

**Evaluation of the Bond Strength and
Sealing Ability of a New Bioceramic Root
Canal Sealer
(In vitro Study)**

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Dedication

*To my dear Mum and Dad for
always encouraging me and
without their help I would have
never completed this work*

*To my dear husband with his
endless love and support*

And

To my lovely daughter

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Endodontic treatment is completed by the three dimensional filling of the root canal system, which provides adequate sealing of the dentin structures after chemomechanical preparation. Root filling is achieved with the association of a solid filling material, such as gutta-percha or, more recently, Resilon and a root canal sealer. Ideally, one of the key roles of the sealer is to aggregate the root filling material and maintain it as compact mass with no gaps, which adheres to the canal walls and provides a single block configuration that seals hermetically the canal space. Therefore, ideal endodontic cement should show good sealing ability. In addition, it should have adhesive strength and also have cohesive strength to hold the obturation together.

Many types and brands of sealing cements are commercially available. Among these types are the zinc- oxide and Eugenol based sealers, resin based sealers; glass ionomers based sealers and bioceramic based sealers. Zinc oxide–eugenol sealers have a history of successful use over an extended period of time. They exhibit a slow setting time, shrinkage on setting, solubility, and they can stain tooth structure. An advantage to this sealer group is antimicrobial activity.

Resin sealers have a long history of use, provide adhesion, and do not contain eugenol. Resin sealers can be divided to methacrylate based sealers and epoxy based sealers. Methacrylate based sealers are known by their hydrophilic properties. While in many studies epoxy-based sealers have shown higher bond strength to dentin and better sealing ability than methacrylate based sealers. Also it has been shown to

have higher bond strength than zinc oxide– eugenol, glass ionomer, and calcium hydroxide– based sealer. The glass ionomers have been advocated for use in obturation because of their chemical dentin-bonding properties. A disadvantage of glass ionomers is that they must be removed if retreatment is required. Glass ionomer sealers are known with their minimal antimicrobial activity.

Bioceramic-based materials have been recently introduced in endodontics. According to manufacturers, bioceramic materials show alkaline pH, antibacterial activity, radiopacity, and biocompatibility. In addition Bioceramics are biocompatible, nontoxic, non shrinking, and chemically stable within the biological environment. Another advantage of the material is its ability during the setting process to form hydroxyapatite and ultimately a bond between dentin and filling material ^(1,2). Therefore conducting a study to compare both the bond strength and sealing ability of a bioceramic based sealer to a resin based and a ZnO based sealers would be of great value.

I) History of root canal sealers:

Before 1800, root canal filling, when done, was limited to gold. Subsequent obturations with various metals, oxychloride of zinc, paraffin, and amalgam resulted in various degrees of success and satisfaction. In 1847 Hill developed the first gutta-percha root canal filling material known as “Hill’s stopping.”

⁽³⁾ The preparation, which consisted principally of bleached gutta-percha and carbonate of lime and quartz, was patented in 1848 and introduced to the dental profession.

In 1867 Bowman made claim (before the St. Louis Dental Society) of the first use of gutta-percha for canal filling in an extracted first molar. ⁽⁴⁾ In 1883 Perry claimed that he had been using a pointed gold wire wrapped with some soft gutta-percha (the origin of the present-day core carrier technique) ⁽⁵⁾. With the introduction of radiographs for the assessment of root canal obturation, it became obvious that the canal was not cylindrical, as earlier imagined, and that additional filling material was necessary to fill the observed voids. At first, hard-setting dental cements were used, but these proved unsatisfactory. It was also thought that the cement used should possess strong antiseptic action, hence the development of many phenolic or formalin-type paste cements.

The softening and dissolution of the gutta-percha to serve as the cementing agent, through the use of rosins, was introduced by Callahan in 1914. ⁽⁶⁾ Subsequently a multitude of various pastes, sealers, and cements were created in an attempt to discover the best possible sealing agent for use with gutta-percha.

Over the past 70 to 80 years the dental community has seen attempts to improve on the nature of root canal obturation with these cements and with variations in the delivery of gutta percha to the prepared canal system. During this era the impetus for these developments was based heavily on the continued belief in the concept of focal infection, elective localization, the hollow-tube theory, and the concept that the primary cause for failure of root canal treatment was the apical percolation of fluids, and microorganisms, into a poorly obturated root canal system. ^(7, 8)

It is well accepted that the sealing properties of a conventionally applied and laterally condensed gutta percha is such that it is essential that they are used in conjunction with root canal sealer cement. The function of the cement is to fill the spaces between the obturating point and the wall of the root canal, producing an antibacterial seal. It also lubricates the gutta percha points during compaction and will fill canal irregularities and lateral canals.

