Effect of New Obturating Materials on Vertical Root Fracture Resistance of Endodontically Treated Teeth

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Abstract

The aim of this study was to compare vertical forces at fracture of teeth obturated with different materials. Single-rooted teeth were divided into five groups. The first group served as a negative control. The remaining four groups were shaped using ProTaper rotary files (Dentsply Maillefer, Ballaigues, Switzerland). The second group was obturated with gutta percha and a zinc oxide sealer. The third group was obturated with EndoRez points and EndoRez sealer (both from Ultradent, South Jordan, UT). The fourth group was obturated with Resilon (Pentron Clinical Technologies, Wallingford, CT) and RealSeal sealer (Pentron Clinical Technologies). The fifth group was obturated with Guttaflow (Colténe/Whaledent, Altstätten, Switzerland). Roots were then fixed into a universal testing machine and loaded with a spreader until fracture. It was found that forces at fracture were statistically significantly higher in the Resilon and EndoRez groups. It was concluded that obturation of roots with resin-based obturation materials (Resilon and EndoRez) increased the resistance of root canal filled teeth to vertical root fracture. *(J Endod 2007;33:732–736)*

Key Words

EndoRez, finger spreader, GuttaFlow, Resilon, Vertical fracture

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When the dental pulp undergoes pathologic changes because of trauma or the progression of dental caries, bacteria and other irritants from the oral cavity invade the root canal system. The major objectives of root canal therapy are removal of pathologic pulp, cleaning, and shaping of the root canal system; disinfection of contaminated root canals; and three-dimensional obturation to prevent reinfection (1–6). Although obturation may not necessarily be the most critical stage in root canal therapy, it should still be performed according to the highest clinical standards (6, 7).

Obtaining an impervious seal is difficult. The use of sealers along with well-adapted gutta percha gives the optimum chance of success (1, 8). 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 accomplished at the expense of its biocompatibility (1, 6, 9).

Different endodontic-filling materials and technologies have been introduced to improve the apical seal (6, 10). Most root canal–filling methods use a root canal sealer as an integral part of the obturation technique. The most popular class of sealer cements used in endodontics is based on zinc oxide and eugenol formulations. Gutta percha is the most commonly used root canal–filling material in contemporary endodontics (6). Gutta percha is a highly biocompatible material and is of such low cytotoxicity that the sealants that are used with it will determine the tissue response (9).

The bonding concept of the root-filling material is hampered by the lack of a chemical union between the polyisoprene component of gutta percha and methacrylate based resin sealers (11).

A most frustrating complication to root canal therapy is vertical root fracture (12). Vertical root fracture is a longitudinal fracture of the root, extending throughout the entire thickness of dentine from the root canal to the periodontium (13, 14).

It is a serious clinical concern, with an unfavorable prognosis (12, 13), resulting almost inevitably in extraction of the tooth or resection of the affected root (15–17). It occurs in endodontically treated teeth and is an important cause of endodontic failure (18–20). The misfortune of a vertical root fracture is catastrophic to both the patient and dentist. This type of trauma occurs to a tooth when considerable investment of time and money have already been expended (12, 14, 17).

Despite apparently satisfactory performance over many decades and in a variety of guises, gutta percha and sealer-filling techniques do not represent the universal ideal. Although few materials have seriously challenged gutta percha and sealer in the majority of filling situations, research continues to find alternatives that may seal better and mechanically reinforce compromised roots (21).

In 2004, a new obturation system was introduced under the name RealSeal (Pentron Clinical Technologies, Wallingford, CT) containing Resilon and a Resin-based sealer. Resilon (Pentron Clinical Technologies) is a thermoplastic synthetic polymer-based root canal filling material. Based on polymers of polyester, Resilon contains bioactive glasses and radiopaque fillers. It performs in a similar way to gutta percha, has the same handling properties, and for retreatment purposes may be heat softened or dissolved with solvents such as chloroform. The RealSeal sealer (Pentron Clinical Technologies) is a dual curable dentin resin composite sealer (22) and may be used in conjunction with Resilon points.

Previous studies compared the fracture forces of roots obturated with Resilon and gutta percha. However, there are no studies comparing the fracture force of another resin-based material (EndoRez; Ultradent, South Jordan, UT) or a recently available alternative silicon based material (GuttaFlow; Colténe/Whaledent, Altstätten, Switzerland).

