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AN OVERVIEW ON DENTAL COMPOSITE RESTORATIVE "WHITE FILLING"

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Abstract
In dentistry, dental composites are complex mixtures of material that generally consist of an organic resin matrix, reinforcing inorganic filler and a silane-coupling agent, which connects the filler and the resin matrix. Composites resins are formulated from a mixture of monomers, which introduced in the latest of past century, and were confined to the front teeth and initially intended for small cavities. However, technological improvements in material strength have made it possible to replace larger cavities with composite and posterior teeth. This paper is a review on dental composites restorative "white filling" in general. The main aim is to present comprehensive an overview on white filling composite. The research approach is focused on previous published studies such as proceeding books and websites, just as an attempt to present a summary on the concept, definition, classification, advantages, disadvantages and the characteristics of the dental materials.
Keywords: Dental materials, Composites, White filling, Restorative

1. INTRODUCTION

Composites are combinations of two materials in which one of the materials, called the reinforcing phase, is in the form of fibres, sheets, or particles, and are embedded in the other materials called the matrix phase. The reinforcing material and the matrix material can be metal, ceramic, or polymer. Composites are used because overall properties of the composites are superior to those of the individual components (Composite, 2009). A composite resin filling (also known as a white filling) introduced in the 1960s, dental composites were confined to the front teeth because they were not strong enough to withstand the pressure and wear generated by the back teeth. Since then composites have been significantly improved and can be successfully placed in the back teeth as well. Composites are not only used to restore decayed areas but are also used for cosmetic improvements of the smile by changing the colour of the teeth or reshaping disfigured teeth. A composite filling can be tinted to match any tooth colour and it forms a natural bond with the existing tooth in a way that metal fillings cannot. In order to bond a filling material to your tooth it is first necessary to remove decay prepare the tooth and then to condition the enamel and dentin. Once conditioned a thin resin is applied which bonds to the etched surface. Placement time depends on the size and location of the cavity and the larger the size the longer it will take. After placement composites are hardened by shining an intense light on them for a specified period of time usually around 40 seconds. Composite fillings tend to be used as an alternative to metal or silver amalgam fillings and are used to treat decay on a portion of a tooth replace an old silver amalgam filling and to maintain a white smile. Composite fillings are more than just attractive and they have distinct advantages over other types of fillings especially metal ones. Composite fillings are environmentally non-toxic because they use no mercury. They are stronger because they bond directly to the surface of the tooth. They protect the tooth from fracturing because they don't require the severe "undercut"(removal of healthy tooth structure) as mercury fillings. Another type of 'white filling' is called a Composite or Porcelain Inlay. These fillings are usually placed in back teeth when aesthetics is of utmost concern in order to increase their strength and longevity they are fabricated in the laboratory and then bonded into position at the dentists (Dentalfind, 2009). However, the objectives of this research are to: (1) To give brief an overview on dental composite "White filling" restoration; (2) Illustrating classification of dental materials and dental composites; (3) Defining of dental composite "White filling" restoration; (4) Identifying the advantages and

disadvantages of dental composite filling (5) To describe composition and structure of composite restorative materials. The research method was based on published previous studies on dental materials and white filling composites. Where, some details and information on dental materials and composites were obtained from several published books and electronic websites.

