

DOI: <http://dx.doi.org/10.22122/johoe.v7i2.334>

Received: 17 Apr. 2017

Accepted: 27 Sep. 2017

Fluoride releasing dental materials used in orthodontics: Literature review

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Review Article

Abstract

BACKGROUND AND AIM: In this manuscript, fluoride releasing dental materials controlling demineralization in fixed orthodontic patients, and the current strategies to prevent white spots were evaluated.

METHODS: General literature review was carried out in SciVerse ScienceDirect databases. The search strategy included the terms from Medical Subject Headings (MeSH) created by National Library of Medicine.

RESULTS: 44 relevant studies were included and the respective data were extracted. Many studies showed new alternatives for the treatment of white spot lesions by the use of orthodontic appliances.

CONCLUSION: Patients receiving fixed orthodontic treatment should be instructed in a proper brushing technique using a fluoride containing toothpaste, and high risk patients should be bonded with fluoride releasing agent. Additionally, it is recommended to apply fluoride varnish periodically during orthodontic treatment.

KEYWORDS: Orthodontics; Dental Materials; Fluorides; Tooth Demineralization

Citation: Lara-Carrillo E, Millán-Hernández XA, Salmerón-Valdez EN, Scougall-Vilchis RJ, Medina-Solís CE, Toral-Rizo VH. **Fluoride releasing dental materials used in orthodontics: Literature review.** *J Oral Health Oral Epidemiol* 2018; 7(2): 52-8.

Orthodontic treatment is one of the elective procedures to improve the patient's dentofacial appearance. The placement of orthodontic appliances is a standard procedure to align teeth with.^{1,2}

Patients taking orthodontic treatment have variations in oral environment, sometimes increasing bacterial counts, increasing salivary pH acidity, retention of food particles on the fixed appliances. Problems occur principally when fixed appliances are placed because the permanent retentive areas makes the oral hygiene difficult.³⁻⁵ This may cause decalcification in certain patients after

active treatment.^{4,6} The effects of demineralization differ from no perceptible alteration to white spots lesions on the teeth, or cavitation. They may require further therapy after orthodontic treatment to mask or remove them. Decalcification is a substantial problem during treatment, with 2% to 96% frequency.^{1,2}

Commonly applied material for treatment of lesions is topical fluoride.⁷ Fluoride-releasing products have been developed to be selected as restorative materials, liners, sealants, and orthodontic adhesives. All these mechanisms may therefore reduce

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demineralization and promote prevention of dental hard tissues. Nowadays, fluoride-containing dental materials are available for the professional use, including glass-ionomers, resin modified glass-ionomer (RMGI) cements, compomers, giomer, composites, varnishes, bracket adhesives, and inclusive fluoride-releasing elastomeric ligatures. However, it is assumed that the antibacterial and cariostatic properties are often associated with the amount of fluoride released.^{1,8-11}

Clinicians and researchers are concerned about enamel demineralization related with orthodontic treatment. Topical presentation of fluoride is known to reduce caries, plaque activity is blocking bacterial enzyme systems.⁴ Patients under orthodontic treatment have sources of topical fluoride that can use at home, including dentifrices and mouth rinses.^{12,13}

This manuscript evaluated literature for fluoride releasing dental materials controlling demineralization in fixed orthodontic patients; moreover, it discusses about the current strategies for preventing white spots, and makes respective recommendations.

Methods

General literature review was carried out, rather than systematic review. For this review we used some methodological steps followed in other studies.¹⁴

In December 2016, two reviewers (X. A. M-H. and E.N.S-V.) searched in SciVerse ScienceDirect databases for articles published from 2000 through 2016. The search strategy included the terms from Medical Subject Headings (MeSH) of National Library of Medicine (fluoride release, tooth remineralization, and orthodontics). They limited the search to studies involving fluoride releasing in orthodontics treatment which published in English. This review was a planned strategy to guarantee high compassion originally, rather than specificity.

Two researchers (R.J.S-V. and E. L-C.) reviewed articles and abstracts produced by

the search engine to classify those that appeared to be investigations addressing the structured review. They eliminated meeting reports and summaries, editorials, opinion pieces and unpublished papers.

