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Review Article

Fracture Strength of Root Filled Premolar Teeth Restored with Silorane and Methacrylate-Based Resin Composite

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Abstract

Introduction: Root canal treatment tends to weaken the crown as well as the root structure. The post endodontic restoration is also supposed to hold the indirect restoration provided to the tooth and hence should either be able to bond to the indirect restoration or be compatible to hold the indirect restoration when cemented on it. Adhesive restorations tend to increase the strength of the remaining tooth structure by micromechanical bonding. The preferred choice of restorative materials is composite resin.

Aim of study: This review aims at explaining the various modifications of composite resin and a comparison of fracture strength between silorane based composite resin to methacrylate based resin material.

Methodology: This review is a comprehensive research of google scholar and PUBMED from the year 1989 to 2020.

Conclusion: Restoration of root filled teeth is of utmost importance to increase the longevity of the remaining tooth structure whether or not the tooth is planned to get an indirect restoration. The advent of adhesive restorative materials helps in forming a micromechanical bond with the tooth thereby increasing the mechanical strength of the remaining tooth material. Due to the increased toxicity and volumetric shrinkage of methacrylate based resin material, a ring opening oxilane based monomer, Silorane has been used in the recent times. Silorane has a decreased polymerization shrinkage and better marginal integrity as compared to methacrylate based resin, but within the limitation of this review, no significant difference was seen in fracture strength of silorane and methacrylate based resin material.

Keywords: *Oxiranes; Siloranes; Alkoxides; Ormocers; Volumetric Shrinkage*

Introduction

After performing a Root canal treatment on a tooth, the inherent strength of the tooth becomes less. Root canal treatment tends to weaken the crown as well as the root structure. Removal of the carious lesion leading to a root canal followed by access cavity that is prepared to gain access to the canals tends to remove a large amount of the coronal portion of the tooth leading to weakening of the tooth structure thereby being an important factor in causing tooth fracture. Removal of the hard tissue causes a decrease in the strength of the remaining tooth structure by around 60%, the defection in the cusps increases thereby leading to fracture [1]. The irrigants used for cleaning of the canals, and the extent upto which the bio-mechanical preparation of the roots has been done also causes weakening

of the tooth structure. During the course of time, many researchers have tried to solve the weakening of endodontically treated tooth by using adhesive restoration that decreases cusp defection, covering the cusps with indirect restoration which converts the lateral forces into vertical forces thus reducing the force on the remaining tooth structure. Indirect restoration is the most preferred treatment option for restoring the endodontically treated teeth [2].

The restorative material used after endodontic treatment has to mimic the tooth both structurally and functionally. The missing tooth structure is substituted by the restorative material structurally, and the masticatory forces have to be borne by the restorative material functionally. The post endodontic restoration is also supposed to hold the indirect restoration provided to the tooth and hence should either be able to bond to the indirect restoration or be compatible to hold the indirect restoration when cemented on it. Teeth with restorations have higher chances of fracture under extreme mechanical forces, increased stress and fatigue as compared to natural teeth. Factors that contribute to the decreased strength are the design of the cavity, amount of healthy and carious tooth structure that is removed while excavating the caries and the kind of restorative material that has been used [3].

Although, failure of restored teeth is of utmost importance, failure of the restoration that is placed is also equally important. Fracture of the restorative material generally includes only sub critical fractures like chipping and indents on the tooth. Fracture of the restoration generally accompanies fracture of parts of natural teeth contributing to tooth loss as one of the major causes together with caries and periodontal issues [4]. The choice between a direct adhesive restoration and an indirect restoration is dependent on a lot of factors like cost, time and how complex the treatment can get. Indirect restoration are more invasive and time consuming as they involve multiple visits for the patient and involvement of external lab and technician thus making the treatment more technique sensitive. In order to accommodate the crown or any other cusp covering restoration, a huge amount of healthy tooth is compromised and hence the volume of natural tooth decreases which weakens the tooth structure [5].

Various studies have shown us that compromising even small amount of healthy tooth structure reduces the overall fracture resistance and strength of the tooth and hence preference should always be given to non-invasive procedures which includes adhesive restorations of various kinds [6]. Even if indirect restorations are being used for the patient, the foundation for indirect restoration is adhesive restorations like composite resin, Glass ionomer cement and amalgam restorations. Whenever an esthetic rehabilitation is required, composite resin is the choice of material due to increased translucency and strength. GIC has also shown similar strength as compared to composite resin but it has been seen that the GIC restoration deteriorates over time and hence can be used as only a temporary core build up material [7]. Various modifications are being made continuously in the composite resin that is available in the market to increase the strength, esthetic and functionality of the resin.

The aim of this review is to compare the fracture strength of endodontically treated premolars that are restored with methacrylate and silorane based composite resins.