2. HISTORY OF DENTAL MATERIALS

The earliest known use of dental material can be traced to approximately 500 B.C. and the Etruscans, who used gold to make the first dental bridge (Ferracane, 1995). The pontic for the first bridges was a tooth that had been extracted, probably from a deceased person. When these gold appliances were found 2000 or more years later, they were still gold colored and virtually free of corrosion, underscoring the durability of gold, one of its major benefits as a dental restorative (Ferracane, 1995). In the first century A.D., carious teeth were filled with molten metal to facilitate extraction by keeping them intact during the procedure. It was not until approximately 1500 A.D. that very thin pieces of gold foil or leaf were used in Italy as a restorative material (Ferracane, 1995). Not long afterward, wax was used to make impressions from which plaster models of the gums or teeth were formed. These models were then used to carve replacement dentition from ivory or animal bones. In France, in the early 1700s, lead, tin, and gold were first used as filling materials (Ferracane, 1995). At the same time, sealing wax mixtures or metals with low melting temperatures were used like cement to fix ivory natural teeth in place. The late 1700s is also associated with the first use of porcelain to make complete dentures or individual teeth. The first dental amalgam or (silver filling) was produced in France in the early 1800s and found its way to the United States in approximately 1830 (Ferracane, 1995). Porcelain teeth were introduced in America at about the same time. A version of amalgam containing high levels of copper, the so-called copper amalgam, was introduced around 1850. Also, at that time, plaster began to be used to make impression; gutta percha appeared for the filling of root canals, metal mixtures based on gold and platinum came into use, the hard rubber material vulcanite was introduced as a replacement for ivory dentures, and a compound made of zinc oxychloride was developed as both cementing agent and restorative (Ferracane, 1995). In the late 1880s, zinc phosphate and silicate cements were introduced to secure circular gold inlays into prepared cavities. At the end of the 19th century, the father of modern dentistry, Dr. Black, perfected the formulation and use of dental amalgam in his laboratory at north western University in Chicago. In 1910, a dentist named Taggert introduced the lost wax casting technique (Ferracane, 1995). This process would revolutionize dentistry, because it made possible the accurate production of metal inlays, crowns, and bridges made of gold-containing alloys, similar to jeweller's gold. The acrylic occurred around 1940. These polymers or plastic would eventually be used in almost every aspect of human life. After the 1950s, other important contributions included stainless steels for orthodontics, non-noble metals (i.e., gold-"free") for the casting process, elastic impression materials (Ferracane, 1995). Acid conditioning of dental structures was introduced by Buonocore (1955), who tested application of phosphoric acid on enamel surface. Buonocore et al. (1956) was again the first to use acid on dentin surface trying to improve adhesion of restorative materials. Only a few years later, when Bowen (1963) developed Bis-GMA molecule studies about dentinal bonding were started again. Acid conditioning of enamel was recognized and considered an established procedure. Acid etching was defined as any change promoted on dentin after smear layer formation (Bertolotti, 1992). In the1960s dental composites were confined to the front teeth because they were not strong enough to withstand the pressure and wear generated by the back teeth or posterior teeth. Since then, composites have significantly improved in strength and can be used successfully for the back teeth (Medianadenatl, 2009). In the 1970s, glassionomer and polycarboxylate cements were developed, and a host of other materials were introduced, including new wires for orthodontics, new composites, adhesives that could bond to dentin, more accurate impression, materials that enhanced prosthodontic treatment, and ceramics to be used by themselves as restoratives (Ferracane, 1995).

3. CLASSIFICATION OF DENTAL MATERIAL

There are four classes of dental materials which are metal, ceramics, polymers, and composites. These materials are presented in brief as following:

3.1 Metal: It is the oldest of the three major classes of materials that have been used as dental material. A metal is often defined by a certain set of characteristics, including high thermal and electrical conductivity (they can be bent without breaking); opacity (they do not transmit light); and luster (they have a surface that strongly reflects light and appears bright and shiny). Another characteristic of metals is that elements classified as such tend to dissolve in water or other aqueous solutions, producing atoms with positive charge (i.e., cations), (Ferracane, 1995).

3.2. Ceramics: are a compound formed by the union of a metallic and nonmetallic element. Most of these materials are oxides, formed by the union of oxygen with metals such as silicon, aluminium, calcium, and magnesium. Glass, concrete, fine crystal and gypsum all are ceramics. Porcelain is a specific type of ceramic used extensively in dentistry and in other industries. Ceramics maybe crystalline or noncrystalline (i.e., amorphous). The atoms that make up a ceramic maybe bonded together by ionic or covalent bonds. Ceramics are generally very brittle materials. They are characterized by high melting points and low thermal and electrical conductivity. Therefore, they are used as insulators in many industries. Ceramics are manufactured by fusing oxide powders together in ovens at high temperatures. Finally, the fact that these materials are oxides means that they are very inert, that is, not very chemically reactive (Ferracane, 1995).

