International Journal on Oral Health

Biomimetic Approach in Tooth Conservation and Fracture Resistance: A Short Descriptive Review of Current Biomaterials and Techniques

Mini Review

Volume 2 Issue 1- 2022

Author Details

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Article History

Received: June 23, 2022 Accepted: June 23, 2022 Published: June 28, 2022

Abstract

Background: New concepts such as biomimetic dentistry, minimally invasive approach, and the understanding of tooth biomechanics have changed the paradigm on how teeth need to be restored. The emergence of new biomaterials has allowed to improve bonding capacity, as well as the ability to reduce loading stress transmitted to the remaining tooth structure, making it possible to extend the life of a restoration and give the compromised tooth a second chance. To date, several studies have demonstrated the fracture resistance under uniaxial loading of restored Class II mesial-occlusal-distal (MOD) dental cavities in posterior teeth using different restorative biomaterials; however, many of those materials have not yet been compared with each other regarding fracture resistance.

Objectives: A literature review was undertaken to revise current research focusing on the fracture resistance of MOD cavity preparations restored with different filling techniques, including microhybrid and nanohybrid composite resin, short discontinuous fiberglass reinforced composite resin, long continuous polyethylene fiber, fiberglass reinforced net, and the combination of these materials.

Conclusion: This literature review offers information regarding currently used restorative biomaterials' fracture resistance in restored MOD teeth. Most studies were conducted in vitro, demonstrating that fracture resistance under uniaxial load was higher in MOD cavity preparations restored with a combination of polyethylene fibers and composite resin (nanohybrid), followed by a combination of fiberglass and composite resin (nanohybrid). The reviewed information also revealed that the use of composite resin as a single material has the lowest fracture resistance and the highest percentage of catastrophic failures. Given the limited information regarding the combination of these biomaterials in a clinical setting it is suggested to perform controlled clinical trials by using the proposed combinations to demonstrate their clinical relevance and success ratio. Nonetheless, initial data suggests that a biomimetic restorative approach using biomaterials that connect and replace the missing tooth structure and redistribute biologically the loading stress may have a positive impact in terms of tooth preservation in MOD cavities.

Keywords: Biomimetic restorative dentistry; Fracture resistance; Fracture patterns; Reinforced composite

Abbreviations: MOD: Mesial-Occlusal-Distal; LFRC: Long Fiberglass Reinforced Composite; SIPN: Semi-Interpenetrating Polymer Network; DEJ: Dentino-Enamel Junction; SEM: Scanning Electron Microscopy; PFC: Particulate Filler Composite; UHMW: Ultra-High-Molecular-Weight

Introduction

Restorative dentistry is the discipline that uses different biomaterials to replace lost tooth structure due to dental caries, trauma, or genetic tooth alterations [1]. The biomimetic approach, which refers to a holistic view of how to preserve natural dental tissue and replace missing tooth structure by using concepts and knowledge involving biomechanics, biomaterials, and biology, is one novel philosophy for restoring compromised teeth that has emerged [2]. In general terms, the main goal is to restore damaged teeth by using materials that mimic to some extent the original nature and biomechanical properties of natural teeth, while providing an adequate strength, appearance, and physiological function [3].

Some of the advantages of the biomimetic approach are the possibility of using a minimally invasive technique, use of biomaterials that resemble some properties of the missing tooth structure, utilizing adhesive techniques, and preservation of more natural teeth [4]. However, as every technique that requires the replacement of tissues by biomaterials there are some drawbacks that can impair the success of the restorations including the inability to interact with native cells and mechanical compatibility issues [5].

Most of the current techniques in restorative dentistry rely on the adhesive capacity of a bonding agent, which allows the biomaterials to be retained micromechanically to the tooth structure after a preconditioning of the enamel to increase the porosity in case of a selective etching or exposure of peritubular collagen in case of a total etching [6]. The mechanical bond is formed when the bonding agent is put over the etched surface which allows it to penetrate into the microscopic pores of the tooth surface creating resin tags that lock into the tooth. The bonding agent then forms a physicochemical bond which further aids the adhesion of composite resin to the enamel by increasing the wettability and surface area with other resin placed on top of it such as a composite resin. Some in vitro studies have demonstrated that the two bottles fourth generation adhesive systems in combination with selective etch-and-rinse have shown the highest bonding strength with the tooth structure [6].

