THE EFFECT OF DIFFERENT POLISHING SYSTEMS ON THE SURFACE ROUGHNESS OF THE TOOTH COLOURED RESTORATIVE MATERIALS

by

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DECLARATION

I certify that this dissertation (Surface roughness of nanofilled and microfilled glass-ionomer polished with three polishing systems and confocal analysis after application of Streptococcus mutans) is my own work (practical experiments,research and written thesis), except where indicated by referencing and that I have followed the university regulations regarding authenticity.

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Signature

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Zaid Hameed Mohammed Ali Nema

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Abstrak

Kajian ini bertujuan mengkaji kekasaran permukaan simen glass ionomer terisi nano berbanding dengan simen glass ionomer terisi mikro dan komposit terisi nano, dengan menggunakan tiga jenis teknik gilapan yang berbeza. Kajian ini juga mengkaji ketebalan biofilem yang terbentuk di atas bahan – bahan ujikaji selepas 14 dan 30 hari pembiakan *Streptococus mutans (S.mutans)*, dan juga kekasaran permukaan selepas 30 hari pembentukan biofilem. Acuan akrilik digunakan untuk menyediakan cakera bahan ujikaji berdimensi 5 mm x 2 mm. Bahan ujikaji dipadatkan di dalam acuan untuk membentuk 21 cakera (Set A) yang berdimensi sama, tujuh cakera untuk setiap bahan ujikaji, iaitu simen glass ionomer terisi nano, simen glass ionomer terisi mikro dan komposit terisi nano. Semua cakera yang mengandungi bahan ujikaji diliputi dengan jalur Mylar dan dikeraskan dengan menggunakan sebuah unit 'light curing' biasa, mengikut aturan pengilang. Selepas itu, semua cakera ujikaji tadi diperiksa menggunakan mikroskop daya atom (AFM) di bawah mod sentuhan untuk mengkaji kekasaran permukaan ketiga – tiga bahan ujikaji tadi. 10 µml titisan ampaian bakteria (*S.mutans)* dititiskan ke atas setiap sampel, dan diletakkan di dalam bekas mengandungi 50 ml infusi hati dan otak (IHO), 0.2 units/ml media bacitracin, dan 20% sukrosa. Sampel-sampel diinkubasikan pada 37^oC untuk membenarkan pembentukan biofilem selama 30 hari. Selepas 30 hari, kekasaran permukaan ketiga – tiga bahan ujikaji tadi

diperiksa sekali lagi dengan AFM. Set B mengandungi 84 cakera yang berdimensi sama dengan Set A; 28 cakera untuk setiap bahan ujikaji. Setiap bahan ujikaji dibahagikan kepada tiga kumpulan rawatan dan satu kumpulan kawalan; setiap kumpulan mengandungi tujuh sampel (n=7). Tiga kumpulan rawatan masing-masing digilap dengan Enhance / Pogo^{TM}, Astropol® dan Sof - Lex^{TM} mengikut aturan pengilang. Kumpulan kawalan menggunakan jalur Mylar. Selepas digilap, bahan – bahan ujikaji dikultur dengan *S.mutans* selama 14 hari. Selepas 14 hari, ketebalan biofilem *S.mutans* di atas bahan – bahan ujikaji tadi diukur menggunakan mikroskop imbasan laser konfokal (CLSM). Sebanyak 84 lagi cakera (Set C) digilap dengan teknik gilapan yang sama dengan Set B, tetapi dikultur dengan *S.mutans* selama 30 hari. CLSM digunakan untuk mengukur ketebalan biofilem Set C seperti dalam Set B. Ini bagi membolehkan perbandingan ketebalan biofilem kultur *S.mutans* antara 14 dan 30 hari. Selepas itu, semua cakera – cakera Set C dikaji kekasaran permukaannya menggunakan AFM. Data dimasukkan ke dalam perisian SPSS dan dianalisa menggunakan satu – hala ANOVA di mana *P < 0.05* dianggap signifikan secara statistik. Selepas 30 hari pengkulturan *S.mutans,* simen glass ionomer terisi nano dan simen glass ionomer terisi mikro yang digilap dengan cakera Sof - Lex menunjukkan kekasaran permukaan paling sedikit, manakala komposit terisi nano menunjukkan kekasaran permukaan paling sedikit apabila digilap dengan Astropol. Selepas 30 hari pengkulturan, ketebalan biofilem di atas simen glass ionomer terisi mikro lebih nipis berbanding simen glass ionomer terisi nano dan juga komposit terisi nano. Cakera Sof – Lex menghasilkan biofilem *S.mutans* yang lebih nipis berbanding Enhance/Pogo dan Astropol. Namun, tidak semua keputusan ini signifikan secara statistik dalam kumpulan – kumpulan perbandingan. Biofilem *S.mutans* yang berusia 14 hari adalah lebih nipis

berbanding yang berusia 30 hari di atas semua bahan-bahan ujikaji tanpa mengira sebarang sistem gilapan.