EndoRez is a new hydrophilic, urethane dimethacrylate–based resin sealer that has been developed for use with a single, gutta-percha cone for canal obturation (8). Urethane dimethacrylate is the main component. It is a monomer commonly used as part of the organic matrix of resin composites. Resin including materials can adhere to the dentine. According to the manufacturer, EndoRez has satisfactory sealing properties and an easy delivery system (23). Recently, resin-coated gutta-percha points have been introduced. Historically, gutta percha has only shown a weaker, chemical bond with canal sealers. A resin coating of gutta percha facilitates a chemical bond with any resin based sealer, thus creating a monoblock.

A new root canal–filling paste GuttaFlow is a modification of RoekoSeal sealer (Coltène/Whaledent, Langenau, Germany). GuttaFlow contains gutta-percha particles as filler. The material is flowable and sets within 10 minutes. It is said to be easily applied using lentulo spirals or application syringes.

The aim of this article was to evaluate the effect of different combinations of obturating materials and sealers on vertical forces at fracture of endodontically treated teeth. These were (1) Resilon and a resin sealer, (2) resin-coated gutta percha and Endorez sealer, (3) GuttaFlow, and (4) gutta percha with a zinc oxide sealer using a universal testing machine. The null hypothesis was that there are no differences in the vertical forces of fracture between materials.

Materials and Methods

Sixty-seven single-canal extracted teeth were collected and stored in sterile water. The teeth were carefully examined. Teeth with immature apices, had undergone root canal treatment, had root caries or restorations, or had root fractures or cracks were excluded from the study.

Tooth Preparation

The teeth were sectioned at the cementoenamel junction with a diamond wheel saw. Roots were randomly allocated into five groups. The first group served as a negative control; roots were not instrumented or obturated. In the remaining four groups, access cavities were prepared, and the working length was determined by introducing a size 10 file into the canal until it exited from the apex; this length was measured, and the working length was set 1 mm short of that length. The roots were prepared by using ProTaper nickel titanium rotary files. After introduction of hand files and establishment of a glide path, ProTaper files were used to clean and shape the root canal. During preparation and between each file, 1 ml of 0.5% sodium hypochlorite was used as an irrigant. Also, a small size 10 hand file was introduced to maintain patency of the apical constriction. The canals were all prepared to a F3 ProTaper file.

After completion of instrumentation, all specimens received a final flush of 17% EDTA following the manufacturer's instructions and dried with paper points.

Filling of the Root Canals

The first group served as a negative control group. Roots were not instrumented or obturated. The second group received a root filling by cold lateral condensation technique with gutta percha and Tubliseal (SybronEndo, Orange, CA) (zinc oxide–eugenol–based sealer). The apical one third of the master gutta percha cone was coated with the sealer and placed into the canal then a size 20 finger spreader was inserted, rotated, and withdrawn. An accessory gutta percha cone, coated with a thin layer of the sealer, was placed into the space created by the spreader. The process repeated until the canal was completely obturated. Excess gutta percha was removed and condensed with a hot plugger.

The third group was root canal filled using cold lateral condensation with EndoRez points (resin-coated gutta percha) and EndoRez (resin based sealer). The apical one third of the master EndoRez cone was coated with the sealer and placed into the canal, and then a size 20 finger spreader was inserted, rotated, and withdrawn. An accessory EndoRez cone, coated with a thin layer of sealer, was placed into the space created by the spreader, and the process repeated until the canal was completely obturated. Excess EndoRez points were removed and condensed with a hot plugger.

The fourth group received a root filling by lateral condensation using Resilon points and RealSeal (resin-based sealer). The RealSeal primer was applied by using a microbrush in the canal, and excess was removed by using papers points. The apical one third of the master Resilon cone was coated with the sealer and placed into the canal, and then a size 20 finger spreader was inserted, rotated, and withdrawn. An accessory Resilon cone, coated with a thin layer of sealer, was placed into the space created by the spreader, and the process repeated until the canal was completely obturated. Excess Resilon points were removed and condensed with a hot plugger.

The fifth group received a root canal filling using a single gutta-percha master cone and GuttaFlow as a sealer. A master gutta-percha point was selected. The GuttaFlow capsule was mixed for 30 seconds in a triturator. Then the canal tip was attached to the capsule that was inserted into the dispenser. The canal tip was inserted into the apical third of the canal 1 mm short of the working length. A small amount of GuttaFlow was gently dispensed into the apical third. GuttaFlow was also directly applied on the master point that was then inserted into the canal. The canal was back filled with GuttaFlow. Excess obturating material was removed with a heated hand instrument. All roots were kept at 37°C with 100% humidity for at least 72 hours to allow the sealers to set completely.

