REVIEW ARTICLE

Restorative Materials Used in Pediatric Dentistry

Shivam Mathur[1], J.N. Jaiswal[2], Abhay Mani Tripathi[3], Sonali Saha[4], Madhuchanda Palit[5]

1- Student (M.D.S), Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow. 2- Professor and Director, Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow. 3- Reader, Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow. 4- Senior Lec., Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow.

Correspondence to:
Dr. Shivam Mathur, Student (M.D.S), Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow.
Contact Us: www.ijohmr.com

ABSTRACT

Dental caries has been a highly prevalent and costly disease in the world, representing the most common infectious disease in the paediatric population. Caries risk is greater in children from rural setting, poor and from ethnic background or who have limited access to care. Restorative treatment shall be based upon the results of an appropriate clinical examination and ideally should be an integral part of a comprehensive treatment plan which should consider developmental status of the dentition, caries-risk assessment, the patient's oral hygiene, anticipated parental compliance and likelihood of timely recall and the patient's ability to cooperate for treatment. Materials such as glass–ionomers, resin ionomers, resin ionomer products, and improved resin-based composite systems have been developed which are having profound impact on the restoration of primary teeth.

KEYWORDS: Dental Caries, Restorative Materials, Amalgam, Glass Ionomer Cement, Composite

INTRODUCTION

Dental caries has been a highly prevalent and costly disease in the world, representing the most common infectious disease in the paediatric population. The disease is also increasingly isolated in specific teeth and tooth morphology types in both primary and mixed dentitions, with pits and fissures being the predominant decayed sites.[1]

Materials such as glass–ionomers, resin ionomers, resin ionomer products, and improved resin-based composite systems have been developed which are having profound impact on the restoration of primary teeth, particularly the treatment of proximal and anterior caries. The principal advantage of these new materials is that they require less retention form, and this is particularly important in primary teeth to conserve the relatively thin enamel that could help prevent subsequent caries invasion of dentin.[2]

This review highlights the evolution of restorative materials used in Pediatric Dentistry from amalgam to bonding materials and provides information on the clinical use, current trends and future directions in material research.

VARIOUS MATERIALS

AMALGAM: Of the many restorative materials available to the profession today, dental amalgam is by far the most frequently used. It has many positive properties that sustain its popularity, including its ease of manipulation, durability, lower cost, reduced microleakage with time and reduced technique sensitivity compared to other restorative materials.[3]

From the time of its introduction, there have been a lot of criticism against amalgam, especially regarding its biocompatibility and safety. But there is no conclusive evidence of health hazards being linked to amalgam.[4]

Indications
- Class I, II & VI cavities
- Cuspal restoration
- Class V restorations
- As a foundation while planning for a cast restoration in case of badly broken teeth.
- Post – endodontic access filling and core
- Teeth with questionable prognosis
- Economic status: Amalgam is the restoration of choice for posterior teeth when patient cannot afford expensive alternatives like cast restorations.[5]

Contraindications
- Esthetics: When esthetics is a prime concern for the patient.
- Extensive loss of tooth structure: Amalgam is avoided as it does not reinforce the remaining tooth structure. In such cases, cast restorations are preferred.
- Small Class I and Class II cavities: Composite restorations are preferred as they are more conservative.[5]

Properties[6,7]

a) Dimensional changes: Excessive delayed expansion can occur if a zinc containing amalgam is contaminated by saliva or moisture during trituration or condensation. This delayed expansion can start 3

How to cite this article:
Mathur S, Jaiswal JN, Tripathi AM, Saha S, Palit M. Restorative Materials Used in Pediatric Dentistry. Int J Oral Health Med Res 2016;2(6):101-X.

to 5 days after the restoration is placed and continue for several months.

b) Strength: High copper amalgams have the highest compressive strength, ranging from 380 to 550 Mpa which is close to that of enamel and dentin. Whereas the tensile strength is low for both low and high copper amalgams, in the range of 48 to 64 Mpa.

c) Creep: Generally, creep is influenced by γ_2 phase. Low copper amalgams exhibit high creep rates of over 2.5 % due to the presence of γ_2 phase.

d) Thermal properties: The linear coefficient of thermal expansion of amalgam is 2.5 times more than the tooth.

e) **Rigidity:** Compared to low copper amalgams, high copper amalgams are more rigid.[6]

f) **Corrosion Resistance:** Low copper amalgam undergoes tarnish and corrosion by oxidation of the γ_2 phase. In high copper amalgams, the copper tin (η) phase is more prone to corrosion.