Another researcher (C.E. M-S) abstracted the articles, evaluated the quality of the measures used in the studies and reviewed the studies' designs and analytic methods. He noted member enrolment, procedures of remineralization, and analysis methods. Differences in interpretation was discussed and resolved.

Results

By using this search strategy, we found 44 citations published between 2000 and 2016. Although we can see that various attempts have been made to modify materials and minimize white-spot lesion formation during fixed appliance treatment, demineralization is still a problem.

A lot of studies that show new alternatives for the treatment of white spot lesions by the use of orthodontic appliances (mainly fixed) were detected. However, we focused on those that investigated regarding fluoride release.

Effect of fluoride-containing toothpastes and mouth rinses: Toothpastes have been extensively recommended for cleaning teeth. However, in the last century the real therapeutics, mostly fluoride, were combined into their formulation, resulting in important developments to the oral health of people all over the world.¹⁵

Mouth rinsing is a simple method of self-application of fluoride; there was evidence that the combined regimen (fluoride toothpaste plus fluoride mouth rinse) increases the prevention factor, and the rate of the consumption of the fluoride mouth rinse as well as the consistent promotion of fluoride in the oral fluids to preserve an ideal fluoride absorption were important for caries control.^{13,16,17}

Given high concentration of fluoride in toothpastes (F = 1000-1500 ppm), it is credible that they respond with enamel surface

forming a reservoir of ions that are released after brushing. It has been reported that fluoridated toothpaste augmented discharge of fluoride. Several studies suggested that the enamel crown is an important reservoir for topically applied fluoride.^{9,10,18,19}

Moreover, It has been reported that dental brushing at least twice a day using a toothpaste (5000ppm fluoride), was superior in recovering enamel health after demineralization to lower concentration toothpaste (1000ppm fluoride). Concentration and doses of fluoride for dental application are discussed. Fluoride materials that release a larger quantity of fluoride are more bioactive to prevent decalcification and caries. Lesser concentrations of fluoride can be more convenient in enamel recovering. Higher quantity of fluoride might be inconvenient for remineralization. In brief, higher dose of fluoride is better for prevention formation and lower dose of fluoride is better for the remineralization.⁷

Fluoride varnishes: Fluoride varnishes were developed over 30 years ago to increase the connection period with enamel, allowing greater acceptance of fluoride ions into the tooth. In a recent study, certain fluoride varnishes were shown to release fluoride for as long as 28 weeks. Fluoride ions inspire the formation of calcium fluoride and fluoroapatite. This reaction improves remineralization of the etched enamel, making it more unaffected to demineralization.^{20,21}

The effectiveness of combined fluoride varnish and antimicrobial agents in preventing white spot lesions has been investigated. There was no difference in the development of white-spot lesions in teeth treated only with fluoride varnish versus teeth treated with an antimicrobial agent combined with fluoride varnish. Other studies have reported the physical properties and effectiveness of varnishes in reducing dental caries.^{5,17,21,22}

Tooth decalcifications can be developed quickly around brackets. Some scientists described that the submission of fluoride

before or at time of orthodontic fixed appliances placement did not alter the adhesion of the attachments.²⁰

Resins: Direct placement of brackets with a light-cured composite resin began in 1975 and it has become the standard method in clinical practice as well as the most common technique.²³⁻²⁵

Composites may have fluoride in diverse forms, such as mineral salts or leachable glasses. Thus, not only the quantity of fluoride, but also the type and particle size of the fluoridated filler, kind of resin, silane treatment, and porosity might be important issues to fluoride release. Integration of inorganic fluoride enlarged releasement. Most of the fluoride is already released during the setting reaction, followed by a lesser quantity of long-term fluoride release.^{8,26,27}