Preparation for Mechanical Testing

Roots were fitted into tight-fitting rubber tubing to simulate the periodontal ligament. Epoxy resin was mixed to a thin consistency and poured into plastic blocks in which the roots were vertically embedded. Blocks were left for 24 hours until the epoxy resin had set. Excess resin was removed, and blocks with the embedded roots were mounted into a Zwick/Roell Z020 Universal Testing Machine (Zwick GmbH & Co. KG, Germany). A size 40 hand stainless-steel spreader was placed on the universal testing machine fixture and placed directly above the root canal orifice (Fig. 1). The universal testing machine was calibrated to vertically drive the spreader into the root canal at a speed of 10 mm/min. During which, it penetrated the root canal filling and force was applied to the root until it fractured.

Fracture was defined as the point at which a sharp and instantaneous drop greater than 25% of the applied force was observed. The amount of force required for fracture was recorded for each root. For most specimens, an audible crack was also heard.

The force applied to the root canal via the spreader was recorded in the form of a graph (Fig. 2). A gradual increase in force occurred as the spreader was penetrating the root canal through the obturating material. The force increased until the root fractured. At that point, a decrease in force occurred. The machine was adjusted to terminate the test when we had a 25% reduction of the force. At that time, the maximum force was recorded. Whenever bending of the spreader occurred, it was changed with a new same size spreader. Throughout the test, the roots were kept fully hydrated.

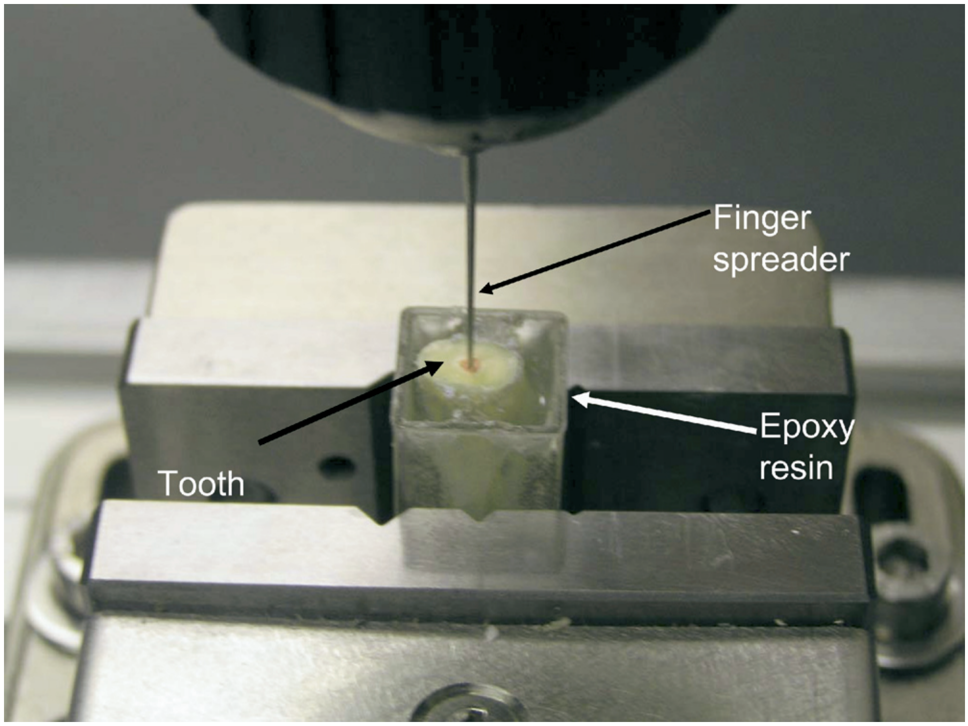

Figure 1. Finger spreader inserted into the root canal penetrating the obturating material. Part of the setup used in the Universal Testing Machine.

Results

Vertical fracture force measurements (N) were obtained from the Universal Testing Machine (Zwick/Roell Z020). The test was conducted on five test groups: a control group (not instrumented and not obturated), a gold standard group (gutta percha), and three experimental groups.

The mean force to fracture of the control group was higher than the mean force to fracture of any other group (Table 1). The two resin-

