



شبكة المعلومات الجامعية
التوثيق الإلكتروني والميكرو فيلم

بسم الله الرحمن الرحيم



MONA MAGHRABY



شبكة المعلومات الجامعية
التوثيق الإلكتروني والميكروفيلم



شبكة المعلومات الجامعية التوثيق الإلكتروني والميكروفيلم



MONA MAGHRABY



شبكة المعلومات الجامعية
التوثيق الإلكتروني والميكروفيلم

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات



يجب أن

تحفظ هذه الأقراص المدمجة بعيدا عن الغبار



MONA MAGHRABY

**Effect Of Aging On Mechanical Properties,
Fluoride Release And Recharging, Water
Sorption And Solubility Of Ceramic Reinforced
Glass Ionomer: An In Vitro Study**

Thesis Submitted to the Faculty of Dentistry, Ain-Shams
University for partial fulfillment of the requirements for the
Master Degree in Dental Biomaterials

By

Shaimaa Hamdy Mohamed Ahmed Dawood

B.D.S (Ain-Shams University, 2011)
Instructor of Dental Biomaterials
Biomaterials Department
Faculty of Dentistry
Ain-Shams University

**Biomaterials Department
Faculty of Dentistry
Ain-shams University
2020**

Supervisors

Prof. Dr. Dalia Ibrahim El-Korashy

Professor and Head of Biomaterials Department
Faculty of Dentistry
Ain-shams University

Dr. Mohamed Mahmoud Kandil

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

Acknowledgement

I would like to express my sincere respect and gratitude to **Prof. Dr. Dalia Ibrahim El-Korashy** Professor and Head of Biomaterials Department, Faculty of dentistry, Ain-Shams University, for her continuous encouragement and endless support. Her precious experience always guides me throughout this work. Thanks Dr. Dalia for your support and treating me as one of your family.

I deeply thank and express my respect to **Dr. Mohamed Mahmoud Kandil**, Lecturer of Dental Biomaterials, Faculty of Dentistry, Ain-shams University, for his continuous guidance and help in this work. I have really learnt a lot from your valuable experience.

Thanks, are extended to all my professors and colleagues in the Biomaterials Department whom I consider my second family.

Dedication

I would like to dedicate this work to my mother and father, to whom I owe everything. They are my backbone and without their prayers, I cannot reach any achievements in my life. I would also like to thank my sister Marwa. She is my supporter and my best friend

I deeply thank my husband Mahmoud, my life partner my everything, for his endless care and support in all hard times and my adorable son, Adam, the main source of happiness in our life.

List of Contents

List of Tables	I
List of Figures	III
Introduction	1
Review of literature	4
1. History of glass ionomer	4
2. Classification of glass ionomer cements (GICs)	6
3. Types of glass ionomer	6
3.1 Conventional Glass Ionomers	6
3.2 Resin-Modified Glass Ionomer (RMGI)	10
3.3 High- Viscosity Glass Ionomer (HVGI)	12
3.4 Ceramic- Reinforced Glass Ionomer	15
4. Properties & evaluation of glass ionomers	16
4.1 Compressive strength and modulus of elasticity	17
4.2 Fluoride release	20
4.3 Water sorption & solubility	25
Aim of the study	29
Materials and Methods	30
1. Materials used in the study	30
2. Methods	32
2.1 Grouping of the specimens	32
2.2 Specimens' preparation and material testing	33

2.2.1 Compressive strength and modulus of elasticity testing	33
2.2.2 Fluoride release without recharge and fluoride release after recharge	37
2.2.3 Water sorption and solubility testing	41
Results	48
Discussion	83
Summary and Conclusions	95
Conclusions	97
References	98

