

A Comparative Study Between Bulk Fill and Conventional Flowable Composites

Thesis

Submitted to the Biomaterials Department

Faculty of Dentistry

Ain-Shams University

**In partial fulfillment of the requirements for the
Master Degree in Dental Biomaterials Science**

By

Basma Yahya Rozza

B.D.S(Ain-Shams University, 2008)

Instructor of Dental Materials

Biomaterials Department

Faculty of Dentistry

Ain-Shams University

Dental Biomaterials Department

Faculty of Dentistry

Ain-Shams University

2017

Supervisors

Prof. Dr. Tarek Salah El Din Hussein

Professor of Dental Biomaterials
Biomaterials Department
Faculty of Dentistry
Ain-Shams University

Dr. Dalia Ibrahim Sherief

Lecturer of Dental Biomaterials
Biomaterials Department
Faculty of Dentistry
Ain-Shams University

Acknowledgment

*I would like to express my sincere respect and gratitude to **Prof.Dr.Tarek Salah El Din**, Professor of Dental Biomaterials, Faculty of Dentistry, Ain-Shams University, for his great support and precious experience in guiding and teaching me. Thanks Dr. Tarek for your endless support and your valuable guidance. I am really proud to be your student.*

*I wish to faithfully express my deep respect and appreciation to **Dr.Dalia Ibrahim Sherief**, Lecturer of Dental Biomaterials, Faculty of Dentistry, Ain-Shams University, for her great efforts in guiding me and her continuous encouragement throughout my work. Thanks Dr.Dalia for your guidance and for treating me as one of your family.*

*Highest appreciation is owed to **Dr.Mohamed Kandil**, Lecturer of Dental Biomaterials, Faculty of Dentistry, Ain-Shams University for his valuable support and guidance.*

*Thanks are extended to all of my professors and colleagues in the Biomaterials Department for their spiritual support and help throughout my work. Last but not least, i want to especially thank my dear colleague and sister **Yasmin Ezz** for her endless support and encouragement.*

Dedication

I would like to dedicate this work to my beloved parents, to whom I owe everything; they are the true reason behind my success.

I would also like to thank my wonderful husband Ahmed, for his endless support and encouragement and for all the happy times.

Last but not least, to my adorable kids Nour El Din and Perla who are the main source of happiness in our life.

List of Contents

<i>List of Contents</i>	5
<i>List of Tables</i>	8
<i>List of figures</i>	9
<i>List of Abbreviations</i>	11
Introduction	1
Review of literature	4
1. Resin composites	4
1.1. Structure of resin composites	4
1.2. Classification of resin composites	6
2. Flowable composites	8
2.1. Clinical indications of flowable composites	8
2.1.1. Preventive Resin Restorations (for minimally invasive occlusal Class I cavities)	8
2.1.2. Pits and fissure sealants	9
2.1.3. Cavity liners	9
2.1.4. Class V abfraction lesions	10
2.1.5. Other applications of flowable composites	11
3. Drawbacks of dental composites	11
3.1. Water sorption and solubility	12
3.2. Wear	13
3.3. Color instability	13
3.4. Postoperative hypersensitivity	13
3.5. Fracture of composite restorations	14
3.6. Polymerization shrinkage and polymerization shrinkage stresses	14
3.6.1 Consequences of polymerization shrinkage stresses ..	15
3.6.2 Factors affecting polymerization shrinkage stresses in dental composites	15

3.6.2.1	Volumetric shrinkage	16
3.6.2.2	Viscoelastic behavior and polymerization kinetics	17
3.6.2.3	C-factor and substrate compliance	20
3.6.3.	Strategies to reduce contraction stresses in dental composites	20
4.	Innovation of bulk-fill resin composites	23
4.1.	Types and mechanism of action of some of the currently marketed bulk-fill composites	24
4.1.1.	Sonicfill dental composite (Kerr)	24
4.1.2.	Tetric Evoceram Bulk fill (Ivoclar vivadent)	24
4.1.3.	Xtra-base and Xtra-Fill (Voco)	26
4.1.4.	Filtek™ Bulk Fill (3M).....	26
4.1.5.	SDR™ Surefill Flow (Dentsply)	27
5.	Evaluation of resin based composites	28
5.1.	Degree of conversion	28
5.1.1.	FTIR spectroscopy.....	29
5.1.1.1.	Determination of the degree of conversion.....	31
5.2.	Flexure strength testing	33
5.2.1.	Types of flexure strength testing	33
5.2.1.1.	Three-point flexure testing	33
5.2.1.2.	Four-point flexure testing	35
5.2.1.3.	Bi-axial flexure testing.....	35
5.2.2.	Mould variability	36
5.3.	Polymerization shrinkage evaluation.....	37
5.3.1.	Shrinkage strain evaluation.....	37
5.3.2.	Shrinkage stress evaluation	38
5.3.3.	The strain gage method for measuring the induced cuspal strain	40
5.3.3.1.	Principle of strain gages	41