The effect of different polishing systems on the surface roughness of the tooth coloured restorative materials

ABSTRACT

The aim of this study was to evaluate the surface roughness of nanofilled glass-ionomer compared to microfilled glass-ionomer and nanofilled composite using three different types of polishing techniques. This study also evaluated the biofilm thickness of the test materials after 14 and 30 days growth *Streptococcus mutans (S.mutans)* and the effect of surface roughness after 30 days biofilm formation. An acrylic mold was used to prepare 5 mm x 2 mm disk specimens. The test material was packed into the mold forming 21 similar disks (Set A), seven of each test material; nanofilled glass-ionomer, microfilled glass-ionomer and nanofilled composite respectively. Then the disks were covered with a Mylar strip and photo-polymerized using a conventional light-curing unit, according to manufacturer's instruction. The disks were then examined in contact mode under Atomic Force Microscopy to evaluate the surface roughness of those three dental materials. After that a 10 µml drop of bacterial suspension (*S. mutans)* was placed on each sample. The samples were then placed in a container with 50 ml of brain heart infusion (BHI) broth supplemented with 0.2 units/ml of bacitracin and sucrose present in an amount of about 20 percent by weight then incubated at 37˚C to allow the formation of a 30 day-old biofilm. After 30 days, all disks were reexamined in contact mode under Atomic Force Microscopy to evaluate their surface roughness. Set B consisted of 84 disks of the test materials with similar dimension to Set A; with 28 disks for each test material. Each test material were divided into three treatment groups and one control group; each group consisting of seven samples (n=7). The treatment

groups were polished with Enhance/ Pogo^{TM}, Astropol® and Sof-lex^{TM}, according to manufacturer's instruction. The control group was cured against Mylar strip. After polishing procedure, the samples were cultered with *S.mutans* for 14 days. At the end of 14 days, the *S.mutans* biofilm thickness on the test materials was measured using Confocal Laser Scanning Microscopy (CLSM). Another 84 disks of the test materials were made (Set C), polished with the same technique as in Set B, however, they were cultured with *S.mutans* for 30 days, for the comparison of the biofilm thickness between 14 days and 30 days of *S.mutans* culture. Furthermore, all disks in Set C were also examined in contact mode under Atomic Force Microscopy for surface roughness evaluation. Data was entered into SPSS software and analyzed using one-way ANOVA where $P < 0.05$ was considered statistically significant. Nanofilled glass-ionomer and microfilled glass-ionomer polished with Sof-Lex disks showed the least surface roughness, while nanofilled composite showed the least surface roughness when polished with Astropol after 30 days of *S.mutans* culture. After 30 days *S.mutans* biofilm culturing, microfilled glass-ionomer displayed less *S.mutans* biofilm thickness compared to nanofilled glass-ionomer and nanofilled composite. Sof-Lex disks produced less *S.mutans* biofilm thickness compared to Enhance/Pogo and Astropol, but not all results were statistically significant within the comparative groups. The thickness of the *S.mutans* biofilm after 14 days of culture was less than after 30 days of culture in all test materials regardless of the polishing systems.

1 INTRODUCTION

1.1 Background of the study

Glass-ionomers are part of a large group of materials that set through an acid base reaction in the presence of water. Historically, these materials have been referred to as cements, and they are involved in a variety of powders and liquids. Glass-ionomers originally acquired their name from the glass filler and ionic polymer matrix which are used to make them (Albers, 2002).

They are available in essentially two types, conventional glass-ionomer and resin-modified glass-ionomer. The latter was created in order to improve the physical properties and decrease the water sensitivity of the conventional materials (Ersin *et al.*, 2006).

The applications of the glass-ionomer filling materials express the advantage of their adhesive nature coupled with an inherent brittleness and fluoride release in spite of the low aesthetic quality. The main use of glass-ionomer is to restore root and teeth abrasion cavity, fissure sealants, as a filling in deciduous teeth and in tunnel preparation technique (McLean, 1992).

