Review Article

The Evolution of Resin-Based Dental Materials/Composites: The Way Forward

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ABSTRACT

Composites have come a long way since replacement of silicates as the material of choice in restorative and esthetic dentistry. The qualities of the resin-based material have immensely increased in the context of bonding and curing mechanisms. Due to its esthetic qualities, the composite has left behind many restorative materials and become the number one choice in the field of esthetic dentistry. Still, a lot needs to be done to reduce the limitations of composites like expansion or shrinkage, optimization of composites according to amorphous calcium phosphate, incorporation of antibacterial properties in composites and enhancement of self-adhesive properties. Fortuitously, an ample amount of research is done in this area in recent years and as a result, an improvement of restorative properties is also seen. This article discusses the evolution of the resin-based composite, the recent advancements and the way forward to achieve better materials.

Key words: *Antimicrobial, Self-adhesive, Indirect composite, Nano-composite, Self-healing*

In the last 5 decades, the developments done in the field of composite in the context of bonding, filler and curing mechanisms were worth praising (Figure 1). Initially, for a very long time, the choice of material for filling cavities was silicates due to their ability to release fluoride and in turn, provide protection from dental caries. But as the evolution took place in the field of filling materials, the use of silicates has only been limited to deciduous teeth. After silicates, acrylics (Polymethylmethacrylate PMMA, used in denture materials) came to take their place. Acrylic was associated with various benefits like tooth-like or natural appearance, insolubility in oral fluids, ease of manipulation, and low cost. Regrettably, the acrylics did not last for a long time and lost the race of materials due to their excessive shrinkage causing further gaps between the cavity walls and hence, leakage. Their sensitivity to different temperature also played a big role in their failure.

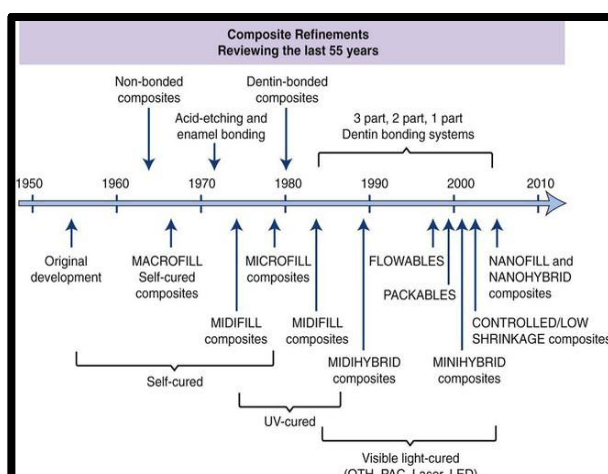

Figure 1: Developments done in the field of composite

Developments in technology related to bonding and restorations with increased esthetics have played a big role in making dental processes more pleasant and achievable [1]. Specifically, due to the esthetic reasons, resin-based composites (RBC's) are the number one choice when it comes to esthetic dentistry [2]. Being a multiphase material, the composite has both organic and inorganic properties and resulted in a material with superior qualities [3,4].

A significant improvement is seen in the last 5 decades since the inception of composites. In 1951, a Swiss chemist Oscar Hager came forward with the first dimethacrylate molecule. Later in 1962, Rafael Bowen came forward with a larger molecule, hydrophobic dimethacrylate monomer, popularly known as Bowen's resin. The basis of the present day composites is Bis-GMA due to its superior values over shrinkage and fracture resistance. Introduction of triethilene glycol dimethacrylate (TEGDMA), further reduced the viscosity limitations of Bowen's resin (viscosity of honey). Both of these monomers make cross-linkages between their double bonds on polymerization and hence increase the physical properties [5].

ADHESIVE TECHNOLOGY

Though, the discussion won't be complete if don't talk about the resin bonding while talking about resin-based composites. There is no doubt that the advancements in the evolution of composites never have reached such heights without the ability of the material to bind with tooth structure. As per definition, adhesive system or bonding agent is defined as the material that, when applied to a surface or substances, can join them together, resist separation, and transmit loads across the bond [6,7].

In 1955, Buonocore first showed that the resin-enamel bond strength increases when the enamel is etched with phosphoric acid [8]. John Gwinnett reported that adhesive resins could penetrate into acid-etched enamel prisms where they could envelop apatite crystallites rendering the acid-resistance [9]. The most important task of dental materials is to provide an equally effective bond between two different hard tissues. Nakabayashi et al. [10] demonstrated for the first time that resins can easily penetrate into the etched dentin to form a new structure which was named new biocomposite hybrid layer.