5.3.3.2. Types of strain Gages	42
5.3.3.3. Principle of strain measurement	43
5.3.3.4. Significance of strain gage result signs	43
Aim of the study	44
Materials and methods.....	45
Results.....	63
Discussion	78
Summary and conclusions	91
References	95

List of Tables

	<i>Page</i>
Table 1: Materials used in the study, their composition, and batch number.	45
Table 2: Means and standard deviations (SD) for DC (%) of the two tested resin composites using various packing techniques at different storage times.	64
Table 3: Means and standard deviations (SD) for DC (%) using different packing techniques for the two various resin composite types at different storage times.	66
Table 4: Means and standard deviations (SD) of DC values (%) at different tested storage times of the two resin composites packed with various techniques.	67
Table 5: Means and standard deviations (SD) of mFS (MPa) for both tested composites using various packing techniques at different storage times.	69
Table 6: Means and standard deviations (SD) of mFS (MPa) using different packing techniques for two different resin composites at different storage times.	71
Table 7: Means and standard deviations (SD) of mFS (MPa) at different storage times for the two resin composite types packed by various packing techniques.	73
Table 8: Pearson correlation coefficient for degree of conversion and mini-flexural strength.	74
Table 9: Means and standard deviations (SD) of induced cuspal strain analysis (μm) during polymerization of different tested material types.	76

List of figures

	<i>Page</i>
Figure 1: Conventional flowable composite.....	46
Figure 2: Self-etch adhesive	46
Figure 3: Bulkfill flowable composite compule.....	46
Figure 4 : Flow chart for DC and mFS groups	48
Figure 5: Split mold for DC sample preparation	49
Figure 6: LED light curing unit	50
Figure 7: Incubator	51
Figure 8: Desiccator	51
Figure 9: Pelleting device.....	52
Figure 10: Hydraulic press	52
Figure 11: FTIR spectrometer	52
Figure 12: Schematic representation of the baseline method used to determine the ratios of the absorbance peaks corresponding to the aliphatic (1638 cm ⁻¹) and aromatic (1608 cm ⁻¹) C=C bonds for a composite material. The peak heights were measured in relation to the baseline (red line).....	54
Figure 13: Split mold for mFS sample preparation	55
Figure 14: Digital micrometer	56
Figure 15: 3-point loading test for measuring the mFS.....	57
Figure 16: Flow chart of cuspal stain specimen grouping.....	58
Figure 17: Prepared MOD cavity (Bucco-lingual view)	59
Figure 18: Prepared MOD cavity (Occlusal view).....	59
Figure 19: Strain gage	61
Figure 20: Prepared MOD cavity filled with RBC and surrounded by celluloid matrix band with a strain gage attached to the buccal surface	61
Figure 21: Strain meter.....	61
Figure 22: Bar chart showing the mean values of DC (%) for the two tested composites using various packing techniques at different storage times.	64
Figure 23: Bar chart showing the mean values of DC (%) using different packing techniques for the two various resin composite types at different storage times.....	66
Figure 24: Bar chart showing the mean values of DC (%) at different tested storage times of the two resin composites packed with various techniques.	68

Figure 25: Bar chart showing the mean mFS (MPa) values for both tested composites using various packing techniques at different storage times.	70
Figure 26: Bar chart showing the mean values of mFS (MPa) using different packing techniques for both resin composites at different storage times.	72
Figure 27: Bar chart showing the mean values of mFS (MPa) at different storage times for the two resin composite types packed by various packing techniques.	73
Figure 28: Scatter plot showing the correlation between degree of conversion and flexural strength.	75
Figure 29: Bar chart showing the mean values of induced cuspal strain analysis during polymerization of different tested material types.	77
Figure 30: Graph of cuspal strain pattern versus time during the light curing of the two flowable resin composite materials.	77

List of Abbreviations

AUDMA: Aromatic Urethane dimetacrylate.

AFM: Addition fragmentation monomers.

ATR: Attenuated total reflectance.

Bis-GMA: Bisphenol A glycidyl methacrylate.

Bis-EMA: Ethoxylated bisphenol A dimethacrylates.