To restore affected teeth, composite resins have been recommended as one alternative to replace the missing tooth tissues and provide an adequate aesthetic and function. They are a popular choice due to their low cost, good aesthetics, easy manipulation, and favourable wear resistance [7].

Even though polymerization shrinkage and secondary caries are major issues for composites [8], the main cause of restoration failure of posterior teeth are catastrophic fractures [9]. Previous research has demonstrated that conventional particulate-filled composite resin has inadequate resistance to fractures when placed in high stress bearing areas, such as the mesial-occlusal-distal (MOD) restorations of posterior teeth [10]. To address this issue, new biomaterials and techniques have been proposed, such as the use of microhybrid and nanohybrid composites, short discontinuous fiberglass reinforced composites, long continuous polyethylene fibers, and combinations of these materials. This provides coupling of the restorative materials with the remaining tooth structure, which has been hypothesised to more efficiently redistribute the stress and loads that restored teeth receive. In this short review our group will describe some of the new biomaterials and techniques that are currently being used in the biomimetic approach to redistribute loading stress over restored MOD cavities.

Microhybrid/Nanohybrid Composites

Fracture Resistance

One of the main material compositions that provide fracture resistance is composite fillers. In those terms, various composites have been developed to improve this property. Two examples of composites that are currently being used in posterior areas are the microhybrid and nanohybrid composites.

Microhybrid composite refers to the combination of 0.4-1 μm glass, zirconia, or ceramic filler particles with smaller 0.04 μm amorphous silica particles [11]. In addition, the filler load of microhybrid composite has been recommended to exceed a minimum filler load of at least 60% of volume [12]. With varying filler load by volume seen in microhybrid composites, having higher filler content as well as lower resin content and filler size, produces desirable mechanical properties such as increased material strength [13,14].

Another composite resin that has gained popularity is the nanohybrid composite, which is a combination of glass particles, colloidal silica (0.04 μm), and nano-sized particles (mean size of less than 1 μm). This decrease in size allows for a greater filler load; thus, increasing the fracture resistance under compressive load [15].

In an in vitro study performed in MOD cavity preparations comparing microhybrid with nanohybrid composites, it was demonstrated that the fracture resistance of nanohybrid composite was higher than the microhybrid composite when placed under uniaxial load [15]. The authors discussed that this effect might be because microhybrid composites have larger particle sizes and a lower percentage of filler particles than nanohybrid composites, resulting in early crack propagation and decreased fracture resistance [16].

Preventing Fractures

An in vitro study showed that restoring a MOD cavity on endodontically treated molars with microhybrid composite resin had statistically higher fracture resistance compared to restoring the molars with a flowable composite material [17]. Another in vitro study performed in maxillary central incisors showed that restorations using nanohybrid composite exhibited no significant difference in fracture resistance compared to restorations filled with microhybrid composite alone [18]. However, when the microhybrid composite was reinforced with polyethylene fiber to restore the incisal edge of fractured maxillary central incisors, the fracture resistance was demonstrated to significantly increase when compared to restorations filled with nanohybrid and microhybrid composite alone [18]. This may be due to the stress applied to the restored teeth being transferred from the weak polymer matrix to a high strength fiber, such as polyethylene fibers, which are woven in alternating patterns, and are capable of dissipating the loading stress more efficiently [19].

Fracture Patterns

Upon assessing the compressive strength and fracture resistance of microhybrid composites (G-Premio Bond and G-aenial Posterior) in large Class II MO cavities, fracture patterns are either described as being favourable or unfavourable if they are above or below the cemento-enamel-junction CEJ [20]. Despite fracturing, teeth with favourable fractures can still be restored using techniques such as post and core followed by a full crown [21]. While certain studies demonstrated favourable fractures, microhybrid composite have also been described by others to produce 80% of unfavourable fractures [20].

Nanohybrid composites on the other hand, have been shown to produce 65% of unfavourable fracture patterns in restored MOD premolar cavities [22]. The unfavourable fractures were suggested to have been the result of resins having poor mechanical properties [22]. The accumulated data of the presented studies concluded that both microhybrid and nanohybrid composites display significant rates of unfavourable fractures.

