Reactive Methacrylate Systems for Dental Bioadhesives

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Summary: The procedure of restoring missing crown part of a human tooth with use of experimental materials, including new functional dimethacrylate monomers, is presented. The essential steps are precise evaluation of root canal cavities and providing a good adhesion of restorative materials to tooth structures. Magnetic resonance microscopy is considered to be a valuable supporting technique in restorative dentistry.

Keywords: adhesives; dental polymers; dimethacrylates; magnetic resonance microscopy; shear bond strength

Introduction

Dental bioadhesives are a sort of restorative materials destined to provide sealing and mechanical stabilization of a restoration of a hard tooth tissue made from an artificial filling material. The prefix *bio* suggests that a material is at least biocompatible, some healing action towards neighbouring tissue is desirable as well.

The dental adhesive systems are composed of various methacrylate monomers and an initiating system; the latter may be either a photoinitiator in light-cured system or peroxide/tertiary amine in chemically-cured one. The most important ingredients of dental adhesives are hydrophilic methacrylates containing reactive functional groups, e.g. carboxylic, anhydride, amine and phosphate ones. Those provide an affinity either to collagen or hydroxyapatite contained in dentin. A reactive group should be joined via some spacer group to the polymerizable methacrylate double bond. The latter copolymerizes with other monomers contained in an adhesive resin and in a binder of a composite filling material [1, 2].

Some more complex restorations require reinforcing by use of devices made of metals or

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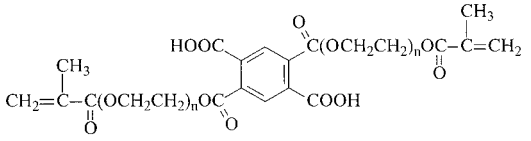
metal alloys. Adhesives destined for such a purpose should be capable of bonding metal surface as well.

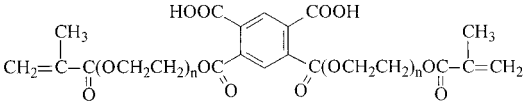
We have developed a series of new multifunctional methacrylate monomers, having the structure below, intended to be employed in dental adhesives of an universal type, i.e. capable to bond:

- composite restoration to hard tooth tissue;
- composite to amalgam and other metal alloys
- amalgam restoration and other metal alloys to hard tooth tissue;



para isomer

n=2 PM2EDM
n=3 PM3EDM
n=4 PM4EDM



meta isomer

The PM2EDM, PM3EDM and PM4EDM monomers may be thought to be homologues of PMDM, well-known HEMA-based dental monomer (n=1 in the scheme) [3]. However, structural features of the new series are advantageous, since flexible oxyethylene spacers provide both functionalities more unconstraint in action as well as miscibility with other methacrylate resins.

This work is aimed to evaluate a performance of the new methacrylate-based adhesive systems employed in a complex, total restoration of a missing tooth crown, involving an individual intra-root canal fixation (so-called "individual post') made of metal alloys. Since a precise knowledge on root canal cavities shape and volume is essential to cast the post precisely, the procedure has been supported by MRM (Magnetic Resonance Microscopy) technique.

Materials and methods

The monomers were synthesized and the adhesive systems were formulated according to the recent report [4]. Both light-cured composite and cobalt-based alloy used to the restoration are experimental materials elaborated by the authors [5]. Experiments were performed onto extracted human teeth. Magnetic resonance microscope working at 4.7 T equipped with DRX console was used to visualize tooth root canals interior, more details are given in [6, 7]. Shear bond strength of composite material to cobalt-based alloy was measured with the aid of Instron apparatus according to the procedure previously reported [5].

Results and discussion

When rebuilding missing crown parts of teeth by use of restorative materials and intra-root fixation, the dentists need to perform precise mapping of the shape and the volume of root cavities. Few imaging techniques are known, among which magnetic resonance seems to be promising as a support to the impression mapping methods [6, 7]. Figure 1 presents exemplary images obtained *in vitro* for the extracted human tooth. A series of images enables creation of three-dimensional picture of a cavity.

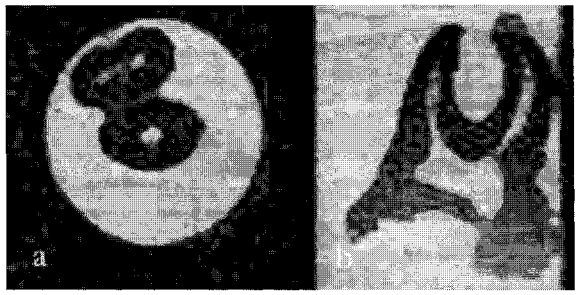


Figure 1. The MRM images of a human tooth root (a) transverse section, (b) longitudinal section.

The data obtained from MRM have been used to verify an impression negative of root canals before subsequent preparation of an appropriate mould to cast the individual post using an experimental cobalt-based alloy (Figure 2a). The tooth root canals were coated with the self-cured adhesive resin based on the PM3EDM monomer to provide bonding of the alloy to the dentin and then the post was introduced therein. After that, the crown part of a tooth was rebuilt gradually, layer by layer, with light-cured composite material. Prior to applying the

first layer, the light-cured version of adhesive resin as above was introduced onto the upper surface of the post to provide bonding of the alloy to the composite. The final restoration is shown in Figure 2b.

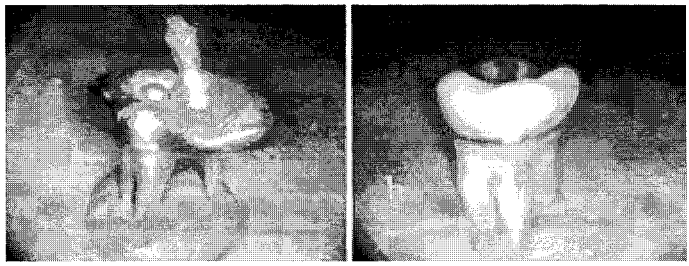


Figure 2. (a) An individual intra-root post, (b) a crown restored with composite material onto the post.

The performance of a restoration made as above can not be evaluated directly without long-term observation period. However, mechanical strength of composite/metal and metal/dentin bonds provided by the adhesive material and measured *in vitro* in standardized way, may be helpful in predicting future properties of the restoration. Thus, shear bond strength measured on samples of the composite bonded to the cobalt-based alloy with the PM3EDM-based adhesive amounted to 5.35 ± 3.82 MPa for samples of polished metal surface and 17.92 ± 3.22 MPa for non-polished ones [5]. The results are satisfactory, however, thermocycling experiments are necessary to verify the results obtained in terms of long-term performance.

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