Materials and Techniques for Pediatric Restorative Dentistry: A Review of the Latest Trends

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Abstract:
Dental caries remains a significant oral health problem affecting children worldwide. Restoring carious lesions in the pediatric dentition requires materials and techniques that are effective, efficient, esthetic, and minimally invasive. This review provides an overview of the latest trends in pediatric restorative dentistry, focusing on restorative materials, esthetic crowns, biological restorations, prosthetic rehabilitation, and alternative techniques for improving esthetics. Advancements in glass ionomer cements, composite resins, and nanofilled composites have improved physical properties and esthetics. Esthetic crowns like zirconia, cerec, and preveneered stainless steel offer durable and natural-looking solutions. Biological restorations (fragment reattachment, natural tooth pontics) and prosthetic techniques (modified appliances, fiber-reinforced space maintainers) enable conservative approaches. Alternative techniques such as bleaching, veneers, lasers, and cosmetic contouring further enhance esthetics. As the field continues evolving, future research should focus on developing biocompatible, minimally invasive, and long-lasting materials and techniques that improve patient compliance and satisfaction while addressing the unique challenges of treating pediatric patients.

Introduction

Dental caries is one of the most prevalent chronic diseases affecting children worldwide, with a significant impact on their overall health, well-being, and quality of life (Finlayson et al., 2007). The restoration of carious lesions in the primary and young permanent dentition presents unique challenges due to the smaller tooth size, thinner enamel and dentin layers, and close proximity of the pulp to the external surface (Marwah, 2014). Additionally, managing the behavior of pediatric patients and ensuring their cooperation during dental procedures can be demanding. Consequently, there is a constant need for restorative materials and techniques that are not only effective but also efficient, esthetically pleasing, and minimally invasive.

Over the past few decades, significant advancements have been made in the field of pediatric restorative dentistry, driven by the increasing demand for esthetic restorations, the need for more biocompatible materials, and the emphasis on minimally invasive dentistry (Karri et al., 2015). This review aims to provide a comprehensive overview of the latest trends in materials and techniques used in pediatric restorative dentistry, including restorative materials, esthetic crowns, biological restorations, prosthetic rehabilitation, and alternative techniques for improving esthetics.

Restorative Materials

Glass Ionomer Cements

Glass ionomer cements (GICs) have been widely used in pediatric dentistry due to their ability to release fluoride, chemical adhesion to tooth structure, and biocompatibility (Nicholson, n.d.). Recent advancements in GICs have focused on improving their physical and mechanical properties, as well as their esthetic qualities. Metal-Modified Glass Ionomer Cements: The addition of metal powders or fibers to GICs has been shown to improve their strength and fracture resistance (Sced & Wilson, 1977; Simmons, 1983).

Cermet (Glass Sintered with Silver): Introduced by McLean and Gasser (1985), cermet combines glass powder with silver particles to enhance the tensile and compressive strength, as well as the abrasion resistance of conventional GICs.

Resin-Modified Glass Ionomer Cements (RMGICs): RMGICs, such as Vitrabond, combine the properties of GICs and composite resins, offering improved working time, command setting on light exposure, better adaptation and adhesion, and superior strength characteristics (Chadha et al., 2017).

High Viscosity Glass Ionomers: These highly viscous, packable GICs are particularly useful for the Atraumatic Restorative Treatment (ART) technique, as they exhibit rapid setting, reduced early moisture sensitivity, improved wear resistance, and low solubility in oral fluids (Chadha et al., 2017).

Composite Resins

Composite resins have become increasingly popular in pediatric restorative dentistry due to their esthetic properties, improved strength, and ability to bond to tooth structure through acid etching (Donly & Garcia-Godoy, 2002). Several advancements have been made in composite resin materials to address their limitations and improve their performance.

Flowable Composites: Introduced in 1996, flowable composites have lower filler content and higher resin content, resulting in improved flow and handling characteristics (Raghu & Srinivasan, 2007). They are commonly used for small Class I restorations, pit and fissure sealants, marginal repairs, and as liners under hybrid or packable composites.