The η phase is more prone to penetration corrosion which proceeds from outer surface of the amalgam along the crystals to the interior of the restoration.

g) Biocompatibility: Biocompatibility of amalgam is related to the known toxicity of mercury and the belief that mercury in amalgam has toxic effects. When there are extensive amalgam restorations in a patient's mouth, the maximum urinary mercury levels are only upto 4µg/gm of creatinine in the urine. This is well below the level at which any toxic changes occur.

Recent Advancements[7]

a) Mercury – free direct filling amalgam alloys: Mercury – free direct filling amalgam alloys consist of silver – coated silver – tin (Ag - Sn) alloy particles that can be cold welded to form a compaction to form a restoration. A fluoroboric acid solution is used to keep the surface of the alloy particles clean. These alloys can be condensed into the prepared cavity similar to the compaction of direct guide.

b) Gallium based alloys: Recently gallium alloys have been developed as alternatives to mercury in amalgam. By addition of small amounts of indium and/or tin to gallium, an alloy which is liquid at room temperature is produced. This alloy can be triturated with high copper amalgam alloy to produce similar handling characteristics as conventional amalgam.

c) Indium in mercury: Recently, interest has increased in admixed amalgam containing 10% to 15% indium in the mercury.

GLASS IONOMER CEMENT: Adhesion of restoration to tooth substance is an important objective in Dentistry. It is believed that a restoration should resemble the tooth in all aspects. It should possess identical properties and should adhere tenaciously to the surrounding enamel and dentin. The glass ionomer cement are developed in this direction as the property to adhere with the tooth structure.

Glass ionomer cement, are restorative materials which are made up of calcium, strontium aluminosilicate glass powder (base) combined with a water-soluble polymer (acid). When the components are mixed together, they undergo a setting reaction involving neutralization of the acid groups by the powdered solid glass base.[8]

Properties[9,10]

a) **Adhesion:** By bonding a restorative material to tooth structure, the cavity is theoretically sealed, protecting the pulp, eliminating secondary caries and preventing leakage at the margins.

b) **Margin adaptation and leakage:** The coefficient of thermal expansion of conventional glass ionomer cement is close to that of dental hard tissues and has been cited as a significant reason for the good marginal adaptation of glass ionomer restorations.

c) **Fluoride release:** Fluoride is released from the glass powder at the time of mixing and lies free within the matrix. It can, therefore, be released without affecting the physical properties of the cement.

d) **Esthetics:** Conventional glass ionomer cement are tooth colored and available in different shades.

e) **Biocompatibility:** The biocompatibility cements is very important because they need to be in direct contact with enamel and dentin if any chemical adhesion is to occur.[9]

f) **Colour and translucency:** Both conventional and resin-modified glass ionomer cement are available in various shades and provide acceptable colour matching and translucency

g) **Radiopacity:** Conventional glass ionomer cements are radiolucent but resin-modified and lining glass ionomer cement are radiopaque due to the presence of lanthanum, barium or strontium in the powder.[10]

h) **Strength and fracture resistance:** The compressive strength is similar to that of zinc phosphate cement, and its diametral strength is slightly higher. The modulus of elasticity of glass ionomer cement ranges from 7 Gpa to 13 Gpa.

i) **Abrasion Resistance:** Glass Ionomer cement have less resistance to abrasion than composite resins, but abrasion resistance improves as the cement matures.

j) **Solubility and Disintegration:** Properly set glass ionomer cement exhibit low solubility in the oral environment. In patients with xerostomia, the use of conventional glass ionomer cement should be avoided as the cement will undergo rapid disintegration. Resin-modified glass ionomers are more resistant to solubility and disintegration than conventional glass ionomer cement.

k) **Thermal Expansion and Diffusibilty:** Glass ionomer cement have a linear coefficient of thermal expansion similar to that of tooth structure.[9]

Indications[10]

- As pit and fissure sealants
- Class I restorations
- Tunnel restorations
- Class III & V restorations
- Root caries
- As a liner/base restoration of deciduous teeth
- As a core build up material
- Luting cement
- As an interim restoration

Contraindications[10]

- In stress bearing areas
- Labial buildups
- Cuspal coverage
- In mouth-breathers

Advantages[10]

- Adhesion to enamel and dentin
- Anticariogenic effect
- Acceptable esthetics
- Low solubility
- Biocompatibilty
- Less technique sensitivity

Disadvantages[10]

- Low fracture resistance
- Low wear resistance
- Colour Sensitivity to moisture soon after setting

Recent Advancements[11,12]

a) **Anhydrous:** In this modification the liquid is delivered in a freeze dried form that is then incorporated into the powder. The liquid to be used is clean water only, and this may enhance shelf-life and facilitate mixing.