Modifications in composite resin

Attempts are being made continuously to modify composite resin in order to achieve a perfect restorative material. Various researchers have modified composite resin by either modifying the monomer, polymer or addition of other chemicals in order to increase the strength and esthetics of composite resin. In a study conducted by Daher., *et al.* [8] they used fiber rings and wrapped them around the buccal and lingual walls of the tooth structure (Figure 1) and as a cross inside the tooth cavity (Figure 2) in large MOD cavities to increase the strength of the remaining tooth structure. They concluded that the stress at cervical level of the tooth was highest in teeth with no restoration and lowest cusp deflection and cervical fracture stress was seen in teeth with the fiber ring which was similar to intact tooth [8]. This technique could be used in normal day to day practice to restore endodontically treated tooth to increase the fracture strength and reduce the cusp deflection without compromising any healthy tooth structure.

Figure 1: *Proximal and Occlusal View After Applying the Fiber Ring on the Buccal and Lingual Walls [8].*

Figure 2: *Fiber Ring Attached to Buccal and Lingual Wall and then Crossed Like an X Inside the Cavity Walls [8].*

Ormocer

Ormocers are a newly developed type of composite resin present since 1991. Ormocer uses filler particles entangled in a new matrix technology. The components of ormocer includes a polymerizable group which helps in functionalizing alkoxy silane group which in turn acts as an initiator. The initiator polymerizes with the polymerisable group which is then followed by hydrolysis and condensation leading to a nanostructure formed of Si-O-Si oligomeric structure [9]. In ormocers, various other alkoxides can also be added either with the silane alkoxide or independently like the metal alkoxide such as aluminium, zirconia and titanium. The main concept of adding the oligomers is the replacement of monomers in the conventional composite resin material and forming a 3-Dimeansional network through polymerization. The main advantages of Ormocers are discussed in table 1.

Advantages of Ormocers
1. Decrease in Polymerization Shrinkage
2. Increase in the wear resistance of the material
3. Increased Biocompatibilty
4. Decreased micro leakage at the margins of the restoration

Table 1: *Advantages of Ormocers [9].*

With the advent of new dental materials and developments in the field of nanotechnology, it has become easier to develop dental materials that combine the advantage of high mechanical strength with high polishing capability, one of the main examples for this is nanotechnology based composite material. Nanotechnology is the science of producing particles in the range of 0.1 to 100 nanometers using chemical as well as physical methods. Nanoparticles are used in filler materials as in Filtek Supreme (3M ESPE) where silica nanofillers of the size 5-20nm were used. The filler particles consist of both nanoparticles and nanoclusters in which the former has particles that are not agglomerated or aggregated and are smaller than the wavelength of visible light, this property helps in giving extreme polishability and gloss to the restorative material. Nano clusters are aggregated and agglomerated particles and their main function is to provide higher loading of filler particles and increased strength thereby increasing the wear resistance [10].

Silorane based resin materials

Silorane based composite materials are based on the ring opening system like the one used in oxirane based resin (Figure 3). These are cured by visible light. The advantages of oxirane based materials are discussed in table 2. The main disadvantage of methacrylate based composite resin was the release of toxic materials from the monomer upon polymerizing. This led to the development of ring opening systems, though their toxicity and mutagenicity is also being studied for further evaluation and developments are being made to increase the biocompatibility of this system [11].

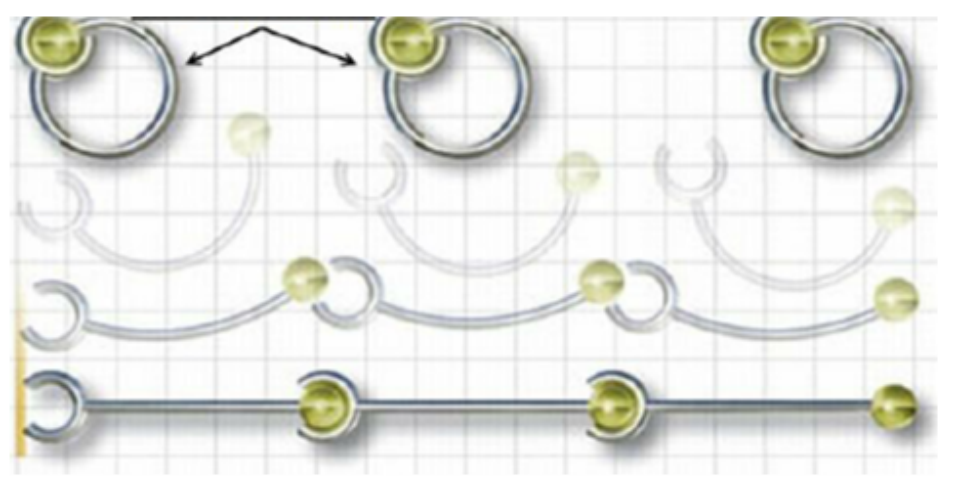

Figure 3: *Ring Opening System Where the Polymerization Occurs by the Opening of Ring Which Helps in Decreasing the Polymerization Shrinkage [16].*

	Advantages of oxirane based composite resin
1.	Increased curing depth
2.	Decreased polymerization shrinkage
3.	Increased strength
4.	Decreased polymerization shrinkage
5.	The glass transition temperature is more acceptable than conventional composite resin
6.	Decreased toxicity and mutagenicity compared to conventional composite resin