List of Tables

Table 1: Materials used in the study, their composition, manufacturers and lot numbers	30
Table 2: Two-way ANOVA for the effect of materials and storage time on the mean compressive strength (MPa)	48
Table 3: Means and standard deviations (SD) for compressive strength (MPa) of different tested materials.....	49
Table 4: Means and standard deviations (SD) for compressive strength (MPa) of the different tested materials with time.....	51
Table 5: Two way-ANOVA for the effect of materials and time on the mean modulus of elasticity (MPa).....	52
Table 6: Means and standard deviations (SD) for modulus of elasticity (Mpa) of the different tested materials	53
Table 7: Bar chart showing the mean modulus of elasticity (MPa) and SD (Error bars) of the different tested materials with time	55
Table 8: Two way-ANOVA for the effect of materials and time on mean fluoride release (ppm)	56
Table 9: Means and standard deviations (SD) for fluoride release (ppm) of the different tested materials and time.....	57
Table 10: Means and standard deviations (SD) for fluoride release (ppm) of the different tested materials with time	59
Table 11: Means and standard deviations (SD) for cumulative fluoride release (ppm) of the different tested materials at different time intervals..	61
Table 12: Two way-ANOVA for the effect of materials and time on mean fluoride release after recharge (ppm).....	63
Table 13: Means and standard deviations (SD) of fluoride release after recharge (ppm) for the different tested materials at different time intervals	64
Table 14: Means and standard deviations (SD) of fluoride release after recharge (ppm) of different tested materials at different time intervals	66

Table 15: Means and standard deviations (SD) for cumulative fluoride release after recharge of the different tested materials and time intervals .	68
Table 16: Two way-ANOVA for the effect of materials and time on mean water sorption ($\mu\text{g}/\text{mm}^3$) values	70
Table 17: Means and standard deviations (SD) for water sorption ($\mu\text{g}/\text{mm}^3$) of the different tested materials	71
Table 18: Means and standard deviations (SD) for water sorption ($\mu\text{g}/\text{mm}^3$) of the different tested materials at different time intervals	72
Table 19: Two way-ANOVA of the effect of materials and time on mean solubility values.....	74
Table 20: Means and standard deviations (SD) for solubility ($\mu\text{g}/\text{mm}^3$) of the different tested materials	75
Table 21: Means and standard deviations (SD) for solubility ($\mu\text{g}/\text{mm}^3$) of the different tested materials at different time intervals	76
Table 22: Pearson correlation for water sorption and solubility.....	77

List of Figures

Figure 1: Materials used in the study	31
Figure 2: Grouping of the specimens	32
Figure 3: Mixed Amalgomer CR.....	34
Figure 4: A- Mixing of Equia Fil capsule using the amalgamator, B- Packing of material inside the mold using capsule applicator.....	35
Figure 5: A-Clamped specimen with screw clamp, B-Split teflon mold for compressive strength specimens' preparation and a prepared specimen....	35
Figure 6: Specimen mounted on the universal testing machine	37
Figure 7: reparation and storage of fluoride release specimens	38
Figure 8: fluoride ion selective electrode	39
Figure 9: preparation of water sorption and solubility specimens.....	43
Figure 10: Quanta 250 FEG scanning electron microscope.	45
Figure 11: Bar chart showing the mean compressive strength (MPa) and SD (Error bars) of the different tested materials	50
Figure 12: Bar chart showing the mean compressive strength (MPa) and SD (Error bars) of the different tested materials with storage time.....	51
Figure 13:.. Bar chart showing the mean modulus of elasticity and SD (Error bars) of the different tested materials	54
Figure 14: Bar chart showing the mean modulus of elasticity and SD (Error bars) of the different tested materials with time	55
Figure 15: Bar chart showing the mean fluoride release and SD (Error bars) of the different tested materials	58
Figure 16: Line chart showing the mean fluoride release and SD (Error bars) of the different tested materials with time	60
Figure 17: Bar chart showing the mean cumulative fluoride release and SD (Error bars) of the different tested materials	62
Figure 18: Line chart showing the mean cumulative fluoride release and SD (Error bars) of the different tested materials at different time intervals	62

