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Research Article

FIBER REINFORCED COMPOSITES IN PEDIATRIC DENTISTRY

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A B S T R A C T

The dental restorative materials have been the focus of a great deal of research in recent years with the goal of improving restoration performances by changing the initiation systems (composite), fillers (GIC) and by developing novel polymerization strategies (composites) etc.
Despite better understanding of the materials and chemistry, and recent improvements in physical properties, no material has been found that is ideal for any dental application. For example, silver amalgam has been used for dental restoration for more than a century; however, there has been a major concern about mercury toxicity from the amalgam restorations for many years. Another major issue is the color of amalgam for aesthetic considerations and alternative materials are being sought to replace. The composite restorative materials have promising aesthetics however these materials are very technique sensitive and mechanical properties are not as good as of amalgam. Restorative dentistry is constantly evolving as a result of innovative treatment solutions based on new materials, treatment techniques and technologies, with composite materials being a prime example.[1]
The advent of fibre reinforcement has further increased the potential uses of composites within restorative dentistry. Fiber-reinforced composites (FRCs) are composite materials with three different components: the matrix (continuous phase), the fibers (dispersed phase), and the zone in between (interphase). FRC materials present high stiffness and strength per weight when compared with other structural materials along with adequate toughness. The development of the fiber-reinforced composite technology has brought a new material into the realm of metal-free adhesive esthetic dentistry.[3]

INTRODUCTION

Dental caries is the most common chronic disease in childhood despite the fact that it is largely preventable. The caries may take a toll and may result in total destruction of the dental elements in cases like early childhood caries. The oral rehabilitation of these teeth is a great challenge for pediatric dentistry. Until very recently, the only treatment option for early childhood caries was extraction of the affected primary anterior tooth, which resulted in severe coronal destruction .

The early loss of primary anterior teeth may result in reduced masticatory efficiency, loss of vertical dimension, development of parafunctional habits (tongue thrusting, speech problems), esthetic functional problems such as malocclusion and space loss, and psychological problems that can interfere in the personality and behavioral development of the child.

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Pediatric restorative dentistry is a dynamic combination of ever improving materials and reliable techniques. Dentistry has rapidly developed during the last few decades, where variety innovative techniques have changed the conventional treatment methods as applications of new dental materials give better outcomes. Fiber reinforced composites(FRCs) is a promising class of material that gives clinicians alternative treatment options. The typical FRC materials are made up of polymer matrix that is reinforced by fine fibres and has wide variety of clinical applications.

Fiber reinforced composites (FRCs) have many clinical applications in dentistry because of the ability to manipulate the properties of composites to match with structural aspects. In addition the mechanical properties of FRC can be optimized to equal that of bone or dentin. This unique property has been tailored for dental needs by designing frameworks for crowns, anterior or posterior fixed prostheses, chair side tooth replacements, posts and appliances such as space maintainers, periodontal splints and orthodontic retainers.[4]

History

FRC materials is a group of materials which have been first time tested in 1960s but more extensively developed and clinically approved for dental use during the last 30 years. The first attempts to use fiber reinforcement in clinical dentistry began more than 35 years ago. In the 1960s and 1970s, investigators sought to reinforce standard polymethyl methacrylate dentures with glass or carbon fibers. In the 1980s, similar attempts were repeated, and initial efforts were made to fabricate fiber-reinforced prosthodontic frameworks for implants, fixed prosthodontics restorations, orthodontic retainers, and splints.[2]

Smith first introduced FRCs in the 1960s when glass fibers were used to reinforce polymethyl methacrylates. In the 1970s, carbon fibres were also used to reinforce acrylic resins and, in the 1980s, similar attempts were repeated. In the 1990s, FRCs were used tofabricate fixed prosthodontics restorations. Since then, there has been a steady increase in research into this interesting group of materials. It has been suggested recently that resinbonded, glass fibre-reinforced fixed partial dentures (FPDs) may be an alternative to resin-bonded FPDs with a cast metal framework. FRCs consists of reinforcing component provides stiffness and strength surrounding matrix supports the reinforcement and provides workability. The fibers most commonly employed in dental applications for reinforcement are polyethylene, glass, polypropylene, carbon or aramid. The matrix comprises of epoxy resin that maintains the position and orientation of the reinforcement and contributes rigidity and strength to a prostheses.

