# A Novel Polyurethane-based Root Canal–obturation Material and Urethane-Acrylate–based Root Canal Sealer—Part 2: Evaluation of Push-out Bond Strengths

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## Abstract

We have developed a visible-light curable urethane-acrylate/tripropylene glycol diacrylate (UA/TPGDA) oligomer to serve as a root canal sealer and a zinc oxide/thermoplastic polyurethane (ZnO/TPU) composite to serve as a root canal obturation material. The purpose of this study was to compare the push-out bond strengths of the following 8 groups of materials: (1) Tubliseal + gutta-percha (TB/GP); (2) Tubliseal + Resilon (TB/R); (3) Epiphany + gutta-percha (EP/GP); (4) Epiphany + Resilon (EP/R); (5) EndoREZ sealer + EndoREZ cone (ES/EC); (6) EndoREZ sealer + ZnO/TPU (ES/PU); (7) UA/TPGDA + EndoREZ cone (UA/EC); and (8) UA/TPGDA + ZnO/TPU (UA/PU). Eighty 1-mm-thick root slices prepared from extracted human permanent molars were randomly divided into 8 groups with 10 specimens in each group. Root slices were filled with the above obturation materials, and then push-out test was performed with a universal testing machine. The results showed that the UA/EC and UA/PU groups had significantly higher bond strengths than the other groups. *(J Endod 2008;34:594–598)*

## Key Words

Push-out bond strength, root canal obturation, ZnO/TPU composite

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A hermetically 3-dimensional obturation plays a crucial role in reducing periapical inflammation and microbial leakage (1). In addition, adhesion of root canal sealers to dentin is important to seal the root canal thoroughly and prevent dislodgement of filling materials (2). The traditional obturation materials used in endodontics are gutta-percha and root canal sealers. However, disadvantages of gutta-percha include no dentinal adhesion, lack of sufficient rigidity, and shrinkage during cooling or solvent evaporation (3). To circumvent these disadvantages, a new polymer-based obturation material, Resilon, in combination with methacrylate-based resin sealers was developed. The manufacturer has claimed that the use of Resilon in combination with self-etching adhesives and methacrylate-based resin sealers offers the advantages of monoblock bonding for the root canal system (4). Resilon has been demonstrated to exhibit less microbial leakage (5) and higher bond strength to root canal dentin (6), reduce periapical inflammation (7), and enhance fracture resistance of endodontically treated teeth (8) compared with gutta-percha. However, previous studies also reported limitations of Resilon including low push-out bond strength (3, 9, 10) and low cohesive strength plus stiffness (11). In addition, Resilon could not achieve a complete hermetic apical seal (4).

We have developed a novel polyurethane-based composite to serve as a root canal obturation material and a visible-light curable urethane-acrylate/tripropylene glycol diacrylate (UA/TPGDA) oligomer to serve as a root canal sealer. The composite is composed of thermoplastic polyurethane (TPU) as well as zinc oxide (ZnO) and exhibits better mechanical properties than Resilon and gutta-percha. In addition, ZnO/TPU composite in combination with UA/TPGDA sealer can bond to the intraradicular dentin. Because strengthening of roots with adhesive materials can be reflected by improved interfacial strength and dislocation resistance (12), the push-out test is one effective method to evaluate the adhesive bond strength of an endodontic obturation material. The purpose of this study was to evaluate the push-out bond strength of our newly developed materials and to compare them with those of other widely used filling materials.

## Materials and Methods

### Specimen Preparation

The procedures used to synthesize ZnO/TPU composite and UA/TPGDA sealer have been described in the first part of this series of studies. Extracted human permanent molars (Fig. 1*A*) from subjects aged 16–40 years were used in this study after informed consent was obtained from the donors. Crowns with caries, restorations, or fractures were discarded. Any remaining soft tissues were thoroughly removed from the tooth surfaces with a dental scaler (Sonicflex 2000; KaVo Co, Biberbach, Germany) under running water. All teeth were then stored at 4°C in distilled water containing 0.2% thymol to inhibit microbial growth until use. While fully hydrated, the palatal roots of maxillary molars or distal roots of mandibular molars were first cut down perpendicular to the long axis of the tooth by using a low-speed diamond wafering blade (Isomet; Buehler Ltd, Lake Bluff, IL). Then the apical 3 mm of each root was cut, and the apical portions were discarded (Fig. 1*B*). Each canal was prepared until the apical opening could be passed by an ISO size 80, 0.02 taper file. The canals were irrigated with 17% ethylenediaminetetraacetic acid (EDTA) and 2.5% sodium hypochlorite during instru-

