canal systems by increasing the surface contact area of filling materials<sup>35</sup>. Besides, several studies demon-

strated that smear layer removal improves the sealing<sup>36</sup>, while other studies show that smear layer removal does not have any influence in root canal sealers or filling materials penetration<sup>7,35,37</sup>. Saleh et al.<sup>38</sup> (2003), suggested that the penetration of the endodontic sealer into dentinal tubules, whose smear layer was removed, was not related to higher bond strengths. The surface tension of the sealers determines the depth of their penetration into dentinal tubules<sup>39</sup>. The microstructure of the sealer paste might be the most important factor for a tight obturation of a smear layer-free root canal<sup>37</sup>. Furthermore chemical and physical characteristics of root canal fillings may affect tubular penetration and adaptation of the sealers following smear layer removal<sup>7,40</sup>.

Leakage is defined as the passage of bacteria, fluids, and chemical substances through the root structure and filling of any type. This is a complicated subject to be analyzed, when considering root canals, because there are many variables<sup>1</sup>. A comparison of different techniques assessing coronal dye leakage showed differences between techniques, but did not show any influence of the smear layer on the leakage testing techniques<sup>41</sup>. There are authors who believed that the apical sealing was not affected by the presence or absence of smear layer<sup>42-43</sup>. On the other hand, there are researchers that advocate smear layer removal<sup>6,10-12</sup>. According to them, smear layer removal is beneficial to root canal sealing, since less microlleakage occurs when smear layer is absent<sup>11,44</sup>. Clark-Holke et al.<sup>45</sup> (2003) reinforced these concepts indicating that smear layer removal reduced the leakage of bacteria. One hypothesis that supports the importance of smear layer remotion is based on degradation of the smear layer. A gap will develop between the filling material and the canal wall, permitting leakage of other bacterial species and their subproducts into dentinal tubules<sup>1</sup>.

# Final considerations

- Manual and mechanical shaping produces smear layer and debris that contains organic and inorganic components.
- This layer might interfere with the adaptation of filling materials on root canal walls and has been related to microleakage.
- Clinical implications of the smear layer are still not fully understood, conflicting results have been obtained from studies regarding significance of smear layer presence and its deleterious effects.

## Resumo

A interferência da *smear layer* no sucesso da terapia endodôntica não está completamente esclarecida. A literatura extensa e controvertida sobre o tema motivou a presente revisão. A primeira parte deste estudo objetivou realizar uma revisão de conceitos gerais sobre *smear layer*: sua estrutura e composição, sua relação com as bactérias e seus efeitos na penetração dos cimentos endodônticos no interior dos túbulos dentinários e na microinfiltração. Embora a formação da *smear layer* durante a instrumentação seja comprovada, as vantagens e desvantagens da sua presença e a necessidade de removê-la ainda representam uma questão na endodontia.

**Palavras-chave:** *smear layer*, selamento, bactéria, microinfiltração, estrutura.

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**Endereço para correspondência**

Paula Dechichi  
Avenida Pará, 1720 - bloco 2B  
CEP: 38405-320 – Uberlândia - MG  
Fone: ??????????????????????????????  
E-mail: ??????????????????????????????????