BHT: Butylated hydroxytoluene.

BFC: Bulk-fill flowable composite.

CQ: Campharquinone.

CFC: Conventional flowable composite

DC: Degree of Conversion.

DSC: Differential scanning calorimetry.

DTA: Differential thermal analysis.

EPR: Electron paramagnetic resonance.

FRC: Fiber reinforced composite.

FTIR: Fourier transform infrared spectroscopy.

FEA: Finite element analysis.

GF: Grandio Flow.

GPDM: Glycerol phosphate dimethacrylate.

HDPE: High density polyethelene.

HEDMA: Hexane ethyl dimethacrylates.

HEMA: Hydroxyethyl methacrylate.

LVDT: Linear variable differential transformer.

LED: Light emitting diode.

MDP: Methacryloyloxydecyl dihydrogen phosphate.

mFS: mini-flexural strength.

Ormocer: Organically modified ceramics.

PENTA: Dipentaerythritol pentaacrylate phosphate.

PRR's: Preventive resin restorations.

PFM: Porcelain fused to metal.

PPD: 1-Phenyl 1,2-propanedione.

PTFE: Polytetrafluoroethylene.

PSS: Polymerization Shrinkage Stresses.

RBC: Resin based composite.

SDR: Smart Dentin Replacement or Stress Decreasing Resin.

TEGDMA: Triethylene glycol dimethacrylate.

TCD-DI-HEA: 2-propenoic acid,(octahydro-4,7 methano-1H-indene-5-diyl) bis(methyleneiminocarbonyloxy-2,1-ethanediyl) ester.

TPO: Diphenyl(2,4,6-trimethylbenzoyl)phosphine oxide.

UDMA: Urethane dimethacrylate.

Introduction

The demand for dental esthetic restorations has led to the development of resin-composite material.⁽¹⁾ Composite is a multiphase material that exhibits the properties of both complimentary phases (organic and inorganic) resulting in a material with enhanced properties. Resin based composites (RBCs) are mainly composed of an organic phase, inorganic fillers, a coupling agent that improves filler/resin interactions and an initiator system.^(2,3)

Resin composites are used in various applications in dentistry. They are used primarily as anterior and posterior filling materials. However, due to their versatility resin products could also be used as pit and fissure sealants, luting composites, cores and buildups, inlays, onlays, temporary crowns and bridges, root canal sealers, root canal posts, and the bonding of brackets and orthodontic bands.⁽²⁾

Most of the direct restorative composites have putty like consistency which is required for certain clinical situations. However, the need to have a low viscosity composite resin to improve the adaptation to the cavity walls has led to the introduction of flowable composites in late 1996. Accordingly, different types of dental RBCs can be distinguished by their viscosity. Flowable composites show a lower viscosity compared to the universal composites. Such lower viscosity could be achieved by the reduction of the filler content and the reduction of the viscosity of the organic resin.⁽²⁾

One of the major indications for flowable composites is to be used as a base under composite restorations. Flowable composite base offers several advantages such as better adaptation to cavity walls, enhancing the initial marginal integrity, reducing microleakage

and postoperative hypersensitivity. Reduction of the polymerization shrinkage stresses is another beneficial action for flowable composite base because of its lower rigidity which offers a more uniform stress distribution.⁽⁴⁾

Placing of the flowable composite bases by the incremental placing technique ensures proper curing and increases the degree of conversion of each increment. This is important because the degree of conversion is crucial in determining the mechanical performance of the material as well as its physical properties.^(5,8) Also the incremental filling techniques are capable of reducing the concentration of stresses at the tooth interface due to a reduction in the volume of the resin materials at placement.^(7,8) Although incremental placing of the composite has a beneficial action, it is also time consuming and increases the technique sensitivity especially in case of restoring large cavities.^(9,10)

There is a growing tendency to simplify the clinical application of composite restorations in terms of reducing the clinical treatment time and the technique sensitivity. For this reason bulk fill RBCs have been introduced. According to its nomenclature this resin composite type can be used in a single 4-5 mm increment. This category of composites includes flowable and high viscosity paste materials. Flowable bulk fill composite is marketed to be used as a base under composite restorations.⁽¹⁾

Manufacturers claim that with this increased thickness of the composite base, new technologies are being adopted to increase the degree of conversion, mechanical properties and to reduce the polymerization shrinkage and its accompanied stresses.

Accordingly, this study was carried out to evaluate one bulk fill flowable composite in comparison with a conventional one regarding the degree of conversion, the mini-flexure strength and the induced dental (cuspal) strain during polymerization.