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MONA MAGHRABY

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MONA MAGHRABY

Fracture Toughness of Different Adhesive/Dentin Interfaces by Laboratory Testing Versus Finite Element Models: An In Vitro Study

Thesis

Submitted to the Faculty of Dentistry, Ain-Shams University, in partial fulfillment of the requirements for the Master degree in Biomaterials Science

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Introduction

The advent and development of adhesive systems have allowed numerous changes in dental clinical practice. The main aim of dental adhesives is to provide adequate bonding of resin composite restoration to tooth structure. In addition to withstanding mechanical forces, dental adhesives ought to the capacity to prevent leakage along the restoration's margins.[1]

The largest area exposed after teeth preparation in most cases is dentin. So, bond strength to dentin is critical for the restoration retention. Sealing of the dentinal tubules is also another important function of adhesive systems. So, the determination of the bond strengths of dental adhesives to dentine is therefore a matter of great importance and interest.[2]

Bond strength measurement tests are used worldwide to assist the bonding efficiency of various adhesive systems to the tooth structure. As the stronger the adhesion between tooth and biomaterial, the better it will resist stress imposed by resin polymerization and oral function. The first article on bond strength tests for biomaterials was published in 1965 by Bowen. However, the fast moving of the manufacturer from one system to a newly developed one does not give satisfactory time for long-term clinical evaluation. [3, 4]

Dental adhesives are usually tested in shear or tension despite the fact that neither of these testing approaches measures the local stress triggering failure. Because the stress level varies extensively over the bonded surface, the validity of these bond strength tests is questionable due to the name as, shear or tensile may not reflect to the true and complete stress situation, i.e., assumed uniform shear or uniaxial tensile conditions.[5]

Fracture toughness is an intrinsic property of a material and is the measure of a materials resistance to crack propagation. Since fracture toughness test could be an appropriate method for characterization of the intrinsic fracture resistance and, the in-service reliability of the dentin-adhesive-interface.[6]

Finite Elements Analysis is a numerical analysis tool that allows the simulation of experimental situations and to analyze and solve complex problems in the biomechanical area.[7]

Therefore this research was conducted to assess the fracture toughness of adhesives bonded to dentin experimentally and by finite elements analysis.

Review of Literature

1.1.Dental adhesives

Adhesion is derived from the Latin term "a state in which two surfaces are held together by interfacial forces like valence forces or interlocking forces or both". Adhesive systems can be considered revolutionary in many aspects of conservative dentistry, making previously possible inconceivable clinical maneuvers. Current adhesive systems allow clinicians to bond to the tooth structure without the need for a retentive cavity as they provide immediate bond strength.(8)

The increasing demand for esthetic restorations has let to intensive research on adhesive materials. Successful adhesion to dental hard tissues is a fundamental requirement prior to the insertion of tooth-colored materials, such as direct resin composites, securing brackets to the teeth in orthodontic treatment and for luting the form of teeth known as jacket crowns in place. In recent years, there has been considerable growth in the use of adhesive systems to repair teeth damaged by caries.(9, 10)

1.2.Bonding History

In 1950, the concept of adhesion to dental tissues was introduced in the field of dentistry, when the Swiss chemist Oskar Hagger developed the archetype of the adhesive monomers, a system based on glycerophosphoric acid dimethacrylate, first used in dentistry by McLean and Kramer who published the first paper on dentin-bonding agents. Because of the poor adherence of this restorative material to prepared teeth, early attempts to restore teeth emphasized the surgical removal of sound tissue by preparing the cavity to provide mechanical retention through features such as dovetails, grooves, undercuts, sharp internal angles and so on.[11, 12]

The “adhesive revolution” was led by Michael Buonocore in 1955, who was the first to introduce the concept of chemically treating the tooth structure with phosphoric acid 85% for 30 seconds of acid to significantly improve its bonding to the resin. The first commercially available bonding agent (NPG-GMA) was established in 1956.[13, 14]

At that time, the “Adhesive Dentistry Era” began: traditional mechanical methods used to prepare teeth for filling based on Black’s concept of “extension for prevention” were replaced by more conservative approaches. Since its introduction, the acid-etch technique has provided an ideal surface morphology as a result of the use of 30±40% phosphoric acid simply increase the microscopic surface area available for resin retention.[15]

However, one of his students, John Gwinnett, who was a trained electron microscopist, looked more closely at the interface. He reported that adhesive resins could penetrate into acid-etched enamel that would provide micromechanical retention.[16]

This was the first true hybrid layer, although that term had not yet been introduced. Resin-treatment of acid-etched enamel created a new structure that was neither enamel nor resin but a hybridization of the two materials.[17, 18]

In late 1960 Buonocore proposed that bonding to dentin could also be done. Compared to enamel, bonding to dentin is a major challenge because of its organic components, humid nature and tubular structure.