Comparison of bond strength of different endodontic sealers to root dentin: An in vitro push-out test

G. Vijaya Madhuri, Sujana Varri, Nagesh Bolla, Pragna Mandava, Lakshmi Swathi Akkala, Jaheer Shaik
Department of Conservative Dentistry and Endodontics, Sibar Institute of Dental Sciences, Guntur, Andhra Pradesh, India

Abstract
Aim: To compare the bond strength of four different endodontic sealers to root dentin through push-out test design.

Materials and Methods: Forty single-rooted teeth with completely formed apices were selected. Teeth were decoronated, and working length was determined. Instrumentation and irrigation were performed. The teeth were divided into four groups based upon the sealer used. Group 1: Bioceramic sealer (Endosequence), Group 2: Mineral trioxide aggregate (MTA) based sealer (MTA Fill apex), Group 3: Epoxy resin based sealer (MM-Seal), and Group 4: Dual cure resin-based sealer (Hybrid Root Seal). Manipulation and application of the sealer was done as per the manufacturer instructions. All the teeth were obturated using 6% gutta-percha. After obturation, each tooth was prepared for push-out test with root slices of 2 mm thickness using universal testing machine.

Results: The highest bond strength was found in Group 1 (Endosequence) \( P < 0.05 \) compared to other groups. The lowest bond strength was found in Group 2 (MTA Fill apex). Statistical analysis is done by two-way ANOVA and Newman-Keuls multiple post hoc.

Conclusion: The push-out bond strength of Bioceramic sealer was highest followed by resin-based sealer and lowest bond strength was observed in MTA-based sealer.

Keywords: Bond strength; Endosequence BC Sealer; Hybrid Root Seal; mineral trioxide aggregate fill apex; MM-Seal; push-out test

INTRODUCTION
Success of endodontic therapy depends on proper cleaning, shaping, and obturating the radicular space by establishing a fluid impervious seal. Gutta-percha is the most commonly used obturating material. As gutta-percha does not bond to root dentin, it is used in combination with a root canal sealer.[1]

Bonding of endodontic sealer to intraradicular dentin is advantageous in maintaining the integrity of the sealer-dentin interface during mechanical stresses caused by tooth flexure and in the preparation of postspace or operative procedures.[2] Bond strength of endodontic sealers to dentin is an important property because it minimizes the risk of filling detachment from dentin during restorative procedures or the masticatory function ensuring that sealing is maintained and consequently clinical success of endodontic treatment.[3]

Traditionally used root canal sealers are zinc oxide eugenol, calcium hydroxide, and resin-based sealers. Newer root canal sealers are constantly being developed to provide improved properties.[2]

Endosequence BC sealer (Brasseler, Savannah, GA, USA) is a recently introduced bioceramic sealer based on calcium silicate composition. It is available as premixed, injectable...
paste containing water-free thickening vehicles and has excellent flow ability and dimensional stability. It utilizes the moisture that remains within the dentinal tubules to initiate and complete its setting reaction.

Mineral trioxide aggregate (MTA)-based sealers have been introduced in order to achieve biologic properties and a proper seal with MTA. One of these sealers is MTA Fill apex (Angelus, Londrina, Brazil) which is presented in the form of two pastes. This sealer has good sealing ability, bactericidal effect, and biocompatibility with low solubility and low setting expansion.

MM-Seal (Micro Mega, France) is an epoxy resin-based root canal sealer packaged in a dual syringe. It has outstanding chemical and physical properties, biocompatible, and provides excellent sealing.

Hybrid Root Seal (Mitsui Chemicals, New Delhi, India) is a dual cure, self-etching resin cement. It is available in the powder liquid form, which is insoluble, radiopaque material that can be used either with resilon or gutta-percha. The formation of hybridized dentin is the major mechanism of bonding and also the high-quality hybridized dentin resists acidic challenges.

The bond between the sealer and canal walls either through the frictional retention or micromechanical adhesion helps in resisting dislodgment of the filling and maintains the integrity of the crucial interface. The push-out test is commonly used to evaluate bond strength between sealer and root dentin. This test provides a better evaluation of bond strength because here fracture occurs parallel to the resin interface.

The purpose of the current study is to compare the bond strength of four different endodontic sealers to root dentin, that is, Bioceramic sealer (Endosequence), MTA-based sealer (MTA Fill apex), epoxy resin-based sealer (MM-Seal), and dual cure resin-based sealer (Hybrid Root Sealer) through push-out test design.