Glass-ionomers are required to meet physical, chemical, biological and esthetic requirements, akin to all materials used in the mouth. Requirements for use include adequate strength, abrasion resistance, resilience and dimensional stability during processing and subsequent use. In order to match the appearance of the oral hard tissue

being replaced, translucency or transparency is also required. In addition, good color stability and resistance to oral fluids with which they are in contact (Culbertson, 2001).

Nanotechnology is used to provide some value added features not typically associated with glass-ionomer restorative materials. Generally, glass-ionomer restoratives can contain a broad range of particle sizes. Filler particle size can influence strength, optical properties, and abrasion resistance. By using bonded nanofillers and nanocluster fillers, along with Aluminum fluorosilicate glass, nanofilled glass-ionomer restorative has improved esthetics, yet still provides the benefits of glass-ionomer chemistry, such as fluoride release (Malsch, 2005).

Furthermore, with nanotechnology, a dental restorative material system will offer high translucency, high polish and polish retention similar to those of microfills while maintaining physical properties and wear resistance equivalent to several commercial hybrid materials. The combination of two types of nanofillers results in the best combination of physical properties, such as superior esthetics, long-term polish retention and other optimized physical properties (Mitra *et al.*, 2003).

One of these physical properties is the surface roughness. The surface texture of dental materials has a major influence on plaque accumulation, discoloration, wear and the aesthetical appearance of both direct and indirect restorations. Increasing roughness is correlated with increased deposition of plaque and roughness is also a determining factor for staining. Furthermore, an increased surface roughness accelerates the wear of dental materials (Heintze *et al.*, 2006).

The critical surface roughness threshold established for bacterial adhesion is 0.2 μm. Any increase in surface roughness above 0.2 μm results in a simultaneous increase of plaque accumulation and the risk of caries and periodontal inflammation (Chung, 1994).

Polishing is another factor that affects the surface roughness beside filler size. Proper finishing and polishing are important steps in clinical restorative dentistry that enhance both esthetics and longevity of restorations. The smoothness of restorations is also influenced by the internal structure such as size and arrangement of the filler content (McCabe and Walls, 2008). This study will evaluate the effect of various finishing/polishing techniques on the surface roughness of different types of glass-ionomer which are classified according to their filler size; nano and micro filler.

As mentioned earlier, one of the outcomes of the surface roughness is dental plaque formation. Dental plaque adheres better and accumulates more quickly on rough surfaces (Ono *et al.*, 2007). Dental biofilm harboring cariogenic bacteria are among the virulence factors associated with the progression of tooth decay and periodontal diseases. *Streptococci mutans* (*S.mutans*) are among the bacteria proliferating in the dental biofilm. Their virulence is mainly due to their high adhesion capability, acidogenicity and aciduric properties. These *S.mutans* characteristics could be responsible for surface damage to restorations, since this microorganism can be found on any hard surface in the oral cavity, such as enamel, implants, orthodontic appliances or restorative materials. Microscopic examination of early plaque formation on teeth shows that the bacteria adhere along cracks and pits in the enamel, suggesting an effect of the surface structure. In addition, the surface free energy affects the accumulation of tooth biofilm. Thus, rough surfaces and surfaces with high surface free energy are more prone to plaque formation. Similarly,

the surface characteristics of dental materials will affect biofilm formation (Carlen *et al.*, 2001).

It was also reported that the effects of *S.mutans* biofilm on the surface properties and microstructure are material-dependent (Fucio *et al.*, 2008). Studies on resin composites showed that's the amount of biofilm accumulation varies according to the particle size of fillers and monomer components of the resin matrix (Ono *et al.*, 2007) and it was proven by another study that the nanofilled composite cause a reduction in the biofilm formation (Hannig *et al.*, 2007).

Other studies on resin composites showed that *S.mutans* growth increases surface roughness. This change in surface integrity may further increase biofilm accumulation (Beyth *et al.*, 2008).

Fillers and matrices of dental resin composites also influence the growth of bacterial biofilm. Resin composite restorations tend to accumulate more dental plaque compared with other restorations (Imazato *et al.*, 2001). It was reported that polymerization of resin composites is incomplete, as indicated by the low degree of conversion (Imazato *et al.*, 2001) and the finding that unpolymerized monomers can be extracted and used to accelerate the growth of cariogenic bacteria. In addition, it was shown that polymerized resin composites accelerate *S.mutans* growth in vitro (Matalon *et al.*, 2004).