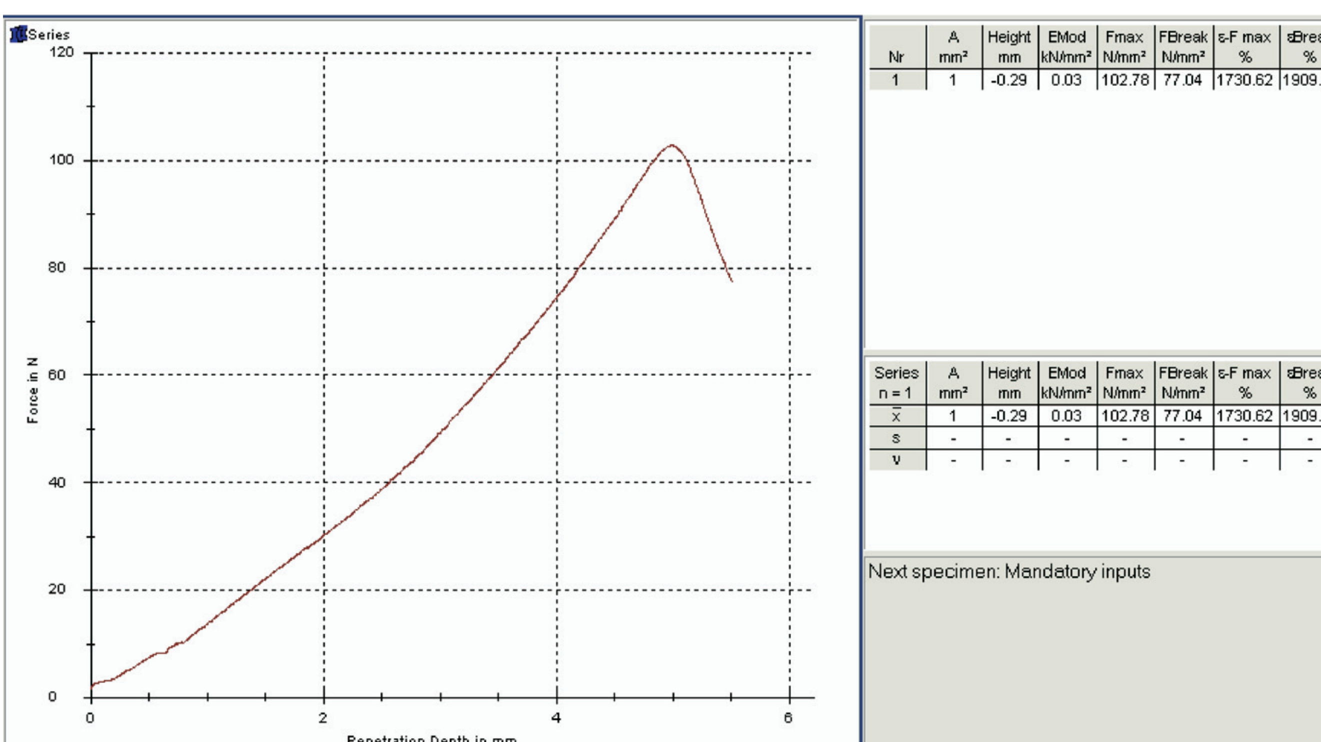

Figure 2. Typical trace obtained showing gradual increase in fracture force (N) plotted against penetration depth in millimeters.

TABLE 1. The Mean Force in Newtons (N) Required for Vertical Root Fracture for All Groups Tested

Groups	Mean Force (N)	Standard Deviation	Maximum Force (N)	Minimum Force (N)
Control group (n = 10)	245.26[a]	41.29	295	221
Gutta-percha group (n = 13)	90.15[b]	13.92	105.1	68
Resilon group (n =13)	146.31[c]	49.64	249	104
EndoRez group(n = 13)	169.40[c]	47.02	241	112
GuttaFlow group (n = 12)	74.06[b]	28.70	130	44.5

Standard deviations for each group are also presented.
Superscript letters [a], [b], [c] represent statistically significant differences ($p < 0.05$).

based obturation materials, Resilon and EndoRez, had a mean force to fracture higher than the gutta-percha and GuttaFlow groups but less than the control group (Table 1). One-way analysis of variance test was performed to compare the means of the different tested groups with a post hoc Bonferroni test ($p = 0.05$) by using SPSS software (13.0.1; SPSS Inc, Chicago, IL).

Discussion

Root canal instrumentation is an essential stage in endodontic treatment (24). Studies showed that instrumentation alone has been found to significantly weaken roots. Inasmuch as it is difficult to ascertain the amount of dentine that can be removed before this weakening effect takes place, it seems logical to remove as little dentine as possible during instrumentation without jeopardizing long-term success (25, 26). If wedging forces of the spreader are added during lateral condensation, or excessive dentine is removed to facilitate plugger placement for vertical condensation, the likelihood for root fracture increases. Any material that can compensate for this weakening effect would be useful (24).

Several factors should be considered when selecting a material or a combination of materials to fill a root canal. One is to select a material that has a potential to reinforce the root structure and protect it against fracture (27).

It would be advantageous if the root canal obturation, in addition to providing an adequate seal, could contribute to the reduction in the incidence of vertical root fractures (25, 28).

