Evaluation of Marginal and internal adaptation of adhesive class II restorations, in vitro fatigue tests
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Conclusion & Summary
Until recently, restorative Dentistry was dominated by a mono-therapy based on metallic restorations. The main advantage of amalgam or cast gold restorations was perhaps that clinical procedures remained consistent over the years and could be applied to almost every decay's size. But among the several drawbacks of metallic restorations, one has to mention the aggressive preparation methods dictated by material's properties and related technical procedures. Moreover, their poor aesthetic integration had resulted in continuous patient's dissatisfaction. The numerous biomechanical failures encountered with amalgam (cracked tooth syndrome), due to the fatigue of dental tissues insufficiently supported by the restoration, have been also a constant frustration for the clinician (Fig. C.1). With the advent of adhesion to enamel, and more recently to dentin. Dentistry entered a new era where treatments became highly selective, following a bio-mimetic approach. Several treatment modalities are currently available, which are aimed to preserve on the long-term the biomechanical status of the tooth-restoration complex. In addition, current aesthetic materials meet patient's expectations almost ideally.

However, the modern clinician must have a deeper knowledge in dental and mastication biomechanics and material's science, as well as improved skills to perform advanced adhesive techniques. State-of-the art restorative Dentistry is currently a combination of refined clinical protocols aimed to create a correct anatomy and function, while maintaining a satisfactory marginal and internal restoration adaptation. According to the decay's size and configuration, this can be achieved by using the best possible combination between the restorative technique (direct, semi-direct or indirect) and tooth coloured material (ceramic or composite). Small to medium size cavities are normally treated with direct techniques, while large decays are restored using semi-direct or indirect techniques, with either ceramic or composite (Fig.C.2 to C.4). To have a specific arrangement of tooth-coloured materials with increasing elasticity (from the cavity depth to the surface) proved also a successful way to distribute evenly and absorb polymerisation and functional stresses. Numerous procedures were identified (i.e.: thick adhesive layer, "soft" base-liners, advanced layering techniques, delaying polymerisation stresses) which can improve and stabilize the bio-seal between the restoration and the tooth. This can be considered as a new bio-mimetic approach of adhesive posterior restorations.

**A vision for the future**

We can however not pretend to have yet achieved all our objectives. Actually, in order to obtain reliable restorations on the long term, some research objectives have to be defined. First, there is a need to refine the chemistry of dental adhesives and related clinical protocols, in order to get optimal efficiency in every tooth location and type of substrate, as well as to achieve an perfect bio-stability of the seal with dental tissues. Then, an optimal control of stress...
development should be exerted during the placement of the restoration, probably by using low or non-shrinking restorative materials.

Among the three restorative options at hand today, at least 2 should remain on the long term. For minimal and small decays, it is actually difficult to conceive to abandon the ease and simplicity of direct restorative techniques. As regard medium to large decays, new technologies like CAD-CAM could once replace the existing sophisticated direct and indirect options. We know that direct techniques have obvious limitations, due to the difficulty in obtaining in-mouth a perfect occlusal and functional restoration anatomy. For this reason, at least, indirect techniques will remain in Dentistry as long as CAD-CAM devices have not reached technological maturity and affordability. Interestingly, a suppression of composite polymerisation shrinkage or the advent of a new type of non-shrinking restorative material should not appreciably change this perspective. We then can consider that current treatment concepts and procedures are not only adapted to our present needs but also represent a solid base and education model for Dentistry in our near future.

Only on a long term perspective, the implantation of protective bacteria or modified genes which would help our tissues to resist the development of caries or periodontal diseases, together with bio-active restorative materials or bio-engineered artificial dentin and enamel might become the ultimate forms of preventive and restorative dental treatments. As time will elapse before this will become a reality, current principles of tooth preservation and restoration through adhesion is likely to remain the foundation of modern Dentistry during the forthcoming years.
Fissures due to fatigue are visible at the mesial and distal parts of the tooth already before the removal of restorations.

Many other fissures can be seen after amalgam removal, which significantly fragilize the tooth structure.
Figure C2: Direct restoration of class I cavities. (1) Preoperative view of two amalgam fillings, which have to be replaced due to deficient margins. Such cavities can be restored with a direct incremental technique. (2) Prepared cavity, after application of a thick adhesive layer, which acts as a stress breaker layer. This attempt to limit the negative effects of polymerization stresses is necessary in this type of cavity, with unfavorable configuration factor. (3) The first composite layer is applied horizontally; the material mimic the color and opacity of natural dentin. (4) A second layer of enamel like composite completes the cavity; the material is sculpted with hand instruments to provide a correct and functional occlusal anatomy. (5) Postoperative view after finishing and polishing.

(6) resin stain (dark brown) was applied in the pits and fissures to obtain a more natural appearance.
Figure C3: Medium-size direct class I and II composite restorations: (1) The preoperative view shows fatigue fissures, which fragilize the mesial and distal aspects of the two molars. (2) The adhesive has infiltrated the fissures and is supposed to block bacterial infiltration and fluid movements; a sectional band closes the proximal cavity. A special ring maintains the band and separates the two teeth. (3) A thin layer of flowable composite (about 1mm thick) covers dentin: this is the second stress-breaker layer (after the adhesive). These two layers will help to limit stress development within the tooth restoration system during increment polymerisation and further masticatory forces. (4) Increments are placed against the buccal and then lingual walls, following the “oblique layering” technique. (5) The material is first polymerised through the remaining walls.

(6) The completed restoration shows a functional anatomy, satisfactory aesthetics and no additional fracture or fissure is visible, providing evidence that polymerization forces were adequately controlled.
Figure C4: Semi-direct intra-oral onlay on a fractured upper premolar

Occlusal (1) and buccal (2) preoperative views; the buccal cusp was previously repaired. (3) After preparation, the lingual wall still is intact, as well as the base of buccal cusp. The cavity volume and the amount of residual enamel however clearly contraindicates a direct approach. (4) The retentions and irregularities were filled with flowable composite (after adhesive application) in order to get the necessary cavity geometry. (5) A hard silicone model was fabricated, chair-side. The model is trimmed and prepared like a traditional stone cast and allow the fabrication of the restoration by direct application of the composite material. (6) The onlay was made of two basic layers - dentin and - enamel, using a direct restorative material. (7) The trial of the work-piece shows its excellent adaptation. (8) Luted restoration; this clinical case demonstrates the potential of the semidirect approach for the treatment of single large decays. The benefit of a luted restoration is also here to limit the development of stresses by restricting the problem of polymerisation shrinkage to the small cementing gap.