Planning for failure: creating dental crumple zones

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Many products that we use are designed to fail predictably in order to protect users from costly damage or injury—from Mercedes-Benz's "crumple zones" designed into cars to protect occupants by absorbing the forces of a crash before it reaches the passenger compartment, to a simple bicycle helmet that absorbs the force of an impact and splits in order to direct the force away from the head. These designs exist for a reason—to fail before more extensive damage can occur.

Procedures in dentistry have many ways of protecting teeth. When we look at split tooth syndrome or a vertical fracture of a tooth, a full cast gold onlay or crown is the ideal choice to protect the tooth. Now that there is such a high demand for esthetics in dentistry, monolithic zirconium has become a popular option for strengthening the tooth. There are many other options, but the idea is always to keep the fracture from propagating and keep the tooth comfortable for the patient. If the system is overloaded—for example, when chewing a hard bagel or an unpopped popcorn kernel—these restorations keep the tooth from flexing, resulting in patient discomfort.

When we look at a fractured tooth that has either lost a cusp or has a fracture line but no symptoms of cracked tooth syndrome, and the tooth still tests vital, we can use a more conservative approach than cast or full crowns while still protecting the tooth via some re-engineering of the system. Often, this type of tooth has been previously restored, and once the tooth has all of the old restorative materials removed, there is very little peripheral tooth structure left to create a good ferrule effect after the preparation for a crown has been completed. In these cases, there are other options beyond an elective root canal with post-and-core and then fabricating the crown.

Minimally invasive biomimetic (MIB) restorations can be fabricated to absorb the forces of occlusion and protect the remainder of the tooth from catastrophic failure. Often, we see teeth that fracture off the buccal cusps of an upper molar or the lingual cusps of a lower molar due to a previous large mesio-occlusodistal restoration. Our classic training would indicate that this tooth is severely compromised and "needs" a crown to restore strength, form, function, and often esthetics (if it is in the smile zone). The reality is that we can be more conservative, preserve much more of the natural tooth structure, and still protect it from future catastrophic failure. By simply removing the old restorative material and freshening up the surfaces to bond, we can then start to build back the tooth in a way that, if it fails in the future, it will fail with the same predictability of the minimally invasive products mentioned above, to protect the patient from more catastrophic failures or pain and suffering.

Simply restoring the tooth with a resin-bonded restoration can increase the strength of the tooth and protect it from most normal occlusal loading forces. However, research has shown that when excessive forces are applied, fracture and failure can occur, often leading to catastrophic fractures that can propagate deep into the tooth and make it nonrestorable.[1] Using layers of energy-absorbing and stress-distributing fibers in the form of a fabric ribbon, which is intimately adapted and bonded to the prepared tooth structure, a cleavage zone is created to allow any crack caused by an excessive loading force to progress only to the structure of the ribbon.[2] Once the force propagates to the ribbon, it will redirect, and the cracks will turn and move along the surface of the ribbon to move out laterally. The fracture that occurs is not catastrophic; it is actually very repairable. The

Fig. 1. Preoperative photo of tooth No. 30 showing fracture of the distolingual cusp and loss of filling with decay.

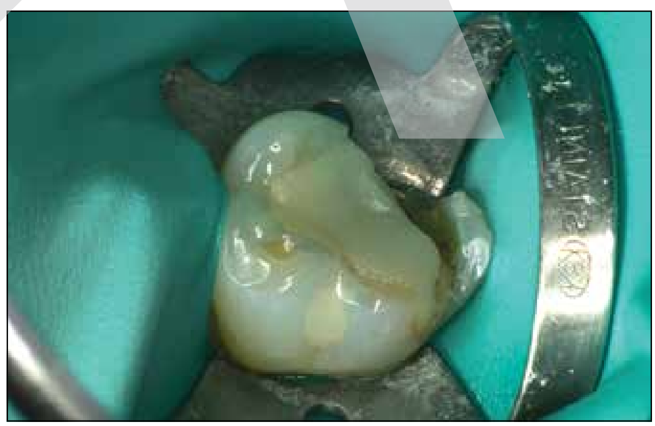

Fig. 2. Tooth No. 30 isolated with a rubber dam showing intact mesial and distal marginal ridges.

