Oral homeostasis, kill the microbiome or not?

Abstract

The objective is to short review the current state of the art of dental antimicrobial agents in term of minimal invasive restorative dentistry. An outline of the most important aspects of dental antimicrobial agents was created, and a subsequent literature search for articles related was conducted. The current state of the art of antimicrobial agents includes a variety of species with broad ranges of properties. There is no agreement as to the choice of substances and concentration, however, there is a growing consensus regarding the need to use antimicrobial agents as additions into dental restorative materials’ compound in patients with high intensity of active caries disease.

Keywords: glass ionomer, antimicrobial

Objective

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Background

Various studies have shown that glass ionomer cements (GICs) have potential bioactivity, adhesion to hard tissues and also reduce the formation of plaque by Streptococcus mutans strains. The antibacterial activity of glass ionomer cements (GIC) is mostly attributed to their fluoride and other ions release for secondary caries control. Moreover, more viscous GICs release substantially less cumulative fluoride ions than less viscous ones, resulting in no microbial balancing ability in vivo. On the other hand, studies have shown that fluoride-releasing activity of GICs is insufficient for effective protection. Thus, these cements are expected to actively control microbial biofilm formation, while biofilms modulate the release of fluoride from GICs. On the other hand, studies have shown that fluoride-releasing activity of GICs is insufficient for effective protection. Moreover, more viscous GICs release substantially less cumulative fluoride ions than less viscous ones, resulting in no microbial balancing ability in vivo.

The oldest documented medical use of an antimicrobial agent concerned copper mentioned in the Smith Papyrus; this Egyptian medical text, written between 2600 and 2200 B.C., describes the application of copper to sterilize chest wounds and drinking water. Ancient Egyptians and Greeks also used specific molds and plant extracts to treat infections. Earlier, since the time of the Persian kings, vessels made of Cu and Ag had been intentionally used for water disinfection and food preservation.

The first contemporary antimicrobial agent in the world was salvarsan, a remedy for syphilis that was synthesized by Ehrlich in 1910. In 1935, sulfonamides were developed by Domagk and other researchers. In 1928, Fleming discovered penicillin. The idea of using antiseptics to control dental decay was originally suggested by Miller in 1890. In 1893 Naegli observed lethal action of heavy metal ions upon microorganisms and called this phenomenon oligodynamic.

Contemporary concepts

Among contemporary antimicrobials modifying glass ionomers’ composition, non-organic, organic – synthetic, with antibiotics and natural, or hybrid agents can be distinguished.

Non-organic antimicrobials

Plenty of non-organic species have been tested, and among them zinc sulphate (ZnSO₄), strontium dioxide (SrO₂), barium sulphate (BaSO₄), ytterbium fluoride (YbF₃), copper, gold, palladium, platinum, strontium, zinc or silver nanoparticle (nCu, nAu, nPd, nP, nSr, nZn, nAg), calcium–zinc–silicate, amorphous calcium phosphate nanoparticles (nACP), zinc oxide (ZnO), copper oxide (CuO), sodium hypochlorite (NaClO), copper iodide (CuI), fluorapatite (FAp), borate glass, hydroxyapatite (HAp), porous nHAp, nanocrystalline calcium deficient hydroxyapatite (nCDHA), titanium dioxide nanoparticles (nTiO₂), zirconia dioxide (nZrO₂), monosodium gold(III)-titanate nanoparticles (nMST-Au(III)), magnesium carbonate apatite, forsterite nanoparticles (nMgSiO₃), ammonium peroxo-titanate (APT), tri-sodium citrate (TSC), sodium hypochlorite (SHC), boric acid (BA), niobium silicate, silver phosphoric zirconium (SPZ), tetrapod-like zinc oxide whisker (T-ZnOw), bioactive glass (BGN), fluorinated graphene (FG) have been intensively evaluated.

Organic antimicrobials

Synthetic

On the other hand, lately popular participation of synthetic organic substances like chlorhexidine digluconate, diacetate, dihydrochloride (CHG, CHA, CHHCl), alexidine (ALX), alexidine combined with N-acetylcycteine (NACALX), monomers 12-methacryloyloxydodecylepyridinium bromide (MDPB), quaternary ammonium dimethacrylate (QADM), furanone chloride and bromide (GLC), thymol, chloroxylenol, polyquaternary ammonium salt (PQAS), cetrimide (CT), polyethyleneimine nanoparticles (nPEI), cetylpyridinium chloride (CPC), gluutaraldehyde (GA), benzalkonium chloride (BACH), sodium fusidate (SF), tricosane (TRC) andtricosane with zinc citrate complex (TRC-ZnC), furanone (FN), Poly(Acrylic Acid-Co-DCAGAGM) GM-tethered 6-arm star-shaped poly(acrylic acid), 2,2′-bipyridine, 2-dimethylaminoethanol (DMEA-CB), anthocyanin, quaternary ammonium monomer dimethylaminododecyl methacrylate (DMADDM), 2-methacryloyloxyethyl dodecyl methyl ammonium bromide (MDMAB), dimethyl ammonium chloride (DMAC), octenidine dihydrochloride (OIDC), theobromine (THEO) is observed in many researches.