**MATERIALS AND METHODS**

Forty extracted single-rooted human teeth devoid of root defects, fractures, and with matured apices were taken for this study. Each tooth was sectioned at the cemento-enamel junction with a low speed diamond blade, and the roots were then stored in normal saline. The root canal was negotiated with a size 10 stainless steel endodontic file until visualized at the apical foramen. Working length was determined by taking radiographs up to 1 mm short of apical foramen with K-type file. All canals were instrumented to the working length using protaper instruments till size F3. Canals were irrigated with 3% NaOCl solution and saline throughout instrumentation. Final irrigation consisted of 3 ml of 17% ethylenediaminetetraacetic for 1 min followed by 5 ml of saline.

The roots were stored in normal saline and divided into four groups based on the sealer used.

- **Group 1**: Bioceramic Sealer (Endosequence, BC Brasseler, USA)
- **Group 2**: MTA-based sealer (MTA Fill apex Angelus, Londrina, Brazil)
- **Group 3**: Epoxy resin-based sealer (MM-Seal, Micro Mega, France)
- **Group 4**: Dual cure resin-based sealer (Hybrid Root Seal, Sun medical co. ltd, Japan)

In Group 1 (Endosequence, Bioceramic Sealer), premixed Bioceramic sealer is placed into the canal with the provided syringe tip up to two-third of the canal. It is tried in a matching propoint and the tip is dipped into the sealer slowly and inserted into the canal until it reaches the working length and it can be trimmed to the level of the canal orifice using a high-speed hand piece and a diamond bur. It has a setting time of 4 h as per the manufacturer’s instructions.

In Group 2 (MTA Fill apex), the sealer is mixed by using a self-mixing tip attached to a syringe. A size 30/0.06 GP cone is coated with MTA Fill apex and placed to working length. The cone is then seared off at the orifice level. As per the manufacturer’s instructions, the setting time of MTA Fill apex is 2 h.

In Group 3 (MM-Seal), according to the manufacturer’s instructions, an appropriate amount of base and catalyst (2:1 wt ratio) is squeezed onto a mixing plate. They were mixed with the spatula for 15–20 s or until creamy and homogeneous. After thorough drying of canals MM-Seal was applied, tips of dry disinfected gutta-percha points dipped into the MM-Seal and placed up to the working length. The setting time of MM-Seal is 45 min according to the manufacturer.

In Group 4 (Hybrid Sealer), 3 drops of liquid and 1 scoop of powder are dispensed onto a mixing pad and stirred thoroughly with a spatula to make a homogeneous texture. Hybrid Root Seal was applied to the entire length of the canal using lentulospiral and placed the gutta-percha point up to the working length. It has a working time of 35 min given by the manufacturer.

The samples were coronally restored with cavit G and stored at 95% relative humidity and 37°C for 24 h. Each root was horizontally sectioned into 2 mm thick slices using a hard tissue microtome.

The filling material was loaded with a 1-mm diameter cylindrical stainless steel plunger. Loading was performed...
on a universal testing machine at a speed of 0.5 mm/min until deboning occurred. The load was applied in an apical-c coronal direction to avoid any interference because of the root canal taper. The bond strength value in megapascals (MPa) was computed by dividing the maximum load needed to dislodge the filling material in Newton’s by the interfacial area (mm²).

RESULTS

The statistical analysis is done by two-way ANOVA and Newman-Keuls multiple post hoc and it revealed a statistically significant difference among the groups. Statistical version used for the study is SPSS 21.0 (IBM Corporation, USA). The highest bond strength was found in Group 1 (Endosequence) (\( P < 0.05 \)) compared to other groups [Figure 1]. The lowest bond strength was found in Group 2 (MTA Fill apex). There was statistically significant difference among all the experimental groups [Table 1].

Stereomicroscopic evaluation of the specimens showed more of cohesive or mixed failures [Figure 2].

DISCUSSION

The aim of endodontic therapy is not only to eliminate microorganisms by cleaning and shaping the root canal but also to ensure that the root canal system to be fluid free and that a single block configuration is created that seals hermetically the canal space. Because of the poor adhesiveness of gutta-percha, the use of sealers has been considered mandatory. The major function of a root canal sealer is to fill imperfections and increase adaptation of the root filling material to the canal walls, failing which the chances of leakage and failure increase.\(^1,3,4,6\)

In dynamic clinical situations, adhesion is necessary to avoid dislocation of sealer because of tooth flexure, operative procedures, or post space preparation.\(^2\) The push-out test is commonly used to evaluate bond strength between sealer and canal walls and is based on the shear stress at the interface between dentine and cement, which is comparable with stresses under clinical conditions. The force is applied in apico-coronal direction to avoid interference due to canal taper, during dislodgement of the filling material.\(^2\) In all the samples, core material is used along with the sealers. Bond strength testing may not completely replicate clinical performance of root canal sealers, it still provides valuable information comparing different sealers or obturation techniques.\(^1\)

In this study, we have selected four different types of endodontic sealers, i.e. Bioceramic sealer (Endosequence), MTA-based sealer (MTA Fill apex), epoxy resin-based sealer (MM-Seal), and dual cure resin-based sealer (Hybrid Root Sealer).