This study evaluated the interaction between surface roughness of nanofilled glass-ionomer and bacterial biofilm. Furthermore, this study also measured the *S.mutans* biofilm thickness and the interaction between polishing methods and nanofilled glass-ionomer.

1.2 Statement of the problem

The new nanofilled glass-ionomer has not been studied comprehensively with regards to its surface polish. The surface polish will affect the surface roughness, which in turn will affect the plaque accumulation. Therefore, this study was conducted to evaluate the surface roughness of nanofilled glass-ionomer compared to microfilled glass-ionomer and nanofilled composite using three different types of polishing techniques. This study also evaluated the biofilm thickness of the test materials after 14 and 30 days growth of *S.mutans* and the effect of surface roughness after 30 days biofilm formation.

1.3 Justification of the study

This study will show the ability of nanofilled glass-ionomer to resist the surface roughness caused by *S.mutans* biofilm, which help us to specify the appropriate usage of nanofilled glass-ionomer. Furthermore, this study will be able to show the most appropriate polishing technique for nanofilled glass-ionomer. The end results will help in determining the benefit of nanotechnology in relation to the glass-ionomer product.

1.4   Objectives of the study

1.4.1   General Objective:-

The general objective is to evaluate the surface roughness of nanofilled glass-ionomer, microfilled glass-ionomer and nanofilled composite polished with three different polishing systems after 30 days of *S.mutans* culture and to measure the biofilm thickness after 14 and 30 days of *S.mutans* culture.

1.4.2   Specific Objectives:-

1. To compare the surface roughness of nanofilled glass-ionomer, microfilled glass-ionomer and nanofilled composite cured against Mylar strip before and after 30 days of *S.mutans* biofilm culturing.

2. To compare the surface roughness of nanofilled glass-ionomer, microfilled glass-ionomer and nanofilled composite between the three polishing techniques after 30 days of *S.mutans* culture.

3. To evaluate and compare the *S.mutans* biofilm thickness cultured for 14 days and 30 days on nanofilled glass-ionomer, microfilled glass-ionomer and nanofilled composite polished with three different polishing techniques.

1.5 Hypotheses

1. Microfilled glass-ionomer cured against Mylar strip will be the roughest surface after 30 days of *S.mutans* culturing compared to nanofilled glass-ionomer and nanofilled composite.

2. The surface roughness is less in nanofilled glass-ionomer compared with microfilled glass-ionomer and nanofilled composite after culturing *S.mutans* biofilm for 30 days regardless of the polishing technique.

3. The biofilm thickness of *S.mutans* formed on the surface of nanofilled glass-ionomer is less than on microfilled glass-ionomer and nanofilled composite after 14 days and 30 days of *S.mutans* culture. The biofilm thickness of *S.mutans* formed in 14 days is more than *S.mutans* biofilm thickness formed in 30 days in all test materials regardless of polishing techniques.

2 LITERATURE REVIEW

2.1 Glass-ionomer and composite

2.1.1 Conventional glass-ionomer cement

Glass-ionomer cements is a combination of polyacrylic acid liquid with silicate cement powder, yielding a material that demonstrates the best properties of both (Albers, 2002). Conventional glass-ionomer is supplied as a powder and liquid or as a powder mixed with water. The powder/liquid in the materials consists of a sodium aluminosilicate glass with about 20% CaF and other minor additives. The liquid may consist of an aqueous solution of acrylic acid or of a maleic acid/acrylic acid copolymer. Tartaric acid, which is used to control setting characteristics, is also included in the liquid component by many manufacturers. The powder/water materials are of two types; both consist of a powder which contains glass powder and vacuum-dried polyacid (acrylic, maleic or copolymers).

2.1.1.1 Properties

The major applications of the glass-ionomer filling materials reflect the advantage of their adhesive nature coupled with an inherent brittleness and a less than perfect aesthetic quality. They are mainly used to restore root and teeth abrasion cavity, fissure sealants, as a filling in deciduous teeth and in tunnel preparation technique (McLean, 1992).

The conventional glass–ionomer cements have some disadvantages, such as the long setting time and the sensitivity to water during the early stages of setting of these materials (Sepet *et al.*, 1997;McKenzie *et al.*, 2003).