Fiberglass Reinforced Composites

Fracture Resistance

In general terms there are two major groups of fiberglass used in restorative dentistry, which are categorized based on their microgeometry and include long continuous fibers and short discontinuous fibers [23]. Fiberglass reinforced composites have high tensile strength with low extensibility, and it has a transparent appearance [24]. Short fiberglass reinforced composite (SFRC) provides reinforcement in three different space directions including the X, Y, and Z axes, whereas long fiberglass reinforced composite (LFRC) provides reinforcement in two directions, the X and Y axes [20]. Fiberglass can be placed occlusally or proximally to restore MOD cavities, however, the location does not influence the tooth's resistance to fracture [25]. An example of short fiber-reinforced composite resin material is known as EverX, which was introduced in 2013, while [26] EverStick, a pre-impregnated E-glass FRC, is an example of a long continuous FRC [27].

The long continuous fibers have a semi-interpenetrating polymer network (SIPN) structure, which clinically leads to superior bonding properties due to the polymer matrix's ability to dissolve partially in the bonding resin [27]. Short fiber-reinforced composite resin adds discontinuous short fiberglass between 0.3 and 1.9 mm in length that increases the resistance to the propagation of cracks and load bearing [14]. The properties of this material offer an exceptional way to replace the missing dentine structure by mimicking to some extent its structural properties [20]. In vitro studies have shown that teeth restored with fiber-reinforced composite cores have greater fracture resistance and have favourable fracture patterns when a fracture is produced under continuous load [28]. These studies suggest that the underlying fiber-reinforced composite core acts as a crack-preventing layer that distributes the applied loads more efficiently in different directions in the restored tooth [1].

Preventing Fractures

The addition of fiberglass in composite restorations has demonstrated to drastically increase the fracture resistance of endodontically treated molars [29]. Fiberglass works by distributing stress throughout the tooth-restoration interface and supports the weakened tooth structure by serving as a crack-preventing layer [29]. Moreover, it can modify the material's elastic modulus and allows the stresses to be transmitted evenly to the residual cavity walls [20].

The SFRC helps to absorb the loading stress that is usually absorbed by the dentino-enamel junction (DEJ), which has an important role in absorbing stresses experienced by the tooth during mechanical load, hence preventing crack propagation in a natural intact tooth [1]. Additionally, this biomaterial displays reduced polymerization stress and improved mechanical properties compared to conventional composites [1]. In accordance with this idea, a previous in vitro study of teeth restored with SFRC demonstrated their higher load bearing capacity and fracture toughness compared to teeth restored with composite [1]. This outcome was attributed to the low elastic modulus of the SFRC, which is believed to absorb and dissipate stress via the non-homogenous distribution of fiberglass.

Fracture Patterns

In class II MOD cavities of molars restored with SFRC it has been demonstrated to have an increased fracture resistance when compared to molars restored with conventional composites, however, the same publication showed that these materials had less resistance than intact controls [1]. In deeper (5 mm) Class II MOD cavities, fracture patterns are reported to be influenced by the restoration technique [20]. Restorations with SFRC in a bulk-fill technique produced the greatest rates of favourable fractures when compared to cavities restored with microhybrid composite applied in an oblique incremental technique [20].

In the case of endodontically treated teeth, the fiberglass material did not prevent unfavourable fractures in maxillary premolars [30]. A similar result was demonstrated by examining the fracture resistance and failure patterns of endodontically treated mandibular first molars restored with fiberglass reinforced composite [29]. Using fractographic analysis with combined stereo and scanning electron microscopy (SEM), fiberglass was shown to partially interrupt fracture propagation, leading the authors to conclude that the addition of fiberglass could not prevent catastrophic fractures [29].

Layering particulate filler composite (PFC) in varying thickness over a FRC core produces increasingly more favourable fracture patterns as PFC thickness decreases [31]. In the absence of FRC, the fracture pattern exhibits catastrophic fractures and cracking, indicating that the presence of the FRC leads to favourable fracture patterns [31].

Polyethylene Fibers

Fracture Resistance

Polyethylene fibers such as Ribbond consist of polyethylene fibers arranged in a cross-linked Leno weave that helps to maintain its structural integrity [32]. Polyethylene fibers, which have a low elastic modulus, are highly adhesive to restorative materials, including chemically cured or light-cured composite resin [33]. The cusps may have bonded together thus the bonding ability of the polyethylene fiber in combination with bonding agent and flowable composite is also responsible for increased fracture resistance [34]. Polyethylene woven fiber is made from aligned polymer chains and is one of the most durable reinforcing fibers available. It is highly aesthetic, has a high degree of flexibility, and is thin but strong, thus it has been suggested that it can be used to reinforce composite resin in large restorations [34]. The use of polyethylene fiber in a restoration's occlusion third of the tooth has resulted in even greater fracture resistance [34], and in addition it has been demonstrated that its use under MOD composite restorations have shown a significant increase in fracture resistance [33].