Fibre-reinforced composite restorations are resin-based restorations containing fibres aimed at enhancing their physical properties. This group of materials is a very heterogeneous one depending on the nature of the fibre, the geometrical arrangement of the fibres and the overlying resin used. The fibres within the composite matrix are ideally bonded to the resin via an adhesive interface.

The key factors which influence the physical properties of FRC structures are listed as follows

- Fibre loading (volumetric fraction) within the restoration;
- The efficacy of the bond at the fibre-resin interface;
- Fibre orientation relative to load;
- Fibre position in restoration[3]

Advantages and Disadvantages of FRCs

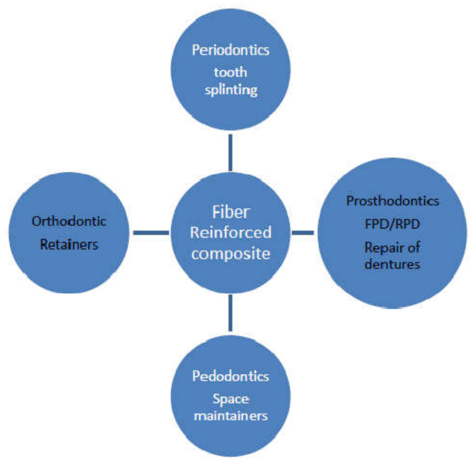
Advantages

- Lower treatment costs.
- Single visit immediate tooth replacements.
- Suitable for transitional and long-term provisional restorations.
- Readily repaired.
- Suitable for young patients (developing dentition) and elderly (time saving).
- Metal free restoration.
- Improved aesthetics.
- Can be produced in a simple manner in the laboratory without the need for waxing,
- investing and casting.
- Can frequently be used with minimal or no tooth preparation.
- Wear to opposing teeth much reduced in comparison to traditional metal-ceramic
- restorations.

Disadvantages

- Potential wear of the overlying veneering composite especially in patients with significantparafunction.
- May lack sufficient rigidity for long span bridges.
- Excellent moisture control required for adhesive technique.
- Space requirements are greater in posterior occlusal situations in comparison to metal
- occlusal surfaces (to allow sufficient room for fibres and adequate bulk for veneering
- composite overlay).
- Uncertain longevity in comparison to traditional techniques.[3]

The Clinical Applications of Fiber Reinforced Composites in All Specialties of Dentistry



Clinical Applications of Frc in Pediatric Dentistry

In paediatric dentistry FRCs can be used in almost all the fields as: restorations, space maintainers, splints, or other frameworks. The main difference is that the enamel of primary teeth is significantly different compared to permanent enamel. The differences have been mainly detected in composition, mechanical characteristics, bond strength, and clinical performance. However, the FRC devices used in paediatric dentistry showed acceptable clinical performance, durability, and ease of use.[7]

Clinical Use of Dental Frcs as Filling Resin Composites (Posterior Bulk Filling Material)

The current concept of using FRC in fillings is based on the bilayered composite system in which FRC base is made of discontinous fibers with length of the fibers exceeding the critical fiber length in the dimethacrylate polymer matrix. Fibers in the FRC increase toughness and other physical properties of the material compared to regular filling composites. Although it is known that protein and microbal adhesion of glass FRC does not considerably differ from that of particulate filler resin composites, the occlusal surface of the FRC is covered with more polishable and wear resistant particulate filler resin composite. The function of the FRC base for filling composites is to provide a crack propagation prevention layer for the restoration. The bilayered resin composite structure is considered as a biomimetic restoration system by mimicking the fibrous structure of dentin-enamel complex.[8]

Fiber-Reinforced Composite as A Post And Core Material In A Pediatric Dentistry

Management of fractured teeth have always presented a challenge to the dentists. The predictability of root canal therapy, as it is today, can retain almost indefinitely, even very badly broken teeth. Fiber reinforced composites(FRCs) is one such material which eliminate all the intermediate steps, and control is rendered in the hands of the dentists, to fabricate on the chair, a resilient, esthetic and bonded post and core.