b) **Resin – Modified:** These are materials which have a small quantity of a resin into the liquid formula. Less than 1% of photoinitiators are allowed for the setting reaction to be initiated by light of the correct wavelength.

c) **Nano-Ionomer:** The Nano-Ionomer delivers greater wear resistance, esthetics and polish compared to other glass ionomers, while offering fluoride release similar to conventional and resin-modified glass ionomer.[11]

d) **Compomer:** This is the term developed by the manufacturer with a term to incorporate some of the properties of glass ionomer with a composite resins. A compomer is a composite resin that uses an ionomer glass which is the major constituent of a glass ionomer as the filler.

e) **Ceramic reinforced glass ionomer:** Ceramic reinforced posterior GIC features stronger compressive, flexural and tensile strengths as compared to amalgam.[12]

COMPOSITE RESIN: To improve the physical characteristics of unfilled acrylic resins, Bowen of the National Bureau of Standards developed a polymeric dental restorative material reinforced with silica particles. The introduction of this filled resin material in 1962 became the basis for the restorations that are generically termed composites. Composites are presently the most popular tooth-colored materials, having completely replaced silicate cement and acrylic resin.[13]

Types of Composite[14]

a) Traditional composites: The fillers in these composites are relatively large (8 to 12 µm) in size, they are also called "macrofilled composites". The filler used is ground quartz in a concentration of 70 to 80% by weight or 60 to 65% by volume. Traditional composites are only employed in stress-bearing Class IV cavities.

b) Small particle composites: Small particle composites have improved surface smoothness and superior properties than those of the traditional composites. The average filler size is 1 to 5 µm, but the distribution of particle sizes is fairly broad.

c) Microfilled composite resins: Microfilled composite resins were developed to overcome the surface roughness and low translucency of traditional and small particle composite resins. The fillers used in these are colloidal silica with a particle size of 0.04 to 0.4 µm.

d) Hybrid composite: These were developed to achieve better surface smoothness than small particle composites while maintaining their desirable properties. This category of composite resins can be employed for both anterior and posterior situations. Hybrid composite resins have two kinds of filler particles: colloidal silica and heavy metal glasses. The filler content is 75 to 80% by weight with heavy metal glasses being the major constituent.[15]

PROPERTIES[14,15]

a) **Mechanical properties:** Flexural strengths of various composites are similar although microfilled and flowable composites exhibit 50% lower values than hybrid and packable composites due to their lower filler content.

b) **The Coefficient of Thermal Expansion:** Composite resins have a higher coefficient of thermal expansion than that of tooth structure. This means that they expand and contract more than enamel and dentin when subjected to temperature changes.

c) **Wear:** Wear of composite resins occurs while they are in function due to masticatory forces, abrasive foods, tooth brushing and as result of chemical degradation in the oral cavity.[14]

d) **Water Sorption:** Water is absorbed by the resin component; so when the resin content is high, the water sorption is increased.

e) **Solubility:** Water solubility of composite resins varies from 0.5 to 1.1 mg/cm^2. Inadequate polymerization of composite increases solubility.

f) **Marginal Integrity:** Composite resins exhibit good marginal adaptation if margins are on enamel and dentin.

g) **Radiopacity:** Resins are inherently radiolucent, modern composite resins have glass fillers containing heavy metal atoms like barium strontium and zirconium which provide radiopacity.

h) **Esthetics, Colour and Colour Stability:** Composite resins are highly esthetic and can simulate the appearance of natural teeth. They are available in a variety of shades, tints and opaque resins for different applications.

i) **Polymerization Shrinkage:** Polymerization shrinkage usually does not cause significant problems with restorations cured in preparation having all-enamel margins. When a tooth preparation has extended onto the root surface, however, polymerization shrinkage can cause a *gap formation at* the junction of the composite and root surface. The V-shaped gap occurs because the force of polymerization of the composite is greater than the initial bond strength of the composite to the dentin of the root.[16]

Indications[16]

- Small pit and fissure caries and occlusal surface caries extending into the dentin
- Class II restorations in primary teeth not extending beyond proximal line angles
- Class II restorations in permanent teeth that extend approximately one-third to one-half the buccolingual intercuspal width of the tooth
- Class III, IV and V restorations in primary and permanent teeth
- Strip crowns in primary and permanent dentition

Contraindications[16]

- Where a tooth cannot be isolated due to inadequate moisture control
- Individuals needing large multiple surface restorations in the posterior dentition
- High-risk patients that have multiple caries and/or tooth[16]

