Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.intl.elsevierhealth.com/journals/dema

Antimicrobial properties of conventional restorative filling materials and advances in antimicrobial properties of composite resins and glass ionomer cements—A literature review

*Cher Farrugia, Josette Camilleri**

Department of Restorative Dentistry, Faculty of Dental Surgery, University of Malta, MSD 2090 Msida, Malta

ARTICLE INFO

Keywords:
Antibacterial
Antimicrobial
Restorative materials
Composite
Glass ionomer cement
Bonding agent

ABSTRACT

Objectives. It has been reported that complete caries removal from cavities during restoration of teeth is difficult. Furthermore with the tissue saving approach it is expected that more of the saved affected tissue will possibly harbor more residual bacteria. Antimicrobial restorative filling materials would be ideal to prevent the spread of caries after completion of tooth restoration, thus preventing recurrent decay and eventually restoration failure. This paper reviews the literature on the antimicrobial properties of dental restorative filling materials.
Methods. Pubmed searches on the antibacterial properties of restorative materials were carried out. Keywords were chosen to assess antibacterial properties of conventional filling materials. Methods of introducing antimicrobial agents in restorative materials were also reviewed together with the methodology used to assess antimicrobial activity.
Results. 174 articles from 1983 till 2014 were included.
Significance. Adhesive materials have decreased antimicrobial activity when compared to amalgams and zinc oxides. Several techniques have been employed in order to increase the antimicrobial activity of restorative materials. Although antimicrobial activity of restorative materials is important, the introduction of antimicrobial agents/techniques should not be at the expense of other material properties. Environmental changes within a material may affect the bacterial response to the antimicrobial. Bacterial adhesion to the restorative materials should be assessed. Long term assessment of antimicrobial activity is important and is clinically relevant. The use of antimicrobial dental materials is important unless such characteristics are gained to the detriment of other material properties.

1. Introduction

The rate of dental caries following restorative treatment is claimed to be high [1,2], with some authors claiming values up to 50–60% [2,3]. Secondary caries is also claimed as the main reason of failure of composite resin or glass-ionomer cements (GIC) restorations [3–11]. More than half of the restorations placed in the United States in 2005 were

* *Corresponding author.* Tel.: +00356 2340 1174.
E-mail addresses: josette.camilleri@um.edu.mt, densincementus@gmail.com (J. Camilleri).

http://dx.doi.org/10.1016/j.dental.2014.12.005
0109-5641/

replacements of failed restorations, with composite restorations showing higher failure rates and more recurrent decay when compared to amalgam, which may be due to the higher antibacterial properties of amalgam when compared to composite [12]. Composites have been claimed to result in more plaque accumulation than other materials [1,12–16], which may also be the cause of the increased rates of recurrent decay experienced with this material [1,12,13,17].

Secondary decay occurs most commonly at the interface between the restoration and the cavity prepared [4,18]. The tooth structure is demineralized following invasion of acid producing bacteria, such as *Streptococcus mutans*, when fermentable carbohydrates are present [4]. Therefore, an effective antibacterial/bactericidal restorative material would be in the ideal location to prevent secondary decay [4,18–20], especially since it has been shown that cariogenic bacteria, mainly *S. mutans*, adhere to restorative materials [21].

Another issue is that nowadays, a more conservative approach of caries removal is suggested by the literature [22]. Through this tissue-saving approach, it is expected that more affected tissue will be saved and possibly will harbor more residual bacteria [23]. These facts highlight the need for development of adhesive materials with antibacterial properties that prevent colonization of bacteria at the tooth to material interface, without the creation of resistant strains. This would theoretically prevent recurrent decay, allow more conservative removal of caries [7,10,12,24], and influence the extent of micro-leakage, which has been shown to influence pulpal inflammation beneath cavities *in vivo* [18,25]. The use of materials with antibacterial or bactericidal effects would also provide an adjunct treatment by suppressing residual infection and increase the survival of the restored tooth especially in minimally invasive approaches [1,22].

Several attempts have been made to introduce antimicrobial properties in restorative materials [26], but some of these attempts resulted in compromized physical properties of the novel material [2,27–30]. The changes in composition carried out to introduce antibacterial properties or leaching of particles may affect the material's strength, making it then unsuitable as a restorative material or restrict its use to non-loadbearing areas [2,27,28]. Another issue may be problems with change in color, as seen with the introduction of silver nanoparticles to light curable resins [2], which may in turn restrict the use of the material to posterior restorations. Another property that may be altered is the material's adhesion to the tooth. Decreased bond strength when compared to the conventional material is not ideal as this would increase the chances of micro-leakage and as a result, recurrent decay [27,28].

The aim of this paper is to review the literature to investigate the current status of antibacterial properties of filling materials, with particular emphasis on advances to resins, bonding systems and glass ionomer cements and on the mechanisms on how the antibacterial properties were achieved and assessed. The review looks into antibacterial properties of conventional restorative materials and then highlights different methods used to improve antibacterial properties of currently used materials. Methodologies used to assess antibacterial properties were also highlighted.

Articles in English related to antimicrobial properties of dental restorative materials from 1983 till 2014 were included. The PubMed search included literature reviews, *in vitro* and *in vivo* studies. Articles written in other languages, without available abstract, those related to other fields of restorative dentistry were excluded. Keywords related to restorative materials and specific materials were used. A search using "antibacterial dental material" resulted in 1958 hits; therefore more specific phrases were used to narrow down the search. Keywords used, number of articles chosen, hits per keyword and date of earliest and latest article per search are shown in Table 1.

2. Antimicrobial properties of restorative materials

Several commercially available restorative materials have been tested for their antimicrobial properties. Considerable differences exist in the antibacterial properties of different materials and some variation may also be noted between different formulations of related materials. The antimicrobial properties of same materials varied as well when tested against different micro-organisms and strains, as well as after different aging times [18,31–34].

Several conventional filling materials have been claimed to be to some extent antimicrobial in the literature. These include amalgams [12,18,31], calcium hydroxide [31,35,36], polycarboxylate cement [31], composite resin [31], zinc oxide eugenol [31,37–39], glass ionomer cement [27,33,34,37,39–44].

Table 1 – Key words and number of publications chosen during a particular time period for antimicrobial properties of various restorative materials.

Key word	Number of publications chosen of Pubmed hits	Earliest	Latest
Antibacterial dental restorative materials	68 out of 134 hits	1983	2014
Antibacterial restorative material	19 out of 47 hits	1983	2014
Antibacterial properties of dental restorative materials	38 out of 54 hits	1983	2014
Anti biofilm properties of restorative materials	7 out of 11 hits	1999	2013
Antimicrobial dental bonding agent	12 out of 292 hits	1996	2014
Antimicrobial properties of amalgam	6 out of 39 hits	1988	2010
Antibacterial properties of amalgam	9 out of 19 hits	1985	2007
Antibacterial glass ionomer	71 out of 149 hits	1983	2014
Antibacterial activity of composite resin	70 out of 101 hits	1983	2014