A recently developed bondable reinforcement fiber, Ribbond, (Ribbond THM, Ribbond Inc., Seattle, WA) is reported to be an alternative to conventional post materials because of its aesthetic qualities, mechanical properties, and the neutral color of the reinforcing material. Ribbond allows it to adapt closely to the teeth and dental arch. This is an advantage over prefabricated fiber posts where adaptability to root canals is difficult. Apart from this feature the Ribbond can be condensed properly in the canals with little microleakage. The application of a fiber layer increases the load bearing capacity of the restoration and prevents crack propagation from the restoration to the tooth. When prefabricated fiber post is placed in flexure, cracks appear on the tensile face and due to brittleness of the material rapidly propagates causing failure.[10]

Fiber Reinforced Composite- Fixed Functional Space Maintainers

Premature loss of the primary teeth is a common occurrence in children. The safest way to prevent future malocclusions pertaining to early loss of a primary tooth is to place a space maintainer that is effective, durable and economical. Among the various space maintainers used in pediatric dentistry, band and loop is the most commonly used fixed space maintainer. However, the construction of band and loop requires three steps, it involves a clinician as well as a laboratory technician, and therefore it is expensive. With the advances in the technology and materials, there is a need to search for an alternative to overcome various disadvantages of the band and loop space maintainer.[12]

Fabrication of SMs with fiber reinforced composite (FRC) possesses the advantages of being easily manipulated and directly chair-side applied. Moreover, they are fixed, minimally invasive, aesthetic, readily repaired, reversible, biocompatible, and of relatively lower treatment costs. However, their longevity is still a controversial issue.

Polyethylene fiber-reinforced composite used as a fixed space maintainer offers many advantages. FRC has an aesthetic appearance, is easily manipulated, can be quickly inserted in a single-visit procedure that requires no laboratory services, poses no risk of damage to abutment teeth and is easy to clean.

Clinical Success of Frc as A Space Maintainer

Space maintainers made from FRCR material which are adhered to the surfaces of teeth have various advantages, such as biocompatibility, esthetics, ease of application, and fast preparation by the dentist or assistant in one appointment.

The FRCR space maintainers were fixed on primary teeth–primary teeth or primary teeth–permanent teeth. When such space maintainers are fixed on primary teeth, the prismless enamel surface structure of primary teeth may have negative effects on the retention of resin material. It has been stated in previous studies that space maintainers prepared similarly using fiber material are more stable when fixed on permanent teeth. The FRCR space maintainers were fixed on primary teeth–primary teeth or primary teeth–permanent teeth. When such space maintainers are fixed on primary teeth, the prismless enamel surface structure of primary teeth may have negative effects on the retention of resin material. It has been stated in previous studies that space maintainers prepared similarly using fiber material are more stable when fixed on permanent teeth.[14]

Anterior Fiber-Reinforced Ribbon Composite Resin Bridge

Different therapeutic options can be considered for the replacement of a congenitally or traumatically missing permanent incisor in young children and adolescents. The esthetic and functional rehabilitation of a missing anterior tooth is one of the greatest challenges that the dentist faces. The procedure becomes difficult when the missing tooth cannot be replaced by an implant-supported prosthesis or a conventional fixed dental prosthesis due to a local bony defect, inadequate volume of bone in the edentulous area, occlusal function, systemic disorders, or the socioeconomic status or unwillingness of the patient to experience invasive implant surgery or the preparation of natural teeth for retainers. The fiber reinforced composite resin FPD (FRCFPD) can be considered a viable alternative in such situations or in those in which conservative preparation is needed.[15]