Advantages

- Esthetics
- Conserve tooth structure
- Adhesion
- Low thermal conductivity
- Universal application
- Ease of manipulation
- Repairable
- Can be polished at the same appointment[14]

Disadvantages

- Polymerization shrinkage
- Technique senstivity
- Time – consuming and expensive
- Difficult to finish and polish
- Increased coefficient of thermal expansion[15]

Recent Advancements[14,15]

a) Packable/Condensable or Polymeric Rigid Inorganic Matrix Material (PRIMM) This system is composed of a resin matrix, and an inorganic ceramic component. Resin is added into the fibrous ceramic filler network. The filler consists of aluminium oxide and silicone dioxide glass particles or barium aluminium silicate or strontium glasses. Glass particles are liquefied to form molten glass which is forced through a die to form thin strands of glass fibers. Colloidal silica ultrafine particles are incorporated to control the handling characteristics such as viscosity, resistance to flow, condensability and reduced stickiness.

b) Flowable Composite: Flowable composites were developed mainly in response to fulfill special handling properties for composite resins rather than any clinical performance criteria.

Since the filler content is reduced in these composites there is a lack of sufficient strength to withstand high stresses and because of the increased resin content these composites exhibit more polymerization shrinkage and have lower elastic moduli and high fracture toughness.

Indirect Composite Resins: Because of the major clinical problems clinicians have experienced with direct posterior composite resins, the indirect inlay or onlay systems were introduced.

c) Art glass: Art glass is a non conventional dental polymer. It is most commonly used in inlays, onlays and crowns. The resin matrix consists of BISGMA/UDMA which provides a higher level of cross linking and better control over the positions along the carbon chain where cross linking occurs.

Artglass is considerably more wear resistant than conventional light cured composites, good marginal adaptation, esthetics and superior proximal contact.

d) Belleglass HP: Belleglass HP was introduced by Belle de St. Claire in 1996 as an indirect restorative material. Its resin matrix consists oBISGMA and fillers.

e) Nanocomposites: Nanoparticle filled composites exhibit outstanding esthetics. They are easy to polish and possess an enhanced wear. Nanoparticle fillers include colloidal silica or Ormocers. These may show an enhanced fracture toughness and adhesion to tooth tissue.

f) **Antimicrobial Materials**: Antimicrobial properties of composites may be accomplished by introducing agents such as silver or one or more antibiotics into the material.

STAINLESS STEEL CROWNS: Rehabilitation of grossly lost tooth structure in primary/young permanent teeth by means of stainless steel crowns (SS crown) has become a viable assistance to the Pediatric Dentist ever since *Rocky Mountain Company* introduced them in 1947 but familiarized by Humphrey and Engel in 1950s. Stainless steel is composed of iron, carbon, chromium, nickel, manganese and other metals.[16]

The distinctive anatomical characteristics of primary teeth, petite lifespan of primary teeth in the oral cavity, short attention span of the child, prolonged duration and intricate treatment planning involved in preparation of Willets inlay/cast crown restorations favors SS crowns as an alternative in Pediatric Dentistry.[17]

Advantages

These crowns are far superior to multisurface amalgam restorations with respect to life span, replacement, retention and resistance.

- They are accepted both by patient and dentist.
- They are also more cost effective because of comparatively simple procedures involved in restoring even severely affected primary molars.
- Can be completed in a single appointment
- Less time consuming than cast restorations
- No need for laboratory procedures
- Less sensitive to moisture
- Less prone to fractures
- Longevity
- Durable as compared to multi-surface restorations
- Premature contacts are well tolerated by the child[18]

Indications[19]

1) **Extensive Caries**:A stainless steel crown is indicated if, after cavity preparation, insufficient tooth substance remains to adequately retain a silver amalgam or a composite resin restoration.
2) **Rampant Caries**: In children with rampant caries, stainless steel crowns offer a quick and cost-effective method of restoring many anterior and posterior teeth.
3) **Following Pulp Therapy:** During the preparation of a tooth for pulp thereby, most of the dentin in the crown is removed. Consequently, the remaining portion of the crown is severely weakened.
4) **Developmental Enamel Defects:** Patients with amelogenesis or dentinogenesis imperfecta or those who have extensive enamel hypoplasia of an acquired nature often complain of pain when eating.
5) **Severe Bruxism:** When the teeth of the primary dentition exhibit excessive wear, they can be restored with stainless steel crowns.
6) **Fractured Incisors:** When a primary incisor is fractured, and extraction is not desirable, a stainless steel crown may be used.
7) **Space Maintainer:** Stainless steel crowns may be used as part of crown and loop space maintainer.
8) **Abutments to the Prosthesis:** Stainless steel crowns are useful extracoronal restorations on the abutment teeth to a removable prosthesis in children.

