Novel RMGIC : May The Forces Be With You

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INTRODUCTION

Following final crown placement after conventional Endodontic procedures, there is a risk of vertical tooth fracture due to the insufficient strength of the filling material and possible Dentin dehydration.

To address this, the present study considers an Endodontic Monoblock approach to connect the dentin 'wall-to-wall'. A novel resin-based material was developed with the following aims: 1) Chemically bond to both radicular and coronal dentin, 2) Reduce internal stress concentration within the tooth by minimizing different material interactions and, 3) Achieve mechanical properties similar to Dentin.

BACKGROUND

- Endodontically treated teeth are susceptible to fracture and failure due to material interactions within the tooth along with development of internal stresses of different restorative components in the tooth, e.g., Figure 1

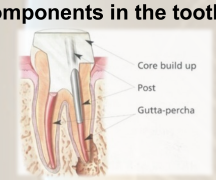


Figure 1: Multiple materials being used in the restoration of the canal have different material properties and interactions. This can lead to large internal stresses resulting in failure of the restoration

- Existing Resin-based Endodontic filling material does not achieve an endodontic monoblock and has very low modulus of elasticity and cohesive strength when compared to Dentin[1]
- Adhesive retrograde filling materials such as Glass-ionomers have shown significant reduction in periapical inflammation and intimate bonding with endodontic systems, i.e., better biocompatibility[2] but at present have Low flexural strength and Low Moduli of Elasticity.
- Biomechanically, a filling material with Modulus Of Elasticity (MoE) similar to Dentin (14.0-18.6 GPa) will allow the tooth to withstand forces which would lead to vertical fracture.[3]
- Materials that allow flexure in unison with remaining dentin reduce likelihood of irreparable damage to the tooth [4] Table 1 demonstrates existing materials do not meet this need

Table 1: Comparison of moduli of elasticity of different materials employed within the root canal space with those of Dentin. [5]

Material	Modulus of elasticity (GPa)	Number of times that of dentin
Dentin	14.0 – 18.6	1
Gutta-percha	0.074 – 0.079	0.005
Resilon	0.087 – 0.129	0.005 – 0.008
Poly(HEMA)	0.18 – 0.25	0.01 – 0.02
Clearfil SE Bond	0.56	0.034

METHODOLOGY

- To address this gap, we developed a novel RMGIC formulation and assessed its Biocompatibility
- TriHydroxy TetraUrethane DiMethAcrylate (THTUDMA) was used as base resin with combinations of different acids and different cross-linking agents
- Over 30 formulations of Resin, Resin + Water and Resin + Water + a Glass Ionomer Filler were studied:
  - The polymerization rate and monomer conversion was assessed via Kinetic measurement tests
  - Sample bars were tested in 3 point bending tests to obtain the MoE, Flexural Strength and Toughness
  - The Microtensile Bond Strength was tested to inform the adhesion between the THTUDMA and Dentin
- The most promising combinations were tested for flexural strength and MoE in water and saliva after Curing in a Dry state for 24 hours

RESULTS

- Overall, the Resin combination with excess Acrylic Acid achieves high polymerization rates (Figure 2).

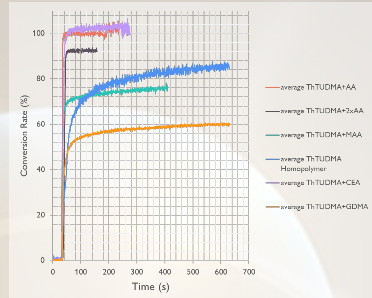


Figure 2: Monomer to Polymer conversion rates highlighting the benefit of excess Acrylic Acid

- The hydrophilic compound forms a strong resin matrix that contributes to excellent mechanical properties of the RMGIC. For example, a maximum Flexural Strength of nearly 211 MPa and MoE of 16.6 GPa was achieved 2 weeks Post Cure (Figure 3).

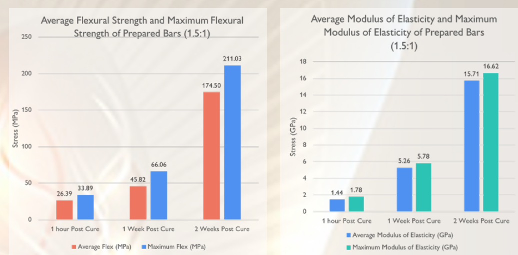


Figure 3: Illustration of the excellent mechanical properties of the novel RMGIC developed

- The MoE of the novel RMGIC, when tested dry, is much closer to Dentin than existing filling materials (Figure 4)
- Strong bonding of the RMGIC to Dentin was also observed, attributed to the ion exchange with the Glass Ionomer
- However, a significant reduction in properties was observed when the material was tested in water and saliva, possibly due to excessive water uptake. Further study is required to assess if this effect is less pronounced in the confines of a tooth

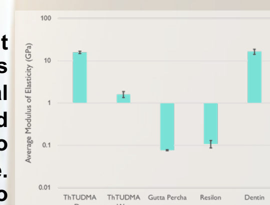
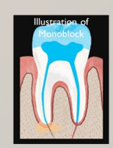


Figure 4: Comparison of the MoE of Dentin, existing filling materials and the novel RMGIC

CLINICAL IMPLICATIONS

- Reduced material interactions with RMGIC monoblocks could reduce internal stresses in the tooth and better propagate occlusal loads; potentially reducing vertical fractures post treatment
- Increased flexural strength and MoE will better support the Dentin, thus the tooth may not require crown support reducing tooth structure loss



ACKNOWLEDGEMENT

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