3.3. Polymers are giant, long-chain organic molecules. Polymers are characterized by covalent bonds within each molecule, giving them tremendous strength in a single direction. The interaction between each polymer chain is usually of a weaker nature, which reduces the structural and thermal stability of the materials in comparison to metals and ceramics. Due to their minimal stability and strength, polymers have not been used extensively in dentistry as permanent structural materials. They are used to make both the teeth and base of dentures, appliances that completely replace the teeth and gums of an edentulous person (Ferracane, 1995).

3.4. Composites: These are mixtures of two or more of the first three classes in which the different components remain distinct from one another in the final structure. A common example is glass fiber, a polymer reinforced with fine glass fibers that remain physically separate and uniformly distributed throughout the polymer matrix (Ferracane, 1995).

4. CLASSIFICATION OF DENTAL COMPOSITES

There are different classifications of dental composites restorative used in dentistry. These are classified according to filler particle size, method of activation, method of dispensing and their applications as shown below:

4.1. Classifying according to filler particle size

Shama Bhat and Nandish (2006) have classified dental composite according to filler particle as following:

- Macro filled composites “Conventional / traditional composite” (Filler particle size is 8-12 um)
- Small particle composite (Filler particle size is 1-5 um)
- Micro filled composites (Filler particle size is 0.04-0.4 um)
- Hybrid composites (Filler particle size is 0.6-1um).

4.2. Classifying according to method of activation

4.2.1 Chemically activated composite

Chemically activated products are supplied as two pastes, one of which contains the benzoyl peroxide (BP) initiator and the other an aromatic tertiary amine activator (e.g. N, N-dimethyl-p-toluidine). When the two pastes are mixed together, the amine reacts with the BP to form free radicals, and additional polymerization is initiated. Today, these materials are mainly used for restoration and large foundation structures (build-ups) that are not readily cured with a light source (Shama Bhat and Nandish, 2006).

4.2.2. Light activated composite

The first light-activated systems were formulated for ***UV light*** to initiate free radicals. Today, the UV light-cured composites have been replaced by visible blue-light-activated systems with greatly improved depth of cure, a controllable working time, and other advantages, Because of these advantages, visible light-activated composites are more widely used than are chemically activated materials (Shama Bhat and Nandish, 2006). ***Light-curable*** dental composites are supplied as a single paste contained in a light-proof syringe. The free radical initiating system, consisting of a photo sensitizer and an amine initiator, is contained in this paste. Camphorquinone (CQ) is a commonly used photo sensitizer that absorbs blue light with wavelengths between 400 and 500 nm. Only small quantities of CQ are required (0.2 wt% or less in the paste). A number of a mine initiators are suitable for interaction with CQ, such as dimethyllaminoethyl methacrylate (DMAEMA), which is also present at low levels, that is, approximately 0.15 wt% (Shama Bhat and Nandish, 2006).

4.3. According to method of dispensing (Shama Bhat and Nandish, 2006):

- Two paste systems: As a base and reactor dispensed in separate jars or cylinders.
- Single paste and liquid (e.g. chemically cured composites).
- Single paste system: supplied in syringes (e.g. light activated composites and u-v light cured composites).
- Disposable capsules (e.g. compomers).

4.4. According to their applications (Shama Bhat and Nandish, 2006):

- Anterior composites (for class III class V cavities);
- Posterior composites;
- Core builds up composites;
- Pit and fissure composites;
- Prosthodontic composite resins (veneering of gold or base metal alloy crowns);
- Glaze resin composites; and
- Bonding agents.

5. DEFINITION DENTAL COMPOSITES

Dental composites are complex mixtures of materials that generally consist of an organic resin matrix, reinforcing inorganic filler and a silane-coupling agent, which connects the filler and the resin matrix. Sometimes known as "white filling" or "synthetic porcelain" (Bisphenol-a, 2009). (Aunusavice, 2003) defined that dental composites are highly cross-linked polymeric materials reinforced by a dis persion of glass, crystalline, or resin filler particles and/or short fibers bounded to the matrix by silane coupling agents. Dental composite resins are types of synthetic resins which are used in dentistry as restorative material or adhesives. Synthetic resins evolved as restorative materials since they were insoluble, aesthetic, and insensitive to dehydration and were inexpensive (Wikipedia, 2009a). Composite resin fillings (also called white fillings) are a mixture of powdered glass and plastic resin, and can be made to resemble the appearance of the natural tooth. They are strong, durable and cosmetically superior to silver or dark grey colored amalgam fillings (Wikipedia, 2009b).