Preventing Fracture

Previous in vitro research has demonstrated that using polyethylene fibers into a thin layer of flowable composite resin can increase the resistance to loading stress by absorbing and redistributing the applied forces of the restored teeth [20]. Polyethylene fibers have been suggested to increase the modulus of elasticity, impact strength, and flexural strength when applied in conjunction with composite resins [20]. This combination of materials increases fracture resistance due to its modifying effect on stress along the tooth-restoration interface [30] because it offers a low modulus of elasticity combined with an interwoven structure that can redirect and redistribute loading stress over a larger tooth area, which ultimately, reduces the chances of fractures [35,36]. Another study reported that the use of polyethylene ribbon fiber under microhybrid composite restorations in root filled teeth with MOD preparations significantly increased fracture strength by preventing crack propagation and withstand forces at the tooth-restoration interface thanks to its elastic modulus being close to that of dentine, which allows stress to be distributed more evenly into a wider area [35].

Fracture Patterns

Most teeth (80-100%) restored with polyethylene fiber in Class II MOD cavities have demonstrated favourable fracture patterns, compared to teeth restored without polyethylene fibers that had dramatically fewer teeth (10%) with favourable fracture patterns [37]. This suggests that MOD cavities restored with polyethylene fibers can improve the fracture patterns towards a more favourable condition.

Material Combinations

Composite and Polyethylene Fiber combination

8.1.1. Fracture resistance: Investigations made in MOD cavities have demonstrated that when uniaxial load is applied in teeth restored with a combination of polyethylene fiber (i.e. Ribbond) with conventional particulate-filled composite resin it may lead to superior fracture resistance [20]. The fracture resistance of this combination was also demonstrated to be superior to a combination including SFRC, specifically EverX posterior [20]. The use of polyethylene fiber within MOD composite restorations increased fracture strength significantly. The fracture resistance was significantly higher when the fiber was placed occlusally in the buccal to lingual direction [33]. The combination of polyethylene fibers (i.e. Ribbond) with fiberglass net (i.e. Everstick NET) embedded together within Class II MOD cavities restored with microhybrid composite produced greater fracture resistance than microhybrid composite alone, and was not statistically different from those of intact teeth [20]. Interestingly, fracture resistance values were not statistically different regardless of the position of the combination within the restoration (bottom of cavity versus 2 mm below occlusal surface) [20]. Moreover, in root-filled premolars with Class II MOD cavities, embedding polyethylene fiber into flowable composite resin increased fracture resistance compared to teeth restored with composite resin only, providing further support for the reinforcing effect of polyethylene fibers [38].

Preventing fracture: It is believed that the dense aggregation of linkages between fibers in multiple directions helps to transfer stress more efficiently along the material [37]. This suggests a lower elastic modulus, which helps to provide a stress-absorbing layer that resists fractures when ribbond is inserted into a flowable composite resins [32,39]. Furthermore, the Ribbond fibers are woven with the lock-stitch leno weave, which prevents fiber slipping within the composite resin matrix and prevents micro-cracks from propagating [21]. An in vitro study found that inserting a piece of ultra-high-molecular-weight (UHMW) polyethylene fiber ribbon from buccal to lingual direction under composite resin restoration increased fracture strength significantly [36]. The presence of the UHMW polyethylene fiber network would alter the stress dynamics at the restoration and adhesive resin interface by supplying multiple stress-paths along the fibers for redistribution of imposed load to intact portions of the teeth and away from the bonded surfaces [36].

Fracture patterns: While the combination of polyethylene fibers and conventional composite in a splint configuration produces the greatest fracture resistance, the very same combination results in the greatest rate of unfavourable fractures [20]. The rate of unfavourable fractures (80%) was comparable to restorations placed using only conventional particulate-filled microhybrid composite resin, whereas 90% of fractured intact teeth had favourable fracture patterns [20].