In the present study, compared to all other sealers, Endosequence BC Sealer showed the highest bond strength with a statistically significant difference (\( P = 0.0001 \)). This may be due to its true self-adhesive nature, which forms a chemical bond (through production of hydroxyapatite during setting) with dentine. Moreover, it is hydrophilic, possess low contact angle allowing it to spread easily over the canal walls providing adaptation and good hermetic seal.\(^7\) In an in vitro study done by Ghoneim et al., it was seen that the resistance to vertical fracture of roots obturated with iRoot SP (Bioceramic-based sealer) and

| Groups   | Group 1 | Group 2 | Group 3 | Group 4 |
|----------|---------|---------|---------|---------|
| Mean     | 98.72   | 30.39   | 71.69   | 51.89   |
| SD       | 19.65   | 5.10    | 12.24   | 8.18    |
| Group 1  | -       |         |         |         |
| Group 2  | \( P=0.0002^* \) | -       |         |         |
| Group 3  | \( P=0.0005^* \) | \( P=0.0002^* \) | -       |         |
| Group 4  | \( P=0.0002^* \) | \( P=0.0052^* \) | \( P=0.0108^* \) | -       |

Figure 1: Comparison of four groups (1, 2, 3, and 4) with respect to mean peak load (Newton)

Figure 2: Stereomicroscopic image showing cohesive bond failure
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Activ GP cones was comparable to that of intact teeth.[8] The Bioceramic cones or Activ GP cones has the capability to absorb water from the tooth environment and expand in the lateral direction only to hermetically seal the root canal.[9] Christopher Delong in his study concluded that Bioceramic sealer showed highest bond strength than MTA plus sealer when used in a single cone technique.[1]

According to Lee et al., resin-based sealers have high bond strength compared to other sealers.[10] Resin sealer penetrates deeper into the dentinal tubules due to its flow ability and long-term polymerization time, and it also has a very low shrinkage while setting and long-term dimensional stability. Gurgel-Filho and Martins concluded that push-out bond strength of AH Plus and gutta-percha core combination were higher than Endo Fill sealer and MTA Fill apex core combination.[3] Patil et al. has conducted an in vitro study comparing the push-out bond strength of AH Plus/gutta-percha, Resilon/Epiphany, Endorez sealer/Endorez points and concluded that AH Plus/gutta-percha combination showed significantly highest bond strength.[11] In the present study also, epoxy resin-based sealer, MM-Seal shows good bond strength next to Endosequence and this may be due to its ability to react with any exposed amino groups in collagen to form covalent bonds between the resin and collagen upon opening of the epoxide ring.[7,12]

Unogar et al. (2009) in their study concluded that push-out bond strengths of methacrylate based sealers (Hybrid Root Seal and real seal) and polymer-based core material (Resilon) combinations were higher than epoxy resin-based sealer (MM-Seal) and gutta-percha combination. But on the contrary, in the present study, Hybrid Root Seal shows less bond strength compared to the bioceramic- and resin-based sealer. This may be due to the use of traditional gutta-percha cones in the Hybrid Root Seal group, that has prevented the adhesive bonding between the core material and sealer and also being a methacrylate based sealers, they inherently undergo polymerization shrinkage coupled with high C factor inside the root canals which can lead to debonding of the resin from the root canal.[4]

Forough Reyhani et al. in their study compared the push-out bond strength of Dorifill, Epiphany and MTA Fill apex sealers to root canal dentin with and without smear layer and he concluded that Epiphany group has highest bond strength compared to MTA Fill apex.[13] Gurgel-Filho and Martins in their study concluded that MTA Fill apex showed lowest bond strength compared to AH Plus and Endo Fill sealers.[14] Sarkar et al.[14] suggested that the release of calcium and hydroxyl ions from the set sealer will result in the formation of apatite as the material comes into contact with phosphate-containing fluids which promote controlled mineral nucleation on dentin, seen as the formation of an interface layer with tag-like structures. The reason for the low bond strength of MTA Fill apex in the present study could be the low adhesion capacity of these tag-like structures corroborated by the study made by Sagsen et al.[15]

CONCLUSION

- Endosequence BC (Bioceramic Sealer) showed the highest push-out bond strength among all the four groups. MM (Epoxy resin based sealer) showed the second highest bond strength followed by Hybrid seal (Dual cure resin based sealer)
- Lowest bond strength was observed in MTA Fill apex.

Limitations of this study

Most of the recent studies done on Endosequence and propoints are in vitro, and there is a need and necessity for more clinical studies regarding its cytotoxicity to establish its long-term use.

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Conflicts of interest

There are no conflicts of interest.

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