6. ADVANTAGE & DISADVANTAGES OF DENTAL COMPOSITE (WHITE FILLING)

6.1. Advantages of dental composite (white fillings):

Since they bond to the tooth, composite fillings restore most of the original strength of the tooth. Silver weakens the teeth, making them more susceptible to breaking. Since broken teeth are very expensive to restore, composites can save a lot of expense over the long run. Composite fillings restore the natural appearance of the tooth. Teeth restored with white fillings are less sensitive to hot and cold than teeth restored with amalgam, if correct techniques are used. Composites are mercury-free; mercury in the fillings is viewed by some as being toxic. Composites require less removal of tooth structure especially with new cavities, the size of the hole made for the filling can be dramatically smaller with composites (mynewsmile, 2009).

6.2. Disadvantages of dental composite (white filling):

This type of filling can break and wear out more easily than metal fillings, especially in areas of heavy biting force. Therefore, composite fillings may need to be replaced more often than metal fillings (ADA, 2009). Therefore, the life span of a composite is shorter than the older silver filling materials. Another disadvantage of dental composite (white filling) if it is compared to other fillings, composites are sometimes difficult and time-consuming to place. They can not be used in all situations. Furthermore, composite generally is more expensive than amalgam and they may require more than one visit for inlays, veneers and crowns (ADA, 2009). Consequently, they may wear faster than natural dental enamel and may leak over time when bonded beneath the layer of enamel. However, in rare cases, a localized, allergic reaction such as inflammation or rash may occur (ADA, 2009).

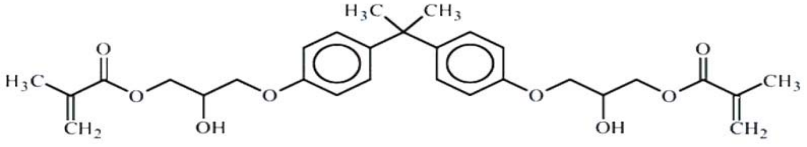
7. COMPOSITION AND STRUCTURE OF COMPOSITE RESTORATIVE MATERIALS

The resin-based composite restorative materials that are used in dentistry have three major components. These components are given in brief details as shown below:

7.1 Organic resin matrix

The resin is the chemically active component of the composite. It is initially a fluid monomer, but is converted into a rigid polymer by a radical addition reaction (Noort, 2002). From a plastic mass into a rigid solid that allows this material to be used for the restoration of dentition. The most commonly used monomer for both anterior and posterior resin is Bis-GMA, which is derived from the reaction of bisphenol-A and glycidyl methacrylate as shown in Formula (1). This resin is commonly referred to as Bowen's resin, after its inventor.

Chemical structure of Bisphenol-a-glycidyl methacrylate.
Source: Esstech (2009)



(1)

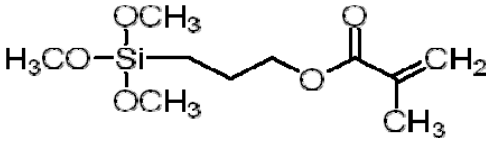
7.2. Filler

A wide variety of fillers have been employed in composites to improve the properties. This practice began in the late 1950s, when fillers such as quartz were introduced into methyl methacrylate-based filling material (Noort, 2002). However, the benefit of filler are so wide such as reinforcement of the matrix resin; reduction in polymerization shrinkage; reduction in thermal expansion and contraction; improved workability by increasing viscosity; reduction in water sorption, softening and staining; increased radiopacity and diagnostic sensitivity through the incorporation of strontium (Sr) absorb x-rays (Anusavice, 2003)

7.3 Coupling agent

In order for a composite to have acceptable mechanical properties, it is of the utmost importance that the filler and the resin are strongly bonded to each other. If there is a breakdown of this interface, the stresses developed under load will not be effectively distributed throughout the material; the interface will act as a primary source for fracture, leading to the subsequent disintegration of the composite (Noort, 2002). The bond is achieved by the use of coupling agents that are incorporated into the resin. These coupling agents are silanes, and the one most commonly used in glass-filled resin composites is γ-methacryloxypropyltrimethoxysilane, or (γ-MPTS) for short (Noort, 2002). Formual (2) is showing the structural Formula γ-methacryloxypropyltrimethoxysilane. A properly applied coupling agent can impart improved physical and mechanical properties, provide hydrolytic stability by preventing water from penetrating along the filler resin interface (Shama Bhat and Nandish, 2006).