Contraindications[20]

- Primary molars close to exfoliation
- Primary molars with more than half the roots resorbed
- Teeth that exhibit mobility
- Teeth which are not restorable
- Patients with known nickel allergy

CONCLUSION

It has been observed that many a time's dental professional finds it difficult to choose the technique and materials to use for restorations of deciduous and permanent teeth in children. Last decade showed a significant growth in the range of tooth-colored materials available to restore primary and mixed dentition in children. An improved conventional glass ionomer cement, composite resin, resin-modified glass ionomer cement, light cured glass ionomer cement, silver reinforced glass ionomer cements and polyacrylic acid modified composites (compomers) have become available in addition to amalgam and stainless steel crowns.

REFERENCES

1. Pizzo G, Re DL, Pizzo I, Giulana G. Advances in Paeditric Restorative Dentistry. In: Taggart JC, editor. Hand Book of Dental Care Diagnostic, Preventive and Restorative Services, 1st ed. New York: Nova Science Publishers; 2009. p. 91-116.
2. Anderson M. Risk assessment and epidemiology of dental caries: Review of the literature. Pediatric Dentistry 2002; 24(5): 377-385.
3. Lambert RL. Amalgam Restorations. In: Baum L, editor. Advanced Restorative Dentistry Modern Materials and Technique. 1st ed. London: W.B Saunders Company; 1979. p. 73-87.
4. Osborne JW, Summitt JB, Roberts HW. The use of dental amalgam in pediatric dentistry: review of literature. Pediatric Dentistry 2002; 24(5): 439-447.
5. Raghu R, Srinivasan R. Amalgam Restorations. In: Raghu R, editor. Clinical Operative Dentistry Principles and Practice, 1st ed. Bangalore: EMMES Medical Publishers; 2007. p. 219-250.
6. Harbart JD. Amalgam fillings. Dental Cosmos 1859; 1(3): 122-124.
7. Shenoy A. Is the end road Is it the end of the road for dental amalgam? A critical review. Journal of Conservative Dentistry 2008; 11(3): 99–107.
8. Nagaraja UP, Kishore G. Glass Ionomer Cement – The Different Generations. Trends in Biomaterials and Artificial Organs 2005; 18(2): 158-164.

9. Cho SY, Cheng AC. A Review of Glass Ionomer Restorations in the Primary Dentition. Journal of Canadian Dental Association 1999; 65(9): 491-445.
10. Mount GJ, Ngo H, Byrant RW. Modern Restorative Materials and Techniques. In: Tandon S, editor. Text Book of Pedodontics, 2nd ed. New Delhi: Paras Medical Publisher; 2009. p. 329-327.
11. Cho SY, Cheng AC. A Review of Glass Ionomer Restorations in the Primary Dentition. Journal of Canadian Dental Association 1999; 65(9): 491-445.
12. Mount GJ, Ngo H, Byrant RW. Modern Restorative Materials and Techniques. In: Tandon S, editor. Text Book of Pedodontics, 2nd ed. New Delhi: Paras Medical Publisher; 2009. p. 329-327.
13. Roberson TM, Heymann HO, Ritter AV. Introduction to composite. In: Roberson TM, Heymann HO, Swift E, editors.Sturdevant's Art and Science of Operative Dentistry, 5th ed. New Delhi: Elsevier; 2006. p. 495-524.
14. Ferracane JL. Resin composite – State of the art. Dental Materials 2011; 1: 29-38.
15. LeSage BP. Aesthetic Anterior Composite Restorations: A Guide to Direct Placement. Dental Clinics of North America 2007; 51: 359-378.
16. Donly KJ, Godoy KJ. The use of resin-based composite in children. Pediatric Dentistry 2002; 24(5): 480-488.
17. Randall RC. Preformed metal crowns for primary and permanent molar teeth: review of literature. Pediatric Dentistry 2002; 24(5): 489-500.
18. Seale NS. The use of stainless steel crowns. Pediatric Dentistry 2002; 24(5): 501-505.
19. Mount GJ, Tandon S. Semi-permanent Restorations. In: Tandon S, editor. Text Book of Pedodontics, 2nd ed. New Delhi: Paras Medical Publisher; 2009. p. 357-373.
20. Marwah N, Ravichandra KS, Ravi GR. Stainless Steel Crown in Pediatric Dentistry. In: Marwah N, editor. Textbook of Pediatric Dentistry, 3rd ed. New Delhi: Jaypee Brothers Medical Publishers; 2014. p. 445-470.

Source of Support: Nil
Conflict of Interest: Nil