2.1.1.2 Fluoride release

Glass-ionomer cement contains significant amounts of fairly mobile fluoride ions. The mobile fluoride ions diffuse to the surface of the cement; they are washed away with saliva or reacted with the surrounding tooth substance. Fluoride ions replace hydroxy groups in the apatite structure and this change makes the apatite more resistant to acid attack. The presence of glass-ionomer cements reduce the chance of caries developing in the surrounding tooth substance. The cement can be considered as applying a long term topical fluoridation effect on the tooth substance with which it is in contact. Fluoride can also absorb from an aqueous medium which has a high fluoride concentration. Hence the level of fluoride in the cement can be 'topped up' as it absorbs ions released from toothpastes, mouthwashes, and drinking water (Nicholson, 1998).

2.1.1.3 Finishing and polishing

The methods for finishing and polishing recommended by manufacturers are similar to those used for composite resins. In previous studies, conventional glass-ionomer obtained the smoothest surface with mylar (Mount, 1994;Liberman and Geiger, 1994).

The decrease in the particle size of the abrasive can give a superior surface. The grit in the polishing material should be smaller than the particle size of the restorative material that is being polished in order to produce better results (Weinstein, 1988). The smoothest surfaces were obtained after 24 hours of placement of the restoration.

It was also observed that a rougher surface was obtained when finishing and polishing was carried out at an early stage after placement (Matis *et al.*, 1988). A study by Pedrini *et al.* (2003) showed that the best finishing and polishing technique for conventional glass-ionomer was obtained through Sof-Lex disks, which was independent of time.

2.1.1.4 Color stability

Glass-ionomers offer a reasonable match for the natural tooth, although most authorities agree that a better match is achieved with resin matrix composites. The translucency of the restorative cements is achieved through the presence of unreacted glass cores which are able to transmit light. Attempts to improve the properties of glass ionomers have involved changes to the composition of the glass in order to enhance reactivity with the acid component. The aesthetic nature of the materials, although not perfect, has improved significantly since the time when the materials were first introduced. An increase in surface roughness can also be responsible for alterations in light reflection that can turn material surface opaque. It has been shown that a surface is considered reflective when imperfections are well below 1 μm (Warren *et al.*, 2002).

2.1.2 Resin Modified Glass-ionomer

Resin modified glass-ionomer materials are a combination of the best properties of composite resins and glass-ionomers. Some cariostatic properties, a low thermal expansion and the hydrophilic qualities are the same as with the glass-ionomer cements. The polymerizing resin matrix of resin modified glass-ionomers improves the fracture toughness, wear resistance, and polish of these materials compared with conventional glass-ionomers (McCabe and Walls, 2008).

In 1992, Mitra added the first auto cured resin capabilities to resin modified glass-ionomer cements. In addition to chemical initiators which allow the resin to polymerize without a presence of light curing unit. These materials are available in auto- and dual-cure forms. The dual-cured materials have three setting reactions: photo cure, auto cure, and acid base reaction between the glass-ionomer powder and the polyacid.

The resin modified glass-ionomer cements develop strength more rapidly because of the resin polymerization component of their setting reaction. The modified poly acrylic acid is less soluble in water. This is considered a problem with these materials. Therefore, hydroxyethyl methacrylate (HEMA) must be added as a co-solvent to avoid phase separation of the resin from the glass-ionomer components. When HEMA and similar hydrophilic monomers are added to glass-ionomer, the set material can swell in water, increase in volume and weaken. In general, the greater the amount of HEMA incorporated into a material, the greater the swelling and reduction in strength (Nicholson *et al.*, 1992).

In brief, resin modified glass-ionomer cements, known as glass-ionomer hybrid cements, set through a combination of acid base reaction and photochemical polymerization.

"Resin-modified" refers to all cements in which the acid base reaction of true glass-ionomer cements is supplemented by a light cure polymerization reaction (McLean *et al.*, 1994).

2.1.2.1 Compositions

Resin modified glass-ionomer consists of powder and liquid which require mixing prior to activation of polymerization. The powder consists primarily of an ion-leachable glass. The liquid contains four main ingredients; methacrylate resin which enables setting to occur by polymerization, a polyacid which reacts with the ionleachable glass to bring about setting by an acid–base mechanism, hydroxyethylmethacrylate (HEMA) and hydrophilic methacrylate which enables both the resin and acid components to co-exist in aqueous solution. Other minor components include polymerization activators and stabilizers. The most convenient of the restorative type resin-modified glass-ionomers are provided in an encapsulated form in which the powder/ liquid ratio is determined by the manufacturer and the mixing is carried out mechanically in only a few seconds (McCabe and Walls, 2008).