Packable Composites: These condensable composites, developed in the late 1990s, have a higher filler content and a continuous network of short silica and alumina fibers, allowing them to be "packed" similarly to amalgam (Raghu & Srinivasan, 2007). They are primarily used for Class I and Class II restorations in posterior teeth.

Ormocers: Organically modified ceramics (Ormocers) are synthesized from multifunctional urethane and thioether(meth)acrylate alkoxysilanes, resulting in a material with reduced polymerization shrinkage and improved shade stability compared to conventional composites (Zimmerli et al., 2010).

Ion-Releasing Composites: These composites, such as Ariston pH, contain alkaline glass fillers that release calcium, hydroxyl, and fluoride ions, providing antibacterial properties and promoting remineralization (Rasheed & Munir, 2018).

Nanofilled Composites: Nanofillers, ranging from 0.005 to 0.04 μm in size, have been incorporated into composites to improve their esthetic properties, translucency, and handling characteristics while maintaining physical and mechanical properties similar to hybrid composites (Hambire & Hambire, 2022).

Compomers: Developed in the 1990s, compomers combine the properties of composites and glass ionomers, providing both durability and fluoride-releasing capability (Raghu & Srinivasan, 2007). Colored compomers, such as MagicFil and Twinky Star, have also been introduced for esthetic restorations in primary teeth (Oba et al., 2009).

Esthetic Crowns

In cases of extensive caries or tooth structure loss, the placement of esthetic crowns can restore the form, function, and appearance of the affected teeth in pediatric patients. Various types of esthetic crowns have been developed to meet the diverse needs of this patient population.

Bonded Crowns:

Pedo Jacket Crowns: Made of tooth-colored polyester material and filled with resin, these crowns can be placed in a single visit and trimmed with scissors (Karri et al., 2015).

Polycarbonate Crowns: These temporary crowns, composed of polycarbonate resin and microglass fibers, can be used as a fixed prosthesis for severely carious or fractured primary anterior teeth (Mittal Kumar et al., 2016).

Artglass Crowns: Also known as "organic crowns," Artglass crowns consist of 55% microglass and 20% silica filler in a multifunctional methacrylate resin matrix (Sahana et al., 2010).

Strip Crowns: These plastic molds, filled with composite and bonded to the tooth, provide a highly esthetic restoration for primary anterior teeth and are easy to fit, trim, and repair (Mittal Kumar et al., 2016).

Luted Crowns:
Stainless Steel Crowns: First introduced in the 1950s, stainless steel crowns (SSCs) offer protection for compromised primary tooth structure and have a low failure rate (Garg et al., 2016).

Open-Faced Stainless-Steel Crowns: Introduced by Hartmann in 1983, these crowns have a facial window for improved esthetics and pulp testing while maintaining the durability of SSCs (Karri et al., 2015).

Preveneered Stainless Steel Crowns: These crowns, with composite resins or thermoplastics bonded to the metal surface, provide an esthetic solution for restoring severely carious primary incisors (Karri et al., 2015).
Pedo Compu Crowns: Stainless steel anterior crowns with a high-quality composite facing, designed to match the natural dentition and reduce plaque accumulation (Karri et al., 2015).

High-Density Polyethylene Veneered Crowns: These crowns rely on mechanical retention and have a higher density composite facing compared to conventional veneered crowns (Karri et al., 2015).
Pedo Pearls: Made of aluminum instead of stainless steel, these crowns can be easily trimmed and customized with composite additions (Garg et al., 2016).

New Millennium Crowns: Similar to Pedo Jacket and Strip crowns, these crowns can be finished and reshaped using high-speed finishing burs (Mittal Kumar et al., 2016).
Zirconia Crowns: Developed by Hansen and Fisher in 2010, zirconia crowns offer superior esthetics and strength, making them suitable for both primary and permanent dentitions (Karri et al., 2015; Garg et al., 2016).

Cerec (Ceramic Reconstruction) Crowns: Fabricated using CAD/CAM technology, these all-ceramic crowns are esthetic and available in various shades for both primary and permanent teeth (Karri et al., 2015).

Biological Restorations
Biological restorations aim to restore extensively damaged teeth using the patient's own tooth fragment, providing a conservative approach that preserves natural tooth structure while achieving esthetic and functional harmony.