Figure 19: Bar chart showing the mean fluoride release after recharge and SD (Error bars) for the different tested materials	65
Figure 20: Line chart showing the mean fluoride release after recharge and SD (Error bars) of the different tested materials with time	67
Figure 21: Bar chart showing the mean cumulative fluoride release after recharge and SD (Error bars) of the different tested materials with time ..	68
Figure 22: Line chart showing the mean cumulative fluoride release after recharge and SD (Error bars) of the different tested materials with time...	69
Figure 23: Bar chart showing the mean water sorption and SD (Error bars) of the different tested materials	71
Figure 24: Line chart showing the mean water sorption and SD (Error bars) of the different tested materials with time	73
Figure 25: Bar chart showing the mean solubility and SD (Error bars) of the different tested materials	75
Figure 26: Line chart showing the mean solubility and SD (Error bars) of the different time intervals.....	77
Figure 27: Scatter plot for the water sorption and solubility of the different materials	78
Figure 28: Scanning electron photomicrographs (2000x magnification) of Amalgomer CR.....	80
Figure 29: Scanning electron photomicrographs (2000x magnification) of Fugii VIII.....	81
Figure 30: Scanning electron photomicrographs (2000x magnification) of Equia fil.	82

Introduction

Recurrent caries at the tooth/restoration interface is one of the most common reasons for replacement of existing restorations. When dental materials release fluoride, it is expected that, besides restoring function, they may control the recurrence of caries and contribute to reduction of caries incidence in the entire dentition.⁽¹⁾

The incorporation of fluoride in materials used for restoring tooth structure, attracts the attention of many researchers for using such materials as a source of fluoride release to the teeth.⁽²⁾ Fluoride is an anticariogenic agent that leads to the formation of fluoroapatite which is more resistant to acid attacks compared to hydroxyapatite and thus reducing recurrent caries especially in patients with high risk of caries.⁽³⁾

Since the evolution of silicate cements, it was observed that recurrent caries around silicate cements was significantly reduced, and this reduction was attributed to the substantial generation of fluoride by this restorative material. Glass ionomer, which was generated from silicate cement can increase the resistance of teeth to recurrent caries because of fluoride release and its ability to recharge fluoride. This has been the hallmark feature that lead to the enormous clinical success of this material along with its ability for chemical bonding to tooth structure, close coefficient of thermal expansion to that of tooth structure and satisfactory biocompatibility. Two major disadvantages of conventional glass ionomer cement are its insufficient translucency resulting in bad esthetics and poor mechanical characteristics such as brittleness, low strength,

toughness and wear resistance which limit its extensive use as a restorative material in stress bearing areas.⁽⁴⁾

Therefore, different trials have been introduced to overcome these limitations. The incorporation of polymerizable hydrophilic resins to the conventional glass ionomer cements resulted in the development of resin-modified glass ionomer. In general, resin modified glass ionomers were reported to show better mechanical properties than conventional ones however, the polymerization shrinkage and low wear resistance constitute major drawbacks.⁽⁵⁾

High-viscosity or packable glass ionomer cements have been introduced showing fast setting and higher viscosity attributed to their finer glass particles, high molecular weight polyacrylic acids and high powder-to-liquid ratio. Their setting reaction is the same as that of conventional glass ionomer cements.⁽⁶⁾

A more recent innovation of glass ionomer was the incorporation of ceramic fillers into glass ionomer. Amalgomer CR is a ceramic reinforced posterior GIC containing 17% by weight zirconia fillers with an average particle size of 0.8 micron. The manufacturer claimed that the material possesses compressive, tensile and flexural strength close to that of amalgam. In addition, a sustained high level of fluoride release, modulus of elasticity close to that of dentin, superior aesthetics, and superior radio-opacity have also been claimed. It still retains the ability for chemical bonding to tooth structure and it has good working time. The material is also claimed to be dimensionally stable, lacks thermal conductivity and have excellent wear resistance.⁽⁷⁾