New generation short fibre-reinforced composite restorations of the posterior dentition

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Finding the ideal material(s) for the restoration of posterior teeth, with the aim of re-establishing the original mastication, has long been a central issue in restorative dentistry. Direct restorations have been widely applied to restore posterior teeth due to their low cost, the smaller amount of healthy tooth substance that has to be removed as compared to indirect restorations, and their acceptable clinical performance[1]. Two main causes of posterior restoration failure have been identified: secondary caries and fracture (either of the restoration or the tooth itself)[2,3]. The later phenomena is a result of multiple factors.

Dental fracture patterns depend onthe direction and amount of force applied, and the ability of the tooth to recover from the deformation[4]. Force may be relatively light and repetitive, as in normal mastication, or relatively heavy and repetitive as seen in bruxism, and extremely heavy and sudden in cases of trauma. In the posterior region, forces range from 8 to 880N during normal mastication[5]. Extreme forces can easily lead to crack development in restored teeth, but this can also be true in case of physiological forces applied on the long term. In the "amalgam era"[6] the belief was that the harder the material chosen for restorative purposes, the more chances it had to prevent crack and fracture occurrence. Conversely, according to biomimetic dentistry there is no need for rigid materials. The primary aim is to substitute the missing hard dental tissues (enamel and dentin) with restorative materials closely resembling the natural tissues regarding their mechanical features and properties[7].

According to the early research of Pascal Magne, the ideal materials to replace the brittle, yet stiff enamel should be feldspathic porcelain or highly filled, laboratory composite, whereas the substitution of dentin should be performed with microhybrid composite resin (8). From the year 2000 several studies emphasised the importance of a third type of tissue (or layer): the dentino-enamel junction (DEJ) (Figure 1)[8,9].

The DEJ has been histologically described as a collagenous interphase between these two bio-mechanically vastly different tissues, partly connecting and unifying them, and partly forming a stress-absorbing layer protecting the underlying elastic

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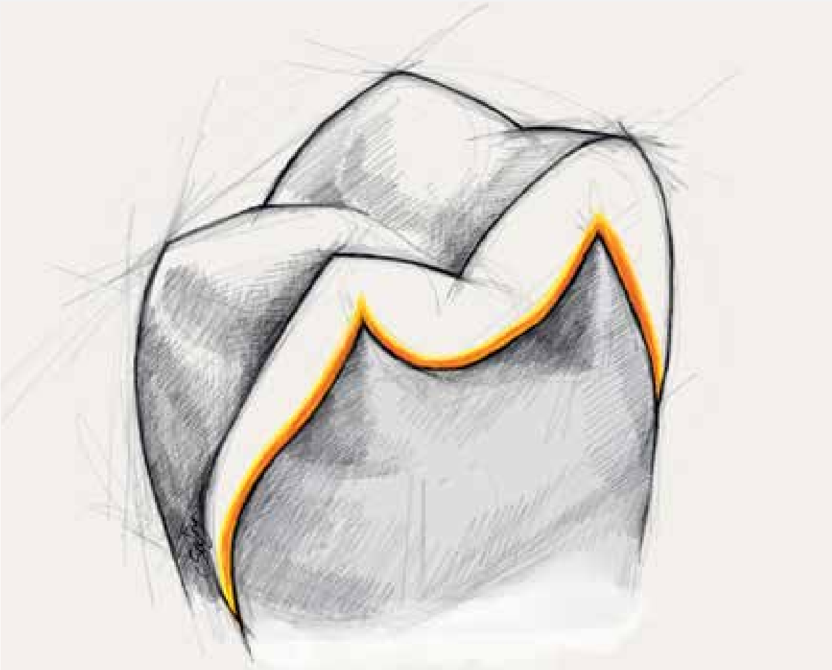

Figure 1: Illustration of a molar showing the natural changes of enamel thickness, the natural histoanatomy of the dentin and the position of the dentino-enamel junction. bIllustration by Dr. Tekla Sáry.

dentin and the vital pulpal tissues. This is the reason why multiple cracks can be seen in the enamel of aged teeth, yet they rarely reach and compromise the supporting dentinal base, therefore usually remain asymptomatic. So far, this latter function of the DEJ has not been successfully mimicked by any restorative material. The excellent biomechanical properties of the DEJ can divert and blunt enamel cracks through considerable plastic deformation, providing a functional shielding mechanism and allowing synergy between enamel and dentin. This is the mechanism that enables right, serving a fundamental function, and when restoring a tooth according to biomimetic principles one should also consider this layer - not only dentin and enamel.