Chemical structure of γ-methacryloxy propyl trimethoxy silane.
Source: (Sigmaaldrich, 2009)



(2)

8. CONCLUSION

Dental composites are complex mixtures of material that generally consist of an organic resin matrix, reinforcing inorganic filler and a silane-coupling agent, which connects the filler and the resin matrix. Resin composites continue to attract major attention as aesthetic anterior restoratives and as the dominant 'amalgam alternative' for direct restoration of posterior teeth. However, this paper was reviewed few important issues in the dental composites. Basically, it focused on reviewing the history of dental materials, classification of dental material, classification of dental composites, definition dental composite, the advantage and disadvantages of dental composite (white filling) and description of composition and structure of composite restorative materials. A general conclusion can be drawn from this article is that this article could shed the light on an important issues in this field and was provided details on dental composite in more and comprehensive sense.

REFERENCES

[1] *American Dental Assoictaion (ADA). Dental fillings facts, information obatined via http://ada.org/dental_fillings_facts_full.pdf , 16/8/2009.*

[2] *Anusavice, K.J. Phillips Sciences of Dental Materials, 11th edition, Elsevier Science, USA, 2003.*

[3] *Bertolotti, K.L. (Conditioning of the dentin substrate. Oper Dent (Suppl) 5: 131-136, 1992.*

[4] *B*isphenol-a *(Resin Dental Sealants and Bisphenol A Oral Exposure, information obtained via exceed website http://www.bisphenol-a.org/human/dental.html, 22/8/2009.*

[5] *Composites. information obtained via exceeded website http:// info.lu.farmingdale.edu/depts/met/met205/composites.html, 19/8/2009*

[6] *Dentalfind. Dental Restorative Materials, information obtained from via exceed website http:// www.dentalfind.com/glossary/composite-filling.html, 15/8/2009.*

[7] *Esstechinc, Inc. X-950-000, BisGMA, information obtained via exceed website: http://esstechinc.thomasnet.com/item/resins/bisgma/x-950-0000?&forward=1 , 25/8/2009.*

[8] *Ferracane, J.L. Materials in Dentistry Principles and Applications, J. B. LIPPINCOTT COMPANY, Philadelphia, 1995.*

[9] *Medianadenatl. White Filling, information obtained via exceeded website http://medianadental.com/white-fillings.html , 10/8/2009.*

[10] *Mortensen, A. Concise encyclopaedia of composite materials, 2nd Edition, Elsevier Ltd. Netherlands, 2007.*

[11] *Mynewsmile. White composite fillings compared with amalgam fillings, information obtained via exceed website http:// www.mynewsmile.com/whitefillings.htm , 2/8/2009.*
[12] *Noort, R.V. Introduction to Dental Materials, 2nd Edition, MOSBY, Elsevier Science Ltd., USA, 2002.*
[13] *Shama Bhat, V. & Nandish, B.T. Science of Dental Materials Clinical Applications, CBS Publishers & Distributors, New Delhi, Bangalore, India, 2006.*
[14] *Sigmaaldrich. Trimethoxysilyl propyl methacrylate, information obatined via http://www.sigmaaldrich.com/catalog/ProductDetail, 7/8/2009.*
[15] *Wikipedia. Dental Composite, information obtained via exceed website http://en.wikipedia.org/wiki/Dental_composite, 29/7/2009a.*
[16] *Wikipedia.Dental Restorative Materials, information obtained via exceed website http://www. en.wikipedia.org/wiki/Dental_restorative_materials.html, 13/8/2009b.*

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