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Review

An update on glass fiber dental restorative composites: A systematic review

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ABSTRACT

Dentistry is a much developed field in the last few decades. New techniques have changed the conventional treatment methods as applications of new dental materials give better outcomes. The current century has suddenly forced on dentistry, a new paradigm regarding expected standards for state-of-the-art patient care. Within the field of restorative dentistry, the incredible advances in dental materials research have led to the current availability of esthetic adhesive restorations. The chemistry and structure of the resins and the nature of the glass fiber reinforced systems in dental composites are reviewed in relation to their influence and properties including mechanical, physical, thermal, biocompatibility, technique sensitivity, mode and rate of failure of restorations on clinical application. It is clear that a deeper understanding of the structure of the polymeric matrix and resin-based dental composite is required. As a result of ongoing research in the area of glass fiber reinforced composites and with the development and advancement of these composites, the future prospects of resin-based composite are encouraging.

Contents

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1. Introduction

Dentistry has rapidly developed during the last few decades, where innovative techniques have changed the conventional treatment methods as applications of new dental materials give better outcomes. The current century has suddenly forced on dentistry a new paradigm regarding expected standards for state-of-the-art patient care. Traditional methods and procedures that have served the profession well are being questioned within the context of evidence-based rationales and emerging information/technologies. Within the field of restorative dentistry, the incredible advances in dental materials research have led to the current availability of esthetic adhesive restorations, conducting the profession into the "post-amalgam era" [1]. Clinicians have been using certain criteria to select dental materials i.e. (i) analysis of the problem, (ii) consideration of requirement, and (iii) available materials and their properties [2]. Resin composites as direct/indirect restorative materials have been used to replace missing tooth structure, (e.g. hypoplasia) or as a direct filling material [3,4]. The current trend toward "minimally invasive dentistry" and in response to the growing patient demand for esthetic, resin composites are the material of choice for the restoration of anterior teeth [5]. During the last half century that applications of composites have become so demanding that the tailoring of well-bonded, durable interfaces (or 'interphases') between the matrix and reinforcement has become a critical concern. The use of coupling agents, chemically reactive with matrix and reinforcement, and/or chemical modification of the surfaces of one or both constituents has been the most successful means of chemically bonding the matrix to the encapsulated reinforcement. Traditionally, the dental composites used for direct esthetic restoration consists of mainly polymer matrix and dispersed reinforcing inorganic filler particles [6]. The development of methacrylate monomer, bisphenol-A-glycidyl-methacrylate (Bis-GMA) monomer and dental composites by Bowen [7,8] and their introduction to restorative dentistry was so successful that they were soon accepted as an esthetic filling material [9,10], however; their properties are affected by the size and volume of filler particle, the resin composition, the matrix-filler bonding, and the polymerization conditions [11]. Composite restorations and veneers are isotropic, having no specific filler orientation. However, these composites have improved particularly in terms of wear, through reduction in size of the filler particles and the use of fiber fillers [12].

1.1. Concept of fiber reinforced composites

Fiber reinforced composites (FRCs) are typical composite materials made of a polymer matrix that is reinforced by fine thin fibers. The polymeric matrix, consisting of polymerized monomers, has the function of holding the fibers together in the composite structure. The matrix may influence the compressive strength; interlaminar shear and in-plate shear properties, interaction between the matrix and the fiber and defects in the composite [13,14]. Various manufacturing methods have been used for particles/fibers reinforced polymers, including injection molding [15], compressive molding [16], hydrostatic extrusion and self-reinforced (die-drawing) [17,18]. The recently used fibers with their properties are given in Table 1.

1.2. Glass fiber reinforced composites

They are amorphous (non-crystalline), homogenous and structurally a three dimensional network of silica, oxygen and other atoms arranged randomly [30]. For dental applications, polycarbonate, polyurethane and acryl base polymers, such as poly-methyl-methacrylate (PMMA) and bisphenol-A glycidyl methacrylate (Bis-GMA) were mainly reinforced with glass fibers and are generally treated by silane coupling agent to enhance chemical bonds between fiber and polymer matrix [31–37]. The ability of the fiber reinforcement to combine with the resin composite is vital in their effectiveness. The physical characteristics of the reinforced glass fiber based composite and tooth are similar, therefore, failure of these composites is less likely compared to resin-based composites. Resin-based composites have inadequate physical properties to allow it to be used for fixed prosthodontic application. Resin impregnated with fibers can be used for this purpose, which can be made either in laboratory with conventional design of tooth preparation or directly at the chair-side. The composition of commercially available reinforced glass fiber dental composites is given in Table 2. Fig. 1 shows the schematic structure of glass fibers reinforced in polymer matrix. These commercial glass fiber reinforced materials designed for core-build up showed 10% improvement in their physical properties compared with conventional materials.

GFRC has gained its application in dentistry and currently it has extensively been used in fixed-partial denture, endodontic post systems, and orthodontic fixed retainers. However, the authors could not find an exclusive updated review paper which covers the main aspects of reinforced glass fiber dental composites. Therefore, the purpose of this review is to organize this topic into its component parts and provide evidence-based principles that are sound from a dental perspective. The article focuses on peer-review only and critical analysis of this material is out of scope. The initial review began with a MEDLINE, Book Chapters, Conference/Symposium's proceedings, and PhD Thesis with in-vitro and clinical trial findings search for citations indexed from 1964 to 2014. The search was limited to dental, biomaterials and materials journals and all citations were collated and duplicates were discarded. Wherever possible the full texts of papers were obtained from the journals. Where it was not possible to obtain a particular journal, the abstracts, where available electronically were examined. Therefore the inclusion criteria for articles were: (i) glass fiber reinforced resin composites and their applications with respect to dentistry. We included laboratory based analysis, in-vitro and in-vivo testing with clinical trials on reinforced glass fiber dental restorative composites. (ii) All papers in a foreign language where an abstract in English was available. Literature

Table 1
Types of fibers and their properties.

Sr. no.	Fibers	Properties	References
1	Carbon/epoxy	Good fatigue and tensile strength and have increased modulus of elasticity, but they are not esthetically acceptable	[19,20]
2	Polyaramide	Cannot be easily cut or polished and there is difficulty in handling them	[21,22]
3	Ultra High Molecular Weight Polyethylene (UHMWPE)	Poor adhesion with the polymer matrix and thus do not give sufficient strength	[23,24]
4	Glass	Improved adhesion to the polymer matrix with better mechanical properties and also have good esthetic appearance	[12,25–29]