In 2013, a short fibre-reinforced composite (SFRC) (everX Posterior, GC) was introduced to the market with the goal to substitute the missing dentin with a material having a similar behaviour; additionally, the material has clinically shown to be also able to mimic the stress-absorbing properties of the DEJ simultaneously. Fibre-reinforced composites have been used in dentistry for the past 30 years but their true potential and function is just being realised.

The reinforcing effect of the fibre these natural tissues to withstand a lifetime of mastication. Therefore, the DEJ might be considered a specialised tissue type of its own fillers is based on stress transfer from the polymer matrix to the fibres[10], which is influenced by the size of the fibres and the connection between the fibres and the matrix. The actual average size of the glass fibres in the SFRC material is 1-2 mm, thus exceeding the critical fibre length and making stress transfer possible (Figure 2).

Additionally the fibres are silanised and are therefore able to chemically connect to the matrix. As a consequence of these features, the SFRC is able to reinforce the dental structures even in case of extreme loading conditions. Since these fibres show random orientation, they can reduce the polymerisation stress generated by the composite resin in all directions[11,12]. This makes it possible to use the material in layers up to 4mm. However, the in vitro research carried out by the authors has shown that everX Posterior applied in 2-3mm thick layers with oblique layering gave the best results regarding the fracture resistance of posterior molar teeth among the restored groups[13].

Figure 2: The unique size of the short fibres is visible when the SFRC material is extruded from the unitip.

Furthermore, this technique showed the highest number of repairable fractures once fracture occurred. Thus this technique (2-3 mm thick layers with oblique layering) seems to be the most beneficial.

When following the biomimetic restorative principles, the indications for the usage of everX Posterior are dentin substitution in medium and large cavities in posterior teeth, which means that in practice the surfaces of these modern direct restorations should be made of microhybrid or nanohybrid composite covering the SFRC "dentinal core" in at least 1 mm thickness everywhere.

The other revolutionary indication of SFRC is in case of indirect restorations or repair of damaged restorations. The SFRC material contains a semi-interpenetrating polymer matrix (semi-IPN), which consists of both linear and cross-linked polymer phases. The linear phase can be dissolved if a suitable adhesive resin is added on its surface, thus enabling the reactivation of the material and also true chemical bonding to it[14].

Unfortunately this is not the case with conventional composite resins, because once the active oxygen inhibition layer is lost from their surface, the cross-linked polymers cannot be broken up anymore. This leads to little if any reactivity left for free radical polymerisation bonding and therefore, no actual chemical bonding can take place. This unique structure leads to the fact that if the core build-up is made with the usage of SFRC, this layer will not only act as a stress-absorber and crack stopper interphase, but will also have the ability to chemically adhere to the indirect restoration placed on it, if adhesive cementation is applied. In clinical settings this can be managed with the following steps: first cleaning the surface from any debris or biofilm, and then applying a pure resin bonding agent (eg. GC StickRESIN).

With the above mentioned unique features, everX Posterior brings the restorative possibilities in the posterior region to a new level, and also opens new horizons for future restorative techniques. Therefore it seems justified to state that SFRC materials will shortly change the face of posterior restorative procedures.

Clinical case report: Restoring tooth 16 according to biomimetic principles with everX Posterior and a GRADIA® PLUS overlay.

Figure 1: Initial situation showing an MOD composite restoration with a vertical crack inside the filling causing pain for the patient

Figure 2: Prepared cavity

Figure 3: Core build-up with SFRC (everX Posterior, GC)

Figure 4: Situation before impression-taking

Figure 5: GRADIA® PLUS overlay

Figure 6: Before adhesive cementation

Figure 7: After adhesive cementation

After removing an old, cracked MOD composite filling, the form was optimised and the dentin and DEJ were substituted using a SFRC as core build-up. The missing enamel shell was then restored with a GRADIA® PLUS overlay.

Clinical case report: Restoring tooth 15 with a direct fibre-reinforced composite restoration.

Figure 1: Initial situation showing distal change of transparency indicating caries.

Figure 2: Prepared OD cavity

Figure 3: Placing a sectional matrix

Figure 4: Building up the interproximal wall with a microhybrid composite (Essentia Universal, GC)

Figure 5: Substituting the missing dentin with a SFRC (everX Posterior, GC)

Figure 6: Final restoration after finishing - SFRC covered with microhybrid composite (Essentia Universal) occlusally

The patient presented with a distal carious lesion on tooth 15. After preparation and cleaning, a matrix was placed and the OD cavity was transformed into a Class I by building up the approximal wall with Essentia Universal composite (GC), according to the centripetal technique. The internal missing dentin was then substituted with a SFRC (everX Posterior, GC) and occlusally covered with a layer of microhybrid composite (Essentia Universal).

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