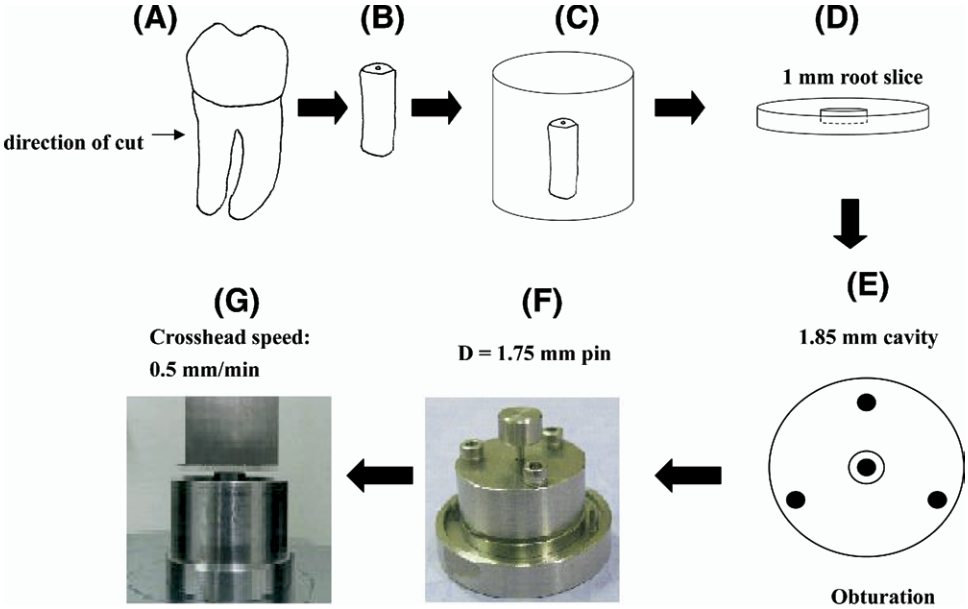


**Figure 1.** Illustration of the push-out bond test procedure. (*A*) Extracted human permanent molars were used. (*B*) Palatal roots of maxillary molars or distal roots of mandibular molars were cut down perpendicular to the long axis of the tooth. The apical 3 mm of each root was cut, and the apical portions were discarded. (*C*) Each prepared root was mounted vertically in a custom-made aluminum cylinder with self-curing acrylic resin. (*D*) Each root was serially sectioned to create a root slice of 1-mm thickness. (*E*) A 1.85-mm diameter hole was centrally prepared in each root slice by using a multi-drilling machine, and the hole was filled with obturation materials. (*F*) The punch-out apparatus consisted of 2 cylindrical steel dies aligned together with 2 dowels and secured with 3 screws. A 1.80-mm diameter hole and a 1.90-mm diameter hole were centrally positioned at the upper and lower dies, respectively. A cylindrical carbon steel rod 1.75 mm in diameter was used as a plunger. (*G*) The push-out apparatus was mounted on an Instron universal testing machine.

mentation. A custom-made aligning device was used to mount each prepared root vertically in custom-made aluminum cylinder (3 cm in diameter and 2 cm in height) with self-curing acrylic resin (Tempron; GC Corp, Tokyo, Japan) (Fig. 1*C*). The aligning device contained a base plate with 3 orientation screws and 1 central guiding pin. Each prepared root was positioned with the central guiding pin, and self-curing acrylic resin was poured to embed the root after application of a thin layer of petroleum jelly on the inner wall of aluminum cylinder. The cylinder was removed after the setting of acrylic resin to obtain resin block with mounted root segment. Each root was serially sectioned to create a root slice of 1-mm thickness by using a high-speed diamond wafering blade (Isomet 2000 Precision High-Speed Saw; Buehler Ltd) (Fig. 1*D*), and the thickness was verified by using an electronic vernier (CD-10CX; Mitutoyo Co Ltd, Tokyo, Japan). The root slice was restrained by an apparatus consisting of 2 cylindrical steel dies aligned together and secured with 3 screws. Under copious distilled water cooling, a 1.85-mm diameter hole was centrally prepared in each root slice by using a multi-drilling machine (LT-848; Dengyng Instruments Co Ltd, Taipei, Taiwan) (Fig. 1*E*). The hole was at least 0.5 mm from the edge of the specimen. All specimens were immersed in an ultrasonic cleaner (Delta; Mandarin Scientific Co Ltd, Taipei, Taiwan) filled with 2.5% sodium hypochlorite for 1 minute, then 17% EDTA for 2 minutes to remove the smear layer, and finally distilled water for 2 minutes 3 times.

### Obturation of Root Canal Space

The materials used included gutta-percha (Obtura II; Obtura-Spartan, Fenton, MO), Tubliseal (SybronEndo, Orange, CA), Epiphany (RealSeal; SybronEndo), EndoREZ (Ultradent, South Jordan, UT), Resilon (RealSeal; SybronEndo), ZnO/TPU composite, and UA/TPGDA sealer.

Eighty root slices were randomly divided into 8 groups with 10 root slices in each group. The sealer and cone used in each group are listed in Table 1. All specimens were filled with warm vertical compaction following the manufacturer's instructions. Briefly, gutta-percha was carried by using Obtura II, and Resilon was carried by using Element obturation unit (SybronEndo). The UA/TPGDA sealer appeared as viscous liquid and was coated on the root canal. It was cured by visible light after the root canal was filled by cone materials. The UA/TPGDA sealer contains D,L-camphorquinone, ethyl 4-dimethylaminobenzoate (EDMAB), and 2,2-azobis-isobutyroni-

**TABLE 1.** Types of Sealer and Cone Used in Each Group and Fracture Mode

| | Sealer | Cone | Abbreviation | Fracture mode |
|---|---|---|---|---|
| Group 1 | Tubliseal | GP | TB/GP | Class I |
| Group 2 | Tubliseal | Resilon | TB/R | Class I |
| Group 3 | Epiphany | GP | EP/GP | Class II |
| Group 4 | Epiphany | Resilon | EP/R | Class II |
| Group 5 | EndoREZ | EndoREZ | ES/EC | Class I |
| Group 6 | EndoREZ | ZnO/TPU | ES/PU | Class I |
| Group 7 | UA/TPGDA | EndoREZ | UA/EC | Class I |
| Group 8 | UA/TPGDA | ZnO/TPU | UA/PU | Class I |

GP, gutta-percha; UA/TPGDA, urethaneacrylate/tripropylene glycol diacrylate oligomer; ZnO/TPU, zinc oxide/thermoplastic polyurethane composite.