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Review

# The dentin organic matrix – limitations of restorative dentistry hidden on the nanometer scale

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ABSTRACT

The prevention and treatment of dental caries are major challenges occurring in dentistry. The foundations for modern management of this dental disease, estimated to affect 90% of adults in Western countries, rest upon the dependence of ultrafine interactions between synthetic polymeric biomaterials and nanostructured supramolecular assemblies that compose the tooth organic substrate. Research has shown, however, that this interaction imposes less than desirable long-term prospects for current resin-based dental restorations. Here we review progress in the identification of the nanostructural organization of the organic matrix of dentin, the largest component of the tooth structure, and highlight aspects relevant to understating the interaction of restorative biomaterials with the dentin substrate. We offer novel insights into the influence of the hierarchically assembled supramolecular structure of dentin collagen fibrils and their structural dependence on water molecules. Secondly, we review recent evidence for the participation of proteoglycans in composing the dentin organic network. Finally, we discuss the relation of these complexly assembled nanostructures with the protease degradative processes driving the low durability of current resin-based dental restorations. We argue in favour of the structural limitations that these complexly organized and inherently hydrated organic structures may impose on the clinical prospects of current hydrophobic and hydrolyzable dental polymers that establish ultrafine contact with the tooth substrate.


## 1. Introduction

The prevention and treatment of tooth decay are major challenges in dentistry. It is estimated that 90% of adults in Western countries suffer from this dental disease [1], and in the USA alone the annual expenditure associated with dental services surpasses $100 billion dollars [2]. Although preventive and restorative dentistry has undergone significant advances in recent years [3–7], a primary reason driving this economic burden is the placement and replacement of tooth fillings due to the low durability of current polymeric restorative dental materials, particularly when damaged dentin is involved [8].

Dentin is a hierarchically organized nanostructured biological composite that combines highly complex protein assemblies to form a strong and durable mineral-rich biological material. The primary objective of restorative dentistry is to repair and replace damaged tooth structures by the systematic application of synthetic materials aiming at the re-establishment of tooth aesthetics and function. Current restorative procedures generally depend on the formation of an adhesive bond between polymeric dental materials and the tooth substrate [5]. Therefore, current tooth coloured restorations rely substantially on the ultrafine interaction of synthetic polymers with the highly complex supramolecular assemblies that compose the tooth organic matrix. This is generally described as restorative adhesive dentistry.

Improvements in our ability to understand the physical processes on the nanometer scale in recent years has raised critical questions regarding the long-term effectiveness of current restorative materials [9]. The dentin organic matrix has been largely explored and novel findings point to a highly complex and somewhat unfavourable interaction between dental materials and its organic constituents from a nanostructural perspective [5,10–12]. In this review we discuss recent evidence on the structural organization of the dentin organic matrix on the sub-micrometer scale. We support the perspective that the paradigms that currently dictate restorative dentistry are founded on structural, molecular and biological phenomena that impose critical limitations on the long-term prospects of polymeric dental restorations. Additionally, we argue that the dentin matrix is comprised of highly orchestrated protein assemblies that present extremely complex organizational features at the nanoscale and at the molecular level which show

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