2.1.2.2 Properties

Resin modified ionomers have a different usage like: - bases, luting agents, restoratives, and bonding agents. They are appropriate for Class V restorations and for older patients and those at high risk for caries because they have long term fluoride release. One unusual benefit of resin modified ionomers is their capacity to take up topically applied fluoride. Both toothpaste with fluoride and topical neutral fluoride solutions have been proven to recharge the fluoride depleted from glass-ionomers (Burgess *et al.*, 1994).

Their major limitations are reduced stiffness and high wear, as well as poor dimensional and color stability. When these limitations are weighed against good adhesion and good caries inhibition properties, resin modified ionomers offer good service for treating the aging dentition in non stress bearing areas.

2.1.2.3   Fluoride release

Resin modified glass-ionomers behavior is similar to the conventional glass- ionomers in terms of both the pattern of release and the daily amount of fluoride released. Key factors in the rate of fluoride release from resin-modified materials are the extent to which the acid–base reaction occurs during setting and the presence of HEMA, which results in the formation of a polymeric hydrogel through which water can diffuse quite rapidly (Kosior and Kaczmarek, 2006). The rate of fluoride release becomes very low after the first few days of initial fluoride burst. However, a long-term release promoted by a continual release, recharge and re-release may well provide the positive therapeutic effects. On the other hand, studies showed that the materials which have the greatest initial fluoride release also have the greatest ability to be recharged (Itota *et al.*, 2004;Markovic *et al.*, 2008).

The effect of fluoride released from glass-ionomers on plaque and bacteria have been examined by many in vitro and in vivo studies. Some of them showed that the long term release inhibits bacterial growth (Marczuk-Kolada *et al.*, 2006;Koo *et al.*, 2005;Hayacibara *et al.*, 2003). Mount in 1994 showed that the glass-ionomer fluoride release curve showed an initial spike followed by a nearly flat but steadily declining release. Furthermore, the move of the material along the spectrum from glass-ionomer to resin polymerization, the less fluoride is available.

2.1.2.4 Finishing and polishing

Resin modified ionomers are smoother when finished than conventional glass-ionomers. However, resin modified ionomers should be left undisturbed for 10 minutes after the initial set, to allow the silicate gel setting reaction to progress far enough which will stabilize the filler and the polyacid components of the polyacid matrix. Susceptibility to dehydration is one of the resin modified glass-ionomers properties. Therefore resin modified glass-ionomers should be finished with a water spray after setting is complete. Although resin modified ionomer restorations are more water stable than conventional glass-ionomers, small defects can be noticed when the resin modified ionomers are coated with an unfilled resin. This will decrease fluoride release and may inhibit later fluoride uptake by the resin modified ionomer. Therefore, applying unfilled resin to the surface is recommended only for patients with a low risk of caries (Burgess *et al.*, 1994). Previous study showed that the use of carbides and one-step rubber abrasive system for finishing/polishing of resin modified glass-ionomer is not recommended. Graded abrasive disk or two-step rubber abrasive systems should be used instead (Yap *et al.*, 2002).

2.1.2.5 Color stability

Composite resins are hydrophobic and set via a polymerization reaction. They have the best long term color stability of any direct placement material. On the other hand, traditional glass-ionomers are hydrophilic and set via acid base reactions with moderate color stability. However, resin modified glass-ionomers have poorer color stability than either of the original materials in spite of its setting reaction which is through a polymerization reaction usually with poly HEMA and an acid base reaction with poly acid and glass particles (McCabe and Walls, 2008).

The color of resin modified materials has been reported to vary with the finishing and polishing techniques used (Heintze *et al.*, 2006). A recent study showed that color changes after cola exposure compromised both color stability and esthetics in the resin-modified glass ionomer cement in all shades and in composites and compomers in the darkest shade (Mohan *et al.*, 2008). Furthermore, the color stability of the resin-modified glass ionomer is shade dependent which is directly related to the glass-ionomer composition and filler size (Yap *et al.*, 2001). Discoloration of the material over time especially in root areas, which may be self limiting, may have little clinical significance. However, in Class V restorations on maxillary central incisors, color stability may be a major concern regardless of the fact that the placement technique is affecting the postoperative discoloration of resin modified glass-ionomers in the long term (O'Brien, 2002).