Experimental techniques for investigating root fracture have generally involved the generation of force within the canal space by means of a spreader inserted into the obturated canal (13, 14, 16, 26, 29).

During selection of teeth, some dimensions of the specimens were controlled (e.g., root length and coronal buccolingual diameter). Teeth were as similar as possible and were randomly assigned into groups (24) (Tables 2 and 3).

Teeth that had originally large canals were excluded from the study. During preparation of the canals, the first binding file was usually a size 15 or size 20 k-file.

Sodium hypochlorite at 0.5% concentration was used as the irrigant of choice during preparation of the canals because it is the most commonly used irrigant. A low concentration was used to minimize the adverse effect on dentine mechanical properties. The canals were rinsed with EDTA as a final flush according to the manufacturer's instructions because any remaining sodium hypochlorite might inhibit the setting of resin materials.

Three recently introduced obturating materials were studied: two resin-based materials (Resilon and EndoRez) and a silicon-based material (GuttaFlow). They were compared with Gutta percha and Tubliseal sealer and with a control group (unprepared and unfilled).

Gutta percha is considered to be the gold standard; it has been in use for about 100 years, and no suitable substitute has yet emerged (9).

A lateral condensation technique was used in this study because it is a more widely recommended technique and facilitates comparison with previous studies (18). Also, EndoRez is only provided in cones, not yet available for vertical thermal condensation. Accessory cones were added to all groups except the GuttaFlow group because the manufacturer's instructions are to use the single-cone technique. The method used to prepare and test the roots was similar to that used in other studies (13, 14, 16, 18, 26, 29).

The method used in this study was chosen because it provides force distribution from inside the root canal wall and fractures occurred as a result of forces transmitted via the obturating material (13). This resembled root fracture of endodontic origin or from a post (18). It was noticed that most fractures occurred on the buccal/lingual surface. Stresses generated from inside the root canal were transmitted through the root to the surface where the interdentine bonding failed (26).

The test was terminated after a 25% drop in the maximum force recorded, similar to that used in other studies (24). The mean force to fracture of the control group was higher than the mean force of fracture of any other group. This was in agreement with other studies (18, 25).

The two resin-based obturation materials used, Resilon and EndoRez, had a mean force to fracture higher than the gutta percha and GuttaFlow groups but less than the control group. This result suggests that Resilon and EndoRez both increased the fracture resistance of endodontically treated roots to internally generated stresses. There was no statistically significant difference in the mean force at fracture between Resilon and EndoRez.

The mean forces at fracture reported in the literature vary, and the mean forces at fracture reported in the study are well within that wide range. The wide range may be because of the type and dimensions of the teeth selected for the study, protocol followed for cleaning and shaping of the roots, and protocol followed for fracture resistance measuring. It has been reported that not using the rubber tubing to simulate the periodontal ligament may lead to abnormally high forces at fracture (16, 25, 30, 31).

The results regarding Resilon were in accordance with a previous study (24). Although root preparation and method of producing vertical

TABLE 2. The Mean Root Lengths in Millimeters of Roots Used in the Study for Each Group

Groups	Mean Root Length (mm)	Maximum Length (mm)	Minimum Length (mm)
Control group (n = 10)	13.2	15	11
Gutta-percha group (n = 13)	12.8	14	11
Resilon group (n = 13)	12.5	14	10
EndoRez group (n = 13)	12.3	14	10
GuttaFlow group (n = 12)	12.8	15	11

Maximum and minimum lengths are also presented.

TABLE 3. The Mean Coronal Buccolingual Root Diameter in Millimeters of Roots Used in the Study for Each GRoup

Groups	Mean Coronal Root Diameter (mm)	Maximum Diameter (mm)	Minimum Diameter (mm)
Control group (n = 10)	6.2	8	5
Gutta-percha group (n = 13)	6.5	8	5.5
Resilon group (n = 13)	6.2	7	5
EndoRez group (n = 13)	6.5	8	5.5
GuttaFlow group (n = 12)	6.5	8	5.5

Maximum and minimum diameters are also presented.

root fracture were different, results were similar. There were no studies found in the literature regarding EndoRez- or GuttaFlow-filled roots resistance to vertical fracture.

Similar to other studies (18, 24, 25, 28), gutta percha did not show increased resistance to internally generated stresses in the root canal because it exhibited lower mean forces to fracture when compared with Resilon and EndoRez. GuttaFlow also did not show increased resistance to internally generated stresses. These findings were not surprising because both gutta percha and GuttaFlow do not chemically bond to the dentine wall, so they do not form the monoblock system. There was no statistically significant difference in the mean force at fracture between Gutta percha and GuttaFlow.

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