Composite and Short Fiber Reinforced Composite Combination

Fracture resistance: The in vitro restoration of Class II MOD cavities with EverX combined with a 2 mm occlusal layer of conventional composite has been reported to yield superior fracture resistance when compared to a cavity restored with consecutive 2 mm thick oblique increments of packable composite resin [40]. This finding shows that regardless of whether EverX was applied in bulk or in 2 mm increments, it still provides superior resistance [40]. However, other studies following a similar application of EverX below an occlusal layer of conventional composite reported greater mean values for fracture resistance when compared to restorations with conventional composite only; nonetheless, they did not find statistical differences [1,20].

Preventing fracture: In addition to superior fracture resistance, EverX can withstand a greater fatigue load, and therefore, is recommended for use in high stress restorations areas such as MOD cavities [41]. The improved fracture resistance may be attributed to the millimeter-scale of the short fiber structure of EverX. Another observation was that an increased bond durability with universal adhesives may also account for the improved performance of EverX over particulate-filled composites [42]. When these restored cavities are subjected to high loads, these fibers can undergo a stress modifying effect in which they absorb and redistribute the forces applied to the tooth, which is made possible by the bond formed between the dentine and the composite resin restorative material [43].

Fracture patterns: After comparing various combinations of restorative materials, including conventional particulate-filled composite (specifically G-aenial Posterior), short fiber-reinforced composite (specifically EverX Posterior), and fiberglass net, the authors report that bulk-fill restorations with EverX Posterior occlusally layered with 2 mm of conventional composite produced the greatest rate of favourable fractures than other combinations [20]. These findings are similar with those of another study reporting that application of EverX via an oblique layering technique occlusally layered with 1 mm of conventional composite produces more favourable fracture patterns than EverX applied in a horizontal incremental technique in which composite was placed in two consecutive maximum 2 mm thick horizontal layers [1]. Taken together, these findings suggest that when restorations do fracture, short fiber-reinforced composites, specifically EverX with composite resin, produces more favourable fracture patterns than conventional particulate-filled composites.

Discussion

With the advent of adhesive technologies and biomaterials that are more biocompatible with the tooth structure it has been also possible to change the philosophies with which a dentist can rehabilitate compromised teeth. Biomimetic dentistry attempts to preserve non-affected/intact tooth structure while re-establishing the function, aesthetics, and biomechanics of teeth. Restorations need to be able to spread the occlusal force to reinforce a weakened tooth structure, which ultimately prevents unnecessary extractions and increases the possibility of saving the natural teeth.

Traditionally in modern operative dentistry, teeth affected by different pathological conditions are restored with resin composites using a direct clinical approach. Composites with small filler particles have demonstrated to be a reliable material for the restoration of posterior teeth. Particularly, this review illustrated that in vitro studies have shown that nanohybrid composite resin had greater fracture resistance (1659.93 N) when compared to microhybrid composite resin (1450.40 N), but it is less resistant when compared to restorations that include SFRC (1890.93 N) (i.e., EverX posterior) [16]. This investigation suggests that the incorporation of fiberglass may increase the strength of a restoration and therefore its fracture resistance. Teeth restored with SFRC might present an elastic modulus that is similar to that of dentin [20] and will allow the restored tooth to prevent crack propagation by absorbing and distributing stress evenly throughout the tooth-restoration interface [36].

In extensive direct restorations, low fracture resistance is a problem because the restorative material may experience volumetric expansion, which could ultimately explain why teeth restored with microhybrid composite resin had predominantly unfavourable fractures [20]. Nanohybrid composites, on the other hand, perform better than microhybrid composites due to their dense filler loading and because of their small filler size [21]. However, because composite resins tend to have a brittle nature, they are not commonly used for extensive restorations where indirect techniques are preferred. Indirect restorations made of various dental materials (i.e. ceramics or metals) provide additional protection, allowing the restorations to withstand the force of mastication for longer periods of time before needing replacement. Nonetheless, to provide additional protection and increase the restoration's fracture resistance a direct restoration would be required, it is possible to add different materials including fiberglass, polyethylene fibers or a combination of them. Fiber reinforcement has been shown to improve the strength and toughness of composite resins [21]. As demonstrated in an in vitro investigation, placing fibers on the occlusal surface of maxillary premolars helps to keep the buccal and lingual cusps connected, and helps to protect the natural cusps from loading separation, resulting in increased fracture resistance [21].