Table 2: *Advantages of Oxirane based resin [12].*

Silorane based monomer system was described by Weinmann., *et al* in the year 2005 where siloxane molecules were made to react with oxirane molecules. The siloxane molecules contributes to the hydrophobic nature of silorane while oxirane helps in increasing the resistance to polymerization shrinkage due to the ring opening mechanism [11,13]. Silorane molecules prove to have a decreased toxicity and mutagenicity as compared to methacrylate based composite resin. In a study conducted by Eick., *et al.* [14] they explained that the solubility of siloranes was much lower and it had more stability in biological fluid as compared to methacrylate based resin. The biological fluid used in the test was simulated by the help of dilute form of hydrochloric acid or porcine liver esterase [14]. These advantages of silorane based composite have been well researched thereby establishing it as a more biocompatible material as compared to composite resin [15].

Properties of silorane based composite resin as compared to methacrylate based resin

In a study conducted by Lien., *et al.* [17] they compared the basic physical properties of silorane based composite with the conventional methacrylate resin and other modified composite materials. The compressive strength ranked in the order that composite resin with nano sized filler particles showed the highest compressive strength followed by compomers and microhybrid composite, silorane had the lowest compressive strength. Flexural strength of silorane (Filtek LS) was comparable to Filtek Z250 (3M ESPE) and was very high as compared to the micrhybrid composite. The modulus of flexure was highest in the giomer group but not significantly different from the silorane group. Fracture toughness of all the composite materials were not significantly different with the exception of the compomer group. When volumetric shrinkage was compared the silorane group had the lowest volumetric shrinkage followed by Filtek Z250 which was the nano filler group.

The increased compressive strength of the methacrylate based composite resin could be attributed to the large filler particles [16]. The increased flexural strength of the silorane group as compared to methacrylate group could be used as an advantage when the material is used for cervical caries and is subjected to cervical forces of mastication.

Fracture strength of silorane based composite resin

Fracture strength is often described as the amount of strength required by a material to resist any propagation of an existing flaw or fracture. The Griffith energy balance concept tells us that when there is propagating crack present in a material, the growth of that crack absorbs the strain energy which has been released from the materials surrounding the crack [18]. So a fracture is seen in a material when the strain energy attains a peak value and the crack present in the material starts to self-propagate. The fracture toughness depends on an optimal proportion of filler size to particle size. Taha., *et al.* used cyclic loading and figred that it impacted the fracture resistance negatively, but for the sole purpose of comparing the two materials rampant loading leading to fatigue and failure was used [19]. Another study conducted by Taha., *et al* [20] where they compared endodontically treated premolar teeth for fracture strength concluded that the size of the cavity greatly affected the fracture strength of the material. The unrestored teeth after root filling were found to be the weakest

as compared to both groups of restorative material. The increased strength of the groups restored with composite resin was attributed to the adhesive nature of the filling materials that made a micromechanical bond with the dentine helping in distribution of the force across the tooth surface thereby reinforcing the remaining tooth structure [21]. A lot of studies have shown that the strength of silorane based composite material was almost similar to or not significantly different from that of an intact tooth [21].

Silorane based composite group showed reduced polymerization shrinkage and higher resistance to micro leakage with better adaptation at the margins of the restoration and a decrease in cuspal deflection as compared to methacrylate based composite resin, the fracture strength, though was not found to be superior to methacrylate based resin as per Taha., *et al.* [20] In a study conducted by Akbarian., *et al.* [22], he discovered that Filtek P60 that is a methacrylate based resin and Filtek P90 that is a silorane based resin showed almost the same fracture strength when used to fill root filled upper premolar teeth as a post endodontic restorative material. The increased resistance to polymerization shrinkage or increased marginal adaptation are not the sole factors to determine the deflection of cusps thereby not affecting the fracture strength. Another study conducted by Isaac., *et al.* [24] concluded that the bond strength of methacrylate and silorane based composite when used to fill cavities with high C-factor gave almost the same value. In a randomized control trial silorane based composite was compared to nanohybrid composite to study the marginal adaptability and discovered that silorane was inferior to nanohybrid composite [25]. More research like clinical trials, and finite element analysis etc are required to get a better picture of comparison of fracture strength of methacrylate based resin compared to Silorane based resin composite.

Conclusion

Restoration of root filled teeth is of utmost importance to increase the longevity of the remaining tooth structure whether or not the tooth is planned to get an indirect restoration. The advent of adhesive restorative materials helps in forming a micromechanical bond with the tooth thereby increasing the mechanical strength of the remaining tooth material. Due to the increased toxicity and volumetric shrinkage of methacrylate based resin material, a ring opening oxirane based monomer, Silorane has been used in the recent times. Silorane has a decreased polymerization shrinkage and better marginal integrity as compared to methacrylate based resin, but within the limitation of this review, no significant difference was seen in fracture strength of silorane and methacrylate based resin material.

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