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Review Article

# Analisys of Quality of Interfacial Connection Between Bioceramic Sealers and Dentin Root Wall

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## Abstract

A critical and thorough analysis of the factors influencing the degree of adhesion of bioceramic sealers to the root dentin walls was made. The role of the root canal obturation technique used is evaluated and discussed. Focused on the conflicting evidence available regarding the importance of the removal and/or preservation of the smear layer. In the light of the chemical nature of the adhesion of bioceramic sealers, their serious drawbacks related to the difficulty of their removal and the need for retreatment are also discussed.

**Keywords:** Bioceramic Sealer, Physical Properties, Sealer Penetration, Adhesion.

## 1. Introduction

According to Polinen et al. ideal root canal sealers should have better wettability thus providing a fluid-tight seal. [1] The degree of adhesion depends on several interacting factors including the adherent's (dentin) intermolecular surface energy and cleanliness and the adhesive" s (sealer) surface tension and wetting ability [2, 3]. But, the degree of adhesion and penetration of sealers into dentinal tubules is influenced by several factors such as the physical and chemical properties of sealer, dentin permeability, filling technique, and smear layer removal [4].

The depth and consistency of the sealer penetration into root dentine tubules are influenced by physical and chemical parameters such as particle size, solubility, viscosity, and surface tension [5]. The quality of the seal was shown to be an influencing factor in the long term success of an endodontic treatment, as root canal obturation acts as a barrier isolating both periapical tissue and radicular space from the ingress of microbial contaminants, and promoting healing as it entombs any remaining pulpal or microbial irritants [6-8] A new category of innovative root canal sealers has recently become prevalent in endodontic practice, based on the development of bioceramic technology in dentistry. The chemical nature of sealers plays a major role in the sealer penetration; hydrophilic sealers penetrate deeper than hydrophobic sealers [9]. Bioceramic-based endodontic sealers can be classified into calcium silicate-based, MTA-based, and calcium phosphate-based [9].

Bioceramic sealers, are injectable and premixed hydrophilic calcium silicate and phosphate-based sealers composed of zirconium oxide, calcium silicates, calcium phosphate monobasic, calcium hydroxide, and a thickening agent [10]. Bioceramic-based sealers use the moisture naturally present in the dentinal tubules to complete their setting reaction because they have a hydrophilic nature. Insufficient water may have interfered with hydration, resulting in a poor and inadequate setting process [11].

During root canal obturation, sufficient flow and wetness are important qualities of the root canal sealer to ensure adequate adhesion between the root canal walls, resulting in a fluid-tight seal. To improve molecular attraction and allow chemical adhesion or micromechanical attachment, the sealer should have good binding with dentinal tubules.

The sealer's hydration products alter the collagen of the interfacial dentin due to their alkali effects [12]. This alteration leads to the formation of a porous structure promoting the diffusion of high concentrations of $Ca^{2+}$, $OH^-$, and $CO_3^{2-}$ ions, favoring mineralization in this area [13].

This chemical and micromechanical interaction (tag-like structures) represents the main reason for the assessment of the adhesion between bioceramic sealer and dentin. It was reported that bioceramic sealer that contains calcium phosphate silicate forms a better chemical bond than bioceramic sealer containing a mixture of tricalcium silicate and resin [14].

The reason for this according to Siboni et al.is probably due to the fact bioceramic sealer containing calcium phosphate silicate has very small particles (<1 μm) that are hydrophilic

and have a low contact angle. The sealer can spread into lateral root canals and accessories, allowing for good penetration ability [15]. There is conflicting information in the literature regarding the influence of the root canal obturation technique and the depth of penetration into the tubules of the sealer. According to Reyonolds et al who found no significant difference in sealer depth penetration regarding the filling method [16]. In contrast Eid, D.et al [17]. found that EndoSequence BC sealer HiFlow and Bio-C sealer penetrated significantly deeper when using the warm vertical compaction technique compared with the single cone technique. Similar results were reported by De Deusand Ordinola-Zapata et al. They were found a higher dentine tubule penetration of bioceramic sealer by warm vertical condensation technique than the cold lateral compaction technique [18, 19].

An important factor may also influence dentinal tubule penetration of the sealers, is the root canal morphology. Another canal morphology aspect that may influence sealer penetration is the "butterfly effect". This is a phenomenon that describes the significantly higher density of dentinal tubules in the buccolingual direction compared with the mesio-distal direction. Interestingly, it produces a characteristic butterfly shape[20]. Teeth with this effect consistently showed significantly deeper penetration in the bucco-lingual direction compared with teeth without the effect[21].

It is important to evaluate the effect of different final irrigation protocols on sealer penetration. The effect of the removal or preservation of the smear layer on sealer depth penetration should also be evaluate. According to Aktemur the removal of the smear layer did not affect the penetration depth of root canal sealers [22]. In contrast other authors found that the penetration depth of sealer significantly higher when the smear layer was preserved [23]. The dentinal tubule penetration of sealers was the deepest coronally and decreased apically. This can be attributed to the number and diameter of dentinal tubules.

In general, dentinal tubule diameter varies from 2 to 3.2 micrometers [24]. The diameter and density of the dentinal tubules are greater at coronal and the middle thirds of the root canal system whereas minimal at the apical third. This factor plays a major role in sealer penetration [25].

The depth of the sealer penetration into root dentine tubules is influenced by particle size, since smaller particle sizes may penetrate the dentinal tubules easily [26]. The average particle size of a bioceramic sealer is 2 μm [27]. The extent of tubule penetration for calcium silicate-based sealers was measured up to 2000μm [28].

To evaluate dentinal tubule penetration or remaining debris in root canal, various methods have been applied in dentistry, including micro computerized tomography (micro CT), stereomicroscopy, SEM, and CLSM. Micro CT is a non-destructive method that provides 3D images with high accuracy and spatial resolution [29]. The combination of CLSM (confocal laser scanning microscopy) and SEM provided both quantitative and morphological evaluations of a representative sample [30]. Three parameters should be assessed regarding dentinal tubule penetration evaluation: maximum depth of penetration, percentage of sealer penetration and total area of sealer penetration.

The chemical nature of the bonding of bioceramic sealers and their depth of penetration into the dentinal tubules define one of their serious disadvantages. Once they set, the difficulty in removing them upon retreatment was regarded as a disadvantage of these sealers. [31].

Retrieval of bioceramic sealer is a difficult task due to the formation of a strong chemical bond with hydroxyapatite from dentin root walls [32, 33]. According to Choudhary D et al.the bioceramic sealer used in their study was not completely removed from the tubules following retreatment. [34]. Root canal retreatment involves the removal of previous root canal fillings via chemical, mechanical disinfection through several methods, such as the use of solvents, Hedstroem files, ultrasonic tips, and/or rotary files.The presence of hard setting bioceramic sealers might lead to more difficulties and complications during the retreatment procedure. Some challenges that can be faced include the separation of instruments, perforation, and difficulty in reaching the proper working length. At this stage of knowledge in dentistry the complete retrievability of the root canal system using the different strategies and techniques has not yet been achieved.

## 2. Conclusion

The chemical nature of the bonding of bioceramic sealers and their depth of penetration into the dentinal tubules provide a fluid-tight seal and in this way, it prevents the ingress of microorganisms into the periodontal space, but at the same time it is also a serious drawback, creating difficulty for the clinician in their removal when retreatment is necessary.

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