2.1.3   Nano glass-ionomer

Nanotechnology is the ability to measure, design and manipulate at the atomic, molecular and supramolecular levels on a scale of about 1 to 100 nm in an effort to understand, create and use material structures, devices and systems with fundamentally new properties and functions attributable to their small structures (Malsch, 2005).

Nanodentistry made possible the maintenance of comprehensive oral health by employing nanomaterials, including tissue engineering and dental nanorobots.

Nanoproducts Corporation has successfully manufactured nonagglomerated discrete nanoparticles that are homogeneously distributed in resins or coatings to produce nano-composites. The nanofiller used include an Aluminosilicate powder having a mean particle size of 80 ran and a 1:4 M ratio of alumina to silica and refractive index of 1.508 (Rybachuk *et al.*, 2009). In resin modified light cure glass-ionomer, recent technical development combine the benefits of a resin modified light cure glass-ionomer and bonded nano filler technology to provide some value added features not typically associated with glass-ionomer restorative materials.

2.1.3.1 Compositions

Nano glass-ionomer consists of de-ionized water, blend including HEMA, a methacrylate modified polyalkenoic acid and surface modified fluoroaluminosilicate (FAS) glass, nanomers and nanoclusters. The filler content of the system consists of an acid reactive FAS glass and a unique combination of nanofillers. It comes in two part system aqueous paste (acidic polyalkenoic acid, reactive resins and nano fillers) and non aqueous paste (FAS glass, reactive resins, and nano fillers). The filler loading is approximately 69% by weight 27% FAS glass and 42% methacrylate functionalized nano fillers. All of the nano fillers are further surface modified with methacrylate silane coupling agents to provide covalent bond formation into the free radically polymerized matrix. The FAS glass is radiopaque with an approximate particle size of less than 3 microns (average particle size approximately 1 micron) and provides the basis for the glass-ionomer reaction and extended fluoride release in the presence of water and a polycarboxylic acid functional polymer. In addition, the nanofilled glass-ionomer contains a unique combination of two types of surface treated nanofillers (approximately 5-25 nm) and nanoclusters (approximately 1.0 to 1.6 microns) (Douglas and Tantibirojn, 2007).

2.1.3.2 Properties

Nano glass-ionomer restoratives can contain a broad range of particle sizes. Filler particle size can influence strength, optical properties and abrasion resistance by using bonded nanofillers and nanocluster fillers, along with FAS glass. Nano glass-ionomer restoratives have improved esthetics, yet still provide the benefits of glass-ionomer chemistry, such as fluoride release. Some in-vitro studies have also demonstrated the addition of nanofillers provides enhanced surface wear and polish relative to some other commercially available dental materials (Douglas and Tantibirojn, 2007). The surface roughness of nano glass-ionomer is low compared to resin modified glass-ionomer after polishing with Sof-Lex disks.

Fluoride release is measured in-vitro in buffer solutions using a fluoride ion specific electrode. Nano glass-ionomer showed a high fluoride release compared to resin modified glass-ionomer. However, this study was conducted by the nano glass-ionomer manufacturer (Douglas and Tantibirojn, 2007). More neutral and comprehensive studies need to focus on nano glass-ionomer physical and chemical properties.

2.1.4   Nano-composite

A composite material is a product which consists of at least two distinct phases normally formed by blending together components having different structures and properties. The purpose of this was to produce a material having properties which could not be achieved from any of the individual components alone. To understand nanotechnology and its relation to the dental material, the concept of filler size and its affect on the properties of materials should be explained. Composite is one of the materials in which nanotechnology had an application.

2.1.4.1   Compositions

All dental composites consist of organic polymer matrix, inorganic filler particles, coupling agent and the initiator-accelerator system. The organic polymer matrix in most composites is either an aromatic or urethane diacrylate oligomer. Oligomers are viscous liquids, the viscosity of which is reduced to a useful clinical level by the addition of a diluent monomer. The inorganic particles may consist of several inorganic materials such as glass or quartz (fine particles) or colloidal silica (microfine particles). Methods used to characterize materials are based upon the technique used to activate polymerization of the resin and on the particle size distribution of filler. Resins: The nature of the resin may alter slightly from one product to another, although, essentially they all contain a modified methacrylate or acrylate. Fillers: The type, concentration, particle size and particle size distribution of the filler used in a composite material are major factors controlling properties (McCabe and Walls, 2008).