Fragment Reattachment: This technique, first reported by Chosack and Eidelman in 1964, involves the reattachment of a fractured tooth fragment using adhesive systems, minimizing the loss of tooth structure (Chaudhary et al., 2015; Vedpathak et al., 2012).

Natural Tooth Pontic: In cases of missing anterior teeth, a natural tooth pontic can provide an esthetic and economical temporary replacement, reducing the psychological impact on the patient (Jain et al., 2015).

Prosthetic Rehabilitation of Missing Primary Teeth
In cases where the normal dentition fails to develop, prosthetic rehabilitation can play a crucial role in addressing functional, esthetic, and psychological concerns associated with tooth loss in pediatric patients.
Modified Hawley's Appliance: This removable appliance, with acrylic teeth embedded onto the labial bow, can restore anterior esthetics and function in cases of intrusion, luxation, avulsion, or extensive caries of primary teeth (Marques et al., 2013).

Modified Nance Palatal Arch: By placing acrylic teeth in the anterior extension of the acrylic button, this fixed appliance provides a cost-effective and compliant-free option for replacing missing primary anterior teeth (Sethi et al., 2013; Kirtaniya et al., 2015).

Glass Fiber-Reinforced Composite Resin Space Maintainers: These space maintainers, reinforced with polyethylene or glass fibers and bonded to adjacent teeth, offer a clinically acceptable and convenient alternative to conventional band and loop appliances (Tayab et al., 2015).

Removable Partial Dentures (RPDs): RPDs can restore one or more missing teeth and associated structures, improving appearance, masticatory efficiency, and esthetics in pediatric patients (Henderson & Steffel, 1973).
Complete Dentures: In cases of complete edentulism, such as ectodermal dysplasia, conventional complete dentures can be a suitable alternative for young patients who have not completed their craniofacial growth (Vilanova et al., 2015).

Alternative Techniques for Improving Esthetics
Bleaching: Bleaching techniques, both internal (for non-vital teeth) and external (for vital teeth), can improve tooth color by oxidizing organic pigments (Sturdevant, 1995). External bleaching methods include chairside, office, and power bleaching, suitable for stains caused by tetracycline usage, fluorosis, or pulp chamber sclerosis.

Veneers: Dental veneers are thin layers of material (e.g., porcelain, composite) placed over the tooth surface to improve esthetics and protect the tooth (Kumar et al., 2012). Partial veneers are indicated for localized defects or intrinsic stains, while full veneers are used for generalized defects or staining involving the entire facial surface.

Lasers in Esthetic Dentistry: Lasers, such as Nd:YAG, argon, and carbon dioxide lasers, have been used in pediatric dentistry for various applications, including laser pediatric crowns and laser bleaching (Shajahan et al., 2015; Jacobson, 2003; Garber, 1997).
Cosmetic Contouring: This minimally invasive technique involves reshaping natural teeth to improve their color, position, shape, size, alignment, and overall smile appearance (Chadha et al., 2017).

Conclusion
The field of pediatric restorative dentistry has witnessed significant advancements in recent years, driven by the increasing demand for esthetic restorations, the need for more biocompatible materials, and the emphasis on minimally invasive dentistry. The introduction of new restorative materials, such as nanofilled composites, ormocers, and high-viscosity glass ionomers, has provided clinicians with a wide range of options to address various clinical situations. Esthetic crowns, including zirconia, cerec, and preveneered stainless steel crowns, offer improved esthetics and durability for restoring severely compromised primary teeth. Biological restorations and prosthetic rehabilitation techniques, such as fragment reattachment, natural tooth pontics, and modified appliances, allow for conservative and patient-centered approaches to restoring form and function. Additionally, alternative techniques like bleaching, veneers, lasers, and cosmetic contouring provide further options for enhancing the esthetics of pediatric patients.

As the field continues to evolve, future research should focus on developing materials and techniques that are not only esthetically pleasing and biocompatible but also minimally invasive and long-lasting. Emphasis should be placed on improving patient compliance and satisfaction while addressing the unique challenges associated with treating the pediatric population. By staying abreast of the latest trends and advancements, pediatric dentists can provide their patients with the best possible care, promoting their overall oral health and well-being.

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