When used in combination with composite resin, polyethylene fibers work as a stress absorber due to its low elastic modulus, allowing it to be more flexible and less brittle to dissipate stress [30]. The biomimetic approach promotes the use of polyethylene fibers in order to reconnect the affected tooth structure, as well as dissipate and minimise the stress of loading forces. This internal "mesh" will then provide the foundation for large restorations. The polyethylene fibers facilitate the superficial restorative material such as composite resin to move in different directions via micro shifting of the woven fibers [44]. Additionally, by embedding polyethylene fibers into a bed of flowable composite, the elastic modulus of the tooth is decreased, which helps to reduce residual stress and prevent the tooth from fracturing [43,45].

Although using fiberglass alone in a direct restoration has been shown that cannot prevent catastrophic fractures, it has also been proved that by layering composite resin over fiberglass can improve the fracture patterns and reduce the percentage of catastrophic failures. Fiberglass has a high tensile strength, density, and percentage of elongation, which allows it to withstand high stresses without fracturing [21], and in contrast to conventional composites, fiberglass can prevent crack propagation below the gingival margin caused by repetitive cyclic fatigue [21]. The fracture resistance of the fiberglass reinforced impregnated composite has shown to be significantly higher than the polyethylene fiber reinforced and the nanohybrid composite restored teeth [21]. It has been discussed in the mentioned study that the pre-impregnation with light cured composite may ensure a good bond with the composite resin; and thus, the fiberglass performed better than polyethylene fibers [21]. However, it is dependent on the fiberglass used, as one study found that restorations reinforced with Ribbond (polyethylene fiber) oriented in bucco-lingual direction and placed on the base of the cavity or on top of it have statistically higher fracture resistance than EverStick which is considered a long fiberglass net. On the contrary, there were no statistical differences between Ribbond supported restorations and EverX (short fiberglass) supported restorations when EverX was used alone or in combination with EverStick as an occlusal splint or circumferentially inside the cavity [27].

It is though to be considered that most of the research cited here utilized static loads to test for fracture resistance, however, the use of cyclic loading to measure maximum values of fracture resistance would provide more accurate representation of masticatory load experienced in the mouth, and it has been suggested that studies that account for these limitations would provide more representative results [46]. Finally, the results obtained in in vitro studies cannot be completely identical to those obtained in vivo experiments, and more clinical studies are required to investigate the findings of the reviewed literature.

Conclusion

Biomimetic dentistry aims to preserve intact tooth structure while also restoring the tooth's function and biomechanics. The key concepts for the biomimetic approach in restorative dentistry are aimed to preserve natural and intact tooth structure, optimise adhesion, minimise residual stress, restore structural integrity, and try to replicate the natural biomechanics.

Single use materials such as microhybrid and nanohybrid composites offer a good and cost-effective direct restorative alternative for MOD cavities in posterior teeth. The nanohybrid composite has demonstrated in several studies to be the best alternative when it is used as a single restorative material followed by microhybrid composite. Additional biomaterials such as polyethylene fibers have shown that they can significantly increase the loading stress resistance of MOD restored teeth when used in the cavity pulpar floor or axial walls and when it is combined with composite resins.

Fiberglass and SFRC, in combination with composite resin, have demonstrated to yield the highest fracture resistance in Class II MOD cavity preparations, supporting the idea that the multiple space orientation of SFRC fibers can distribute the loading stress more uniformly.

Previous in vitro evidence demonstrated that FRCs tend to strengthen the restoration of structurally compromised teeth and improve their fracture resistance when compared to composite restorations without fiber reinforcement which are believed to help reconnect the missing tooth structure. In most studies, short or continuous glass FRCs either performed the same or better than polyethylene (woven) FRCs in terms of fracture resistance [27].

Fracture against loading in extensively restored teeth is an issue that is still under extensive research in tooth conservation. The biomimetic approach offers an innovative view on how various biomaterials and combinations of techniques can favour the longevity of the damaged tooth structure. It has been proposed that by following the biomimetic philosophy, it may be possible to preserve tooth structure, prevent the development or progression of cracks and fractures, minimise the load bearing and residual stress which ultimately reduce complications experienced with more traditional approaches.

More studies regarding material combinations are required to provide relevant information and determine a cost effective and practical restoration method that can improve fracture resistance of compromised posterior teeth.

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Citation: Ruprai S, Shin S, Dang J, et al. Biomimetic Approach in Tooth Conservation and Fracture Resistance: A Short Descriptive Review of Current Biomaterials and Techniques. *Int J Orl Health.* 2022;2(1):1–6. DOI: 10.51626/ijoh.2022.02.00013