Nowadays, mostly adhesives are of two kinds, either etch-and-rinse or self-etch, and they are also quite different in interacting with the tooth [11]. Etch-and-rinse adhesives are the pioneers of the resin bond systems where the 3 step approach involves etching, application of primer and finally the application of the adhesive to tooth structure. In this process, etching leads to increased adhesive bonding by increasing the ability of resins to penetrate enamel and dentin [9]. In contrast, the Self-etch adhesives skip the extra-step of etching, as the application of conditioner and primer was done at the same time due to the presence of acidic monomers. This makes the self-etch system less prone to manual errors, less post operation sensitivity, more user-friendly and less technique sensitive. [12].

CURRENT TRENDS

Currently, resin-based composites being the material of choice in esthetic and restorative dentistry require balancing a large number of requirements. For a restorative purpose, a composite must possess excellent mechanical properties such as high strength, surface hardness, fracture toughness, low water absorption and solubility, low polymerization shrinkage, high radio-opacity etc. At the same time, biological properties and aesthetic considerations such as good biocompatibility, caries inhibiting abilities, color matching, color stability, long-term surface gloss and polishability have a higher input in the success of a resin-based composite restoration [13].

To achieve the above-mentioned properties, the evolution of resin-based composite has led to the following observations: (a) The size of the filler particles incorporated in the resin matrix has continuously decreased over the years [14]. The use of nanohybrid RBC's instead of traditional or microhybrid is evident because the fillers directly affect the mechanical properties and allow reduction of monomer content (polymerization shrinkage) enhancing aesthetics and handling. On the other hand, reduction in the filler size and subsequent increase in the surface area to volume ratio has limited the achievable filler loading, resulting in decreased handling and mechanical properties [14]. (b) Changes in monomer structure and use of newer monomers for resin-based composites which include dimer acid based monomers which help in reducing volume shrinkage during polymerization and in turn improves the structural stability of RBC's, Silorane based monomers have many desirable properties such as improved depth of cure, lower polymerization shrinkage, higher strength etc. when compared with conventional bis-GMA-based dental resins

[15,16] and TCD-urethane based monomers and Ormocers are also used in newer RBC's. (c) Modification of the dynamics of a polymerization reaction has also been introduced.

CONTEMPORARY USE OF RESIN-BASED COMPOSITES

Data indicates that greater than 80% of dentistry provided in a contemporary dental practice is attributed to pit and fissure caries [17]. Preventive resin restorations were introduced by Simonsen and play an important role in the practice of contemporary pediatric dentistry [18]. The overwhelming success of the preventive resin restoration makes it the treatment of choice for occlusal pit and fissure caries if the tooth can be adequately isolated [19].

Resin-based composite has been shown to be effective as a Class II restorative material in both the primary and permanent dentition. However, in the primary dentition, Class II resin composite restorations would be recommended for preparations that do not extend beyond the proximal line angles. Indirect resin restorations offer the advantages of more complete polymerization of the resin, alleviate stresses associated with resin polymerization shrinkage that occurs when direct resin restorations are placed and provide a highly aesthetic final restoration. Resin-based composites are an integral component of contemporary pediatric restorative dentistry. They can be utilized effectively for preventive resin restorations, moderate Class II restorations, Class III restorations, Class IV restorations, Class V restorations and strip crowns [20].

SHORTCOMINGS

Despite every effort to improve the properties of the resin-based composites, several clinical disadvantages are observed. Most of these shortcomings in the modern RBC's are usually associated with polymerization shrinkage stress. Although limited clinical evidence exists to support the relationship. While most of the mechanical, biological and aesthetic properties have been perfected, some of the shortcomings which need to be addressed are marginal discrepancies [21,22], debonding [23], secondary caries, marginal staining, white lines around the restoration, microleakage [24], postoperative pain and sensitivity. These discrepancies observed in the modern composites are a challenge for the ongoing research in the field of material science. Resin-based composites have come a long way, improving in every aspect of their properties and will continue to do so.

CONCLUSION

Composites have a bright and multi-directional future but few areas still exist where thorough research and development are needed. Out of many, few of the areas which need to be explored and require attention are search of a composite material which can resist change in shape i.e. expansion or shrinkage, optimization of composites needs to be done according to the amorphous calcium phosphate as, amorphous calcium phosphate is the direct precursor of hydroxyapatite, incorporation of antibacterial properties in composites and enhancement of self-adhesive properties of the material.

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