Conversely, the use of root-canal cements without obturating points is also contraindicated. When used in bulk, the cements are either too soluble or shrink excessively on setting. Additionally, it is difficult to gauge when, or if, the canal is adequately filled, and there is a danger that the cement may pass beyond the root apex into the surrounding tissues. It is now accepted that the root-canal sealer cement is unable to provide an impervious seal and most of the attention has been focused on incorporating antibacterial properties, with the emphasis on providing an anti-bacterial seal. To provide a fluid-tight seal of the canal space, a sealer is required along

with the core obturating material. Because of this, the sealer has as much or more importance than the core material in providing a successful clinical outcome. ⁽⁹⁾

II) Ideal requirements of a root canal sealer:

The ideal properties of a root canal sealer are that it should be easy to use, be free of air bubbles and homogeneous when mixed, flow to a thin film thickness, insoluble, adapt well to the canal wall and the obturating point, radiopaque, biocompatible, bacteriocidal or at least bacteriostatic, easy to remove in case of failure. ⁽¹⁰⁾ Although no sealer meets all properties of ideal sealer, there are many sealers available that are clinically acceptable and widely used. They can be classified into the general groups of zinc oxide-eugenol-based, polymers, calcium hydroxide-based, glass-ionomer, and resin-based. ⁽⁹⁾

III) Functions of a sealer:

The use of a sealer during root canal obturation is essential for success. Not only does it enhance the possible attainment of an impervious seal, it also serves as filler for canal irregularities and minor discrepancies between the root canal wall and core filling material. Sealers are often expressed through lateral or accessory canals and can assist in microbial control should there be microorganisms left on the root canal walls or in the tubules. ^(10, 11-14) Sealers can also serve as lubricants, enabling thorough seating of the core filling material during compaction. In canals in which the smear layer has been removed, many sealers demonstrate increased adhesive

properties to dentin in addition to flowing into the patent tubules. ⁽¹⁵⁻²⁵⁾

IV) Different properties to be investigated in root canal sealers:

1. Fracture resistance of endodontically treated teeth:

Root filled immature roots or roots that are otherwise weakened internally run a greater risk of fracture. With the introduction of adhesive filling techniques, attempts have been made to strengthen such teeth through reinforcement of the coronal part of the root by composite cements and fillings ⁽²⁶⁻²⁸⁾. More recently, this concept has been taken further by attempting to reinforce the whole root canal system via an adhesive filling and integrated resin core (Resilon). Such effects have been tested in standard mechanical testing machines, with varying degrees of specimen standardization and experimental procedure. These tests have shown that there may be a significant improvement in physical resistance to fracture of such teeth in vitro.

As the bond strength of sealers to dentin and gutta-percha is comparably low, concerns have been raised about the clinical efficacy of the root strengthening concept ⁽²⁹⁾. However, clinical follow up of individual cases in vivo have shown that teeth thus treated may survive for a long time ⁽³⁰⁻³²⁾, but comparative clinical studies are lacking.

2. Biocompatibility:

Biocompatibility is as important as the physical and chemical features when selecting a material for endodontic therapy because of direct contact with the vital tissue. When a sealer is placed at the apex of a root canal it will be in contact with vital tissue. It is important that the material does not elicit an inflammatory response in the tissues as this may induce irritation, pain or tissue necrosis. All of these responses are likely to lead to the loss of the tooth, which is just the opposite of the intended outcome.

A possibly beneficial response would be the formation of an intermediate layer of hard tissue that not only isolates the foreign material from the living tissue, but also helps to improve the quality of the apical seal. A perennial problem in endodontic treatment is the likelihood of recurrent infection due to the presence of bacteria at the apex of the tooth. Thus, another feature one seeks in a root canal sealer is the ability to destroy bacteria. If it is accepted that a perfect seal cannot be achieved; the materials used must have sufficient antibacterial activity to prevent bacteria from infiltrating the canal space and proliferating. However, the antibacterial property of a material should not be achieved at the expense of its biocompatibility.

The zinc oxide–eugenol-based cements are all inclined to induce some inflammatory reaction in the tissues, probably due to the presence of free eugenol. Some formulations must be avoided because they contain paraformaldehyde, which may cause a severe inflammatory response, leading to tissue