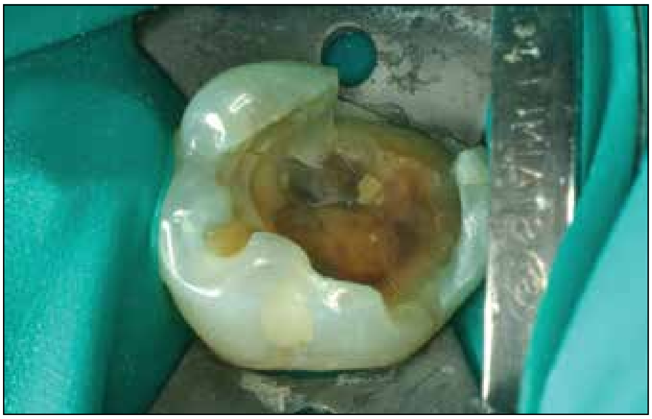

Fig. 3. Tooth No. 30 with all restorative material and caries removed, showing the multiple fractures that will need to be reinforced.

Fig. 4. Clear silicone bite registration fully polymerized after it was adapted to the preparation and then removed from the final prepared tooth.

Fig. 5. The tooth is air-abraded to help create a stronger bond of the restorative materials to the tooth.

Fig. 6. The Ribbond fibers moistened with the wetting agent to allow better adaptation to the filling materials; the far right one is still dry.

advantages of these engineered restorations are that precious tooth structure is saved, there is minimal trauma to the nerve and vascular supply, and, as the tooth absorbs the forces of occlusal loading in a MIB restoration, the forces are dissipated. When a conventional crown is used, and the tooth is overloaded, forces disperse to areas below the coronal portion of the tooth, and, if overloaded too far or in an off-axis direction, the catastrophic failure generally is below the crown and often leads to tooth loss.

The following case is an example of how MIB dentistry (MIBD) protocols were used in a unique way to restore a severely broken down tooth. The preoperative photo shows a classic fracture of the distolingual cusp of tooth No. 30 (Fig. 1). Both mesial and distal marginal ridges were intact and had no preexisting horizontal fractures in the interproximal areas of the tooth.

Vitality testing of the tooth showed equal response to stimulation as adjacent teeth. The tooth was anesthetized and isolated with a rubber dam to facilitate restoration in a more controlled environment (Fig. 2). The restorative material remaining after the fracture was removed, and the tooth was prepared to receive a bonded direct resin restoration (Fig. 3). There were a number of fractures visible in the tooth that appeared to traverse deep into the middle of the tooth, even though the tooth tested vital. As in many of these cases, there was a significant amount of peripheral enamel left of the coronal structure. If a conventional crown was to be prepared in this situation, there would be very little coronal tooth structure left to provide an adequate ferrule effect to create enough retention to hold the crown. Consequently, more drastic measures such as a root canal with a post-and-core restoration would have to be used to retain the crown.

A clear silicone matrix was created by injecting a small amount of clear bite registration material to the height of the marginal ridges, the material was then compressed into the prepared tooth structure to become intimately adapted to the prepared surfaces. After the clear bite registration stent was fully hardened, it was removed and set aside for use when the fibers are placed, allowing them to be more intimately adapted to the prepared tooth surfaces, with the resin and fibers still retaining the ability to be light-polymerized through the clear matrix (Fig. 4).

Finally, the tooth was prepared for bonding with a stream of aluminous oxide and water from a PrepStart H2O unit (Danville Materials) to enhance the bonding (Fig. 5). As an alternative, a fine diamond could have been used to create a fresh surface, but

Fig. 7. The clear silicone matrix is replaced to move the fibers intimately to the internal tooth surfaces.