Antibiotics

Also antibiotics have been tested as potential additives to GICs compound, namely metronidazole, ciprofloxacine, cefaclor, minocycline or doxycycline.
Natural

Due to the widespread antibiotic resistance in the last decades, natural organic compounds, such as miswak extract (ME), grape seed extract (GSE), ethanolic extract of propolis (EEP), epigallocatechin-3-gallate (EGCG), morphogenetic proteins, cinnamon bark oil (CBO), chitosane (CHT), shellash powder, coumarin (CO) derivatives, collagen, cellulose microfibers and nanocrystals, azadirachta indica (neem) or turmeric extract have been previously tested as possible antimicrobial agents.²⁻¹⁴

Some attention was given to the hybrid version of antimicrobial agents, i.e. casein phosphopeptide-amorphous calcium phosphate (CPP-ACP), chlorhexidine–hexametaphosphate nanoparticles (nCHX–HMP), chlorhexidine-bioactive glass, chitosan/chlorhexidine-cetrimide, chitosane-titanium dioxide nanoparticles CHT-nTiO₂, chlorhexidine-encapsulated mesoporous silica nanoparticles, 12-methacryloyloxydodecylpyridinium bromide (MDPB)-nAg.¹⁴⁻¹⁵ Cariostatic effect of GIC is still questionable, and it is also claimed that the low pH of GICs during setting reaction may contribute more than the fluoride leaked to their antibacterial properties and that no antibacterial activity is exhibited after setting.¹⁶⁻¹⁷ thus, the ability of GICs to ions exchange might lead to the hypothesis that GICs could potentially be used as carrier systems/delivery matrix for other active components, e.g. antimicrobial agents¹⁸,¹⁹ in term of caries balancing, microbiome colonization inhibition.

The prevalence of caries and the increase in drug resistance in the pathogenic microbiome at an alarming rate is a matter of serious concern. Therefore, there is a pressing demand to discover novel holistic strategies and identify new solutions, taking into account dental restorative materials. Changes in oral ecosystem may induce shifts of biofilm microflora towards pathologies of teeth hard tissues, gingiva and bone. The caries disease still remains a major systemic health problem in humans.

The caries cavity is an adverse effect of homeostasis confusion towards demineralization and proteinolysis; remineralization through restoration may level this pathology with GICs – biomimetic materials’ compound in patients with high intensity of active caries disease patients and be a step ahead in minimal invasive agents of the first choice in an active form. Possibly the modification of GIC restoration may level this pathology with GICs – biomimetic materials towards demineralization and proteolysis; remineralization through gingiva and bone. The caries disease still remains a major systemic health problem in humans.

The caries cavity is an adverse effect of homeostasis confusion towards demineralization and proteinolysis; remineralization through restoration may level this pathology with GICs – biomimetic materials of the first choice in an active form. Possibly the modification of GIC – a ‘Grandbiomaterial Inactivating Caries’ with microbial inhibiting agents²⁰⁻²¹ would help to solve the holistic problem in high intensity active caries disease patients and be a step ahead in minimal invasive dentistry, taking into consideration equivalent dietary, behavioral, hygiene and prophylaxis aspects.

Conclusion

There is no agreement as to the choice of substances and concentration, however, there is a growing consensus regarding the need to use antimicrobial agents as additions into restorative materials’ compound in patients with high intensity of active caries disease.

Acknowledgments

None

Conflicts of interest

The author declares there are no conflicts of interest.

References

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Dentists and researchers have found that the balance of oral bacteria, or microbiome, is crucial for maintaining oral health. Studies have shown that bacteria within the mouth can cause dental caries, gum disease, and other oral health issues.

Researchers have also found that chronic antibiotic use can disrupt this microbiome, leading to an overgrowth of certain bacteria that can cause problems like bad breath and gum disease.

To combat these issues, some researchers are looking into alternative treatments like antimicrobial agents and probiotics to maintain oral homeostasis without the need for antibiotics.

One study, for example, looked at the use of antibacterial agents in glass-ionomer cements to prevent the growth of oral bacteria.

This study found that glass-ionomer cements containing antibacterial agents like chlorhexidine and doxycycline had a positive effect on reducing the growth of bacteria such as Streptococcus mutans.

Another study looked at the use of grape seed extract and casein phosphopeptide amorphous calcium phosphate (ACP) in glass-ionomer cement to treat cavities.

This study found that the use of these materials had a remineralizing effect and improved surface microhardness of the cement.

In conclusion, the use of antimicrobial agents and probiotics in glass-ionomer cements could be a promising treatment for maintaining oral homeostasis and preventing oral health issues.

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