Fiber reinforced composite resin FPD and resin bonded FPD can be considered conservative approaches for replacing missing anterior tooth in certain favourable clinical conditions. A common problem with metal ceramic resin bonded FPD has been the greyish discoloration of the incisal third of the abutment teeth due to cast metal lingual retainers and debonding of metal retainers from tooth if careful execution of bonding technique is not done. The fiber reinforced composite resin FPD require only preparation of palatal slots on the middle of the palatal/lingual surface. The retention of these FPD depends on the proper placement of fiber framework in the grooves and careful bonding procedure.

The incidences of debonding are less when fiber framework is properly placed in the grooves and bonding procedure is carefully executed. In addition to above-mentioned advantages, other advantages include completion of procedure in single appointment, low cost, and less invasiveness, and repairs can be carried out directly without the need for any complicated techniques or materials. Adjustments to the design, esthetic details, and occlusal relationships may bepreparation, advancement in bonding systems, and reported success suggest that this prosthesis can be used as a long term definitive alternative in situations similar to the case described.

Long term success depends on proper abutment selection, slot preparation, careful bonding technique, and type of occlusion. There should be no contact on the pontic, sufficient horizontal overlap, and minimum vertical overlap. This technique is simple, easy, and less time consuming than other approaches. It is an affordable and quick solution for the patients who reject more invasive treatments.

Future Aspects for the Research of Frcs

Use of FRCs in dentistry and medicine has now taken the first steps and the use is increasing rapidly.

New applications are tested due to versatile properties of FRC in terms of biomechanics, possibility to add biologically active compounds to the medical device structure and into the polymer matrix.[8]

The limitations of biodegradable implants and stem cell based tissue engineering approaches in cranial bone repair can be overcome by using glass FRC-BG implants. New applications for FRC will be found from orthopaedic and trauma surgery and spine surgery and in more specific dental fields including dental implantology.

New Features and Future Applications

Future research on FRCs needs to focus on many aspects such as optimization of the design of the frameworks in FRC devices, incorporation of bioactive minerals into the reinforced resin composites, and the change to fiber binding matrix from resin base to inorganic type.

Another improvement is related to nanotechnology, with the production of functional structures in the range of 0.1-100 nm by various physical or chemical methods. Dental nano composites provided a cosmetically acceptable result with excellent mechanical properties.

The main point involved with this new trend is the addition of nanofillers particles to resin-based dental materials. The utilization of continuous and discontinuous nanofillers has been proposed in conjunction with FRCs.

FRC utilization has been proposed also in combination with Computer-Aided-Design/Computer-Aided-Machining (CAD/CAM) technologies.

The interaction between the two technologies seems to be promising based on limited information.One other field where FRCs are starting to be utilized is implantology. Implant applications could benefit from certain biomechanical properties of FRCs, and the possibility of incorporating additional bioactive components into the implant structure may open new research fields.[7]

FRCs have been suggested for tissue engineering for orthopaedic scaffolds. As biocompatibility results are promising, FRC biomaterials developed may constitute an optimized alternative to the other materials used for the reconstruction of craniofacial bone defects.

The research options with FRC materials are open and future reports about the topic are expected to widen FRC utilization in both dental and medical fields.[7]

Limitations of the Use of Frcs

The main limitations of FRC clinical use are that, even though many in vitro studies have been conducted, research is still lacking regarding long-term clinical performance. The most important weakness of FRC is the interface between the fiber and the organic matrix. Intraoral hydrolysis and degradation weaken this interface and failure can occur. Maybe this might also be a reason for missing long-term results. Principal failure reasons of FRC devices are fracture and delamination but such events could be easily repaired with resin composite materials. Finally, the higher cost than unreinforced or metallic materials is a factor that has to be considered for a global evaluation of FRC employment.[12]

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