Fig. 8. Tooth No. 30 with the 2 layers of fibers bonded to the tooth structure just before the final restoration of the remaining missing tooth structure.

Fig. 9. The final restoration of the tooth to full form, function, and esthetics, along with a predictable mode of failure to protect the remaining tooth structure.

research has shown that an air-abraded surface creates a better bond.[3,4] In this case, a fourth generation bonding agent PQ1 (Ultradent Products, Inc.) was used to hybridize the dentin and bond to the enamel, and the bond resin was polymerized to achieve a strong hybridized layer to protect the tooth. An initial layer of low slumping flowable composite (Beautifil Flow FOO, Shofu Dental Corporation) was laid down to allow a degree of tackiness for the fibers of the Ribbond Triaxial (Ribbond) to stay in place. The fibers were first wetted with Ribbond Wetting Agent (Ribbond), then adapted intimately to the prepared surface in a pattern that first laid down the mesiodistal-oriented strips, then a second, buccolingual-oriented layer was laid down over the first (Fig. 6). The clear matrix that was set aside earlier was replaced and compressed down over the flowable composite, and the fiber strips and excess flowable composite were removed from the peripheries (Fig. 7). A strong curing light was then shone through the clear matrix to polymerize the bond resin and wetted Ribbond Triaxial fibers. The matrix was removed and the area was final polymerized another 20 seconds showing a tight adaptation of the Ribbond Triaxial fibers to the pulpal floor (Fig. 8). As the excess materials had flowed beyond the cavosurface margins, the margins were redefined with a diamond bur, and all of the surfaces were freshened up with a light stream of the aluminous oxide water mix from the PrepStart H2O. The area was rinsed thoroughly and etched again, not only to clean the resin surface, but also, more importantly, to get a fresh bond to the enamel and ensure the area had been bonded and sealed well.

At this point, the tooth was ready for the final restoration. The tooth was etched and bonded, and the final filling was placed with a nanohybrid composite resin filling material, which was placed, shaped, and finally polymerized. The rubber dam was removed, the final contours and occlusion were established, and the restoration was polished (Fig. 9).

Creating restorations that have fail-safe zones built into them protects a tooth from catastrophic failure. Should the patient overstress the tooth with something too firm, the ensuing fracture often times is not completely catastrophic. The fracture is above the fiber mat so that the nerve tissue of the tooth is protected, and most times the patient will not experience any sensitivity from the fracture. This can help prevent emergency situations as a result of a fracture.

Fiber reinforcement has been used in many situations for many years to help with splinting teeth or reinforcing tooth structure. This is just one technique that will allow a clinician to be very conservative in helping protect the remaining tooth structure for years down the road. We must always keep in the back of our minds that what we have today to restore teeth is continually being tested, refined, and improved, so that, in the future, if we have the need to re-restore these types of teeth, we will have better materials, techniques, and equipment to do so. This is one of the core ideas of MIBD. We know that a restoration is at its finest in the 24 hours immediately after the tooth is restored, then entropy takes over. How long the restoration lasts is dependent on the patient's functions, parafunctions, and habits. Our goal is to set up a tooth to be able to withstand these continual assaults, so that if the tooth is over-stressed, the ensuing fracture can be predictably repaired. Just like a Mercedes-Benz, we can create crumple zones to protect the remaining tooth structure by utilizing fiber reinforcement.

Author information

Dr. Malterud is in private general practice in St. Paul, Minnesota. He has practiced some form of MIBD for over 30 years and has been lecturing and publishing on MIBD for more than 18 years.

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Manufacturers

Danville Materials, San Roman, CA
800.827.7940, www.danvillematerials.com

Ribbond, Seattle, WA
800.624.4554, www.ribbond.com

Shofu Dental Corporation, San Marcos, CA
800.827.4638, www.shofu.com

Ultradent Products, Inc., South Jordan, UT
888.230.1420, www.ultradent.com