The amount of fluoride released from composite resins is significantly lower than that from glass-ionomer cements and compomers. Therefore, it is uncertain that fluoride-releasing composites can inhibit caries. Recently, numerous composite resins filled with fluoridated glass particles, which can give a similar level of fluoride release to compomers, have been developed. It is reported that these materials were effective in caries inhibition in vitro. However, it is questionable whether the composite resins filled with fluoridated glass particles can have a significant caries preventive effect over a longer period, because the quantity of fluoride ions released from these materials declines with the aging of the material and finally reaches a low level.^{23,28}

Ionomers: To be clinically successful, composites require a dry field after acid etching of the enamel surface. Because of these problems, glass ionomer cements (GICs), which have the distinct advantage of fluoride release, have been studied as another material for orthodontic bonding.²⁹⁻³¹

Diversity of ions are released from the glass including fluoride during reaction phase.^{8,26,29} Initial high release from glass-ionomers (first 24h) is possible due to the burst

of fluoride released from the glass particles when responding with the polyalkenoate acid through the setting response. It is known that the amount of released fluoride ions decreases subsequently to dental brushing. Studies have demonstrated that the increasing amount of fluoride ions released from GICs, after short time, is distribution measured and follows a decreasing gradient. In this manner, the initial high quantities of fluoride quickly decrease after 24h.⁸

The advantages of glass ionomers are the physiochemical bond of tooth through the absorption of calcium in teeth to carboxylate groups in the reacted GIC, and fluoride released or recharged. GIC also bonds to nonprecious metals and plastics and does not require a completely dry bonding field, as do resin-based composite materials. Despite the advantages of GIC, it has some inadequacies with orthodontic procedures for bonding. Research has demonstrated poor bond strength with GICs, about 2.4 to 5.5 MPa, by using either phosphoric or polyacrylic acids. GICs also have a greater rate of bonding failure than composite resin systems.³⁰

Resin-modified glass ionomer: GICs are sensitive to moisture as well as dehydration conditions while placing, and they have demonstrated poor physical and mechanical properties at setting. It was reported that, with the addition of a small amount of light-cured composite resin, poor early physical and mechanical properties of GICs could be improved. These improvements were combined in the material known as RMGI cement, introduced to the dental profession almost 20 years ago.³⁰

RMGIs were innovated by including methacrylate to the polyacrylic acid, which are light-cured.^{8,30} These materials have a true acid-base reaction on mixing, similar fluoride release and rechargeability as do GICs, but they will set on demand and are not nearly as sensitive to moisture or dehydration on setting as GICs. RMGIs also demonstrate better physical properties. Varied differences

of force in adhesion of RMGIs to dental structure range from 5.4 to 18.9 MPa.³⁰

Polyacid revised resins: To improve some properties such as tensile strength, manufacturers incorporated more amount of resin into GICs. These materials require enamel etching for adhesion. The name of these materials is polyacid modified composite resins (PMCRs), or compomers.⁸

Compomers contain macromonomers, such as bisphenol glycidyl dimethacrylate or urethane dimethacrylate, with low concentration of acid-functional monomers. Filler glass is equal to conventional GICs but in slighter dimensions as known from composites.⁸ These groups of materials do not release same amounts as GICs or RMGIs; however, some studies demonstrated fluoride release. Bond strengths for PMCRs have been reported to be 7.3 to 12.0 MPa.³⁰

Giomer: This is a new group of fluoride-containing esthetic materials for restoration. Giomer uses surface pre-reacted glass (S-PRG) technology. Manufacturers of gomers claim fluoride release, biocompatibility, and smooth surface. Their purported fluoride release and flexural strength, higher than RMGIs already prescribed in orthodontics, make these materials very attractive for research.³⁰

Adhesives: Advances in adhesive dentistry have led orthodontists to include new adhesives, composite resins, and bonding techniques into their clinical practices.³²⁻³⁵

The potential ability of fluoride release and absorption of orthodontic adhesives has attracted considerable interest for preventing enamel demineralization or white spot lesion formation.^{36,37} The fluoride in these materials induces an anticariogenic activity by increasing dentine resistance to acids present in the oral cavity. Adhesives with fluoride, have been shown to release ions with an initial burst at the time of curing, followed by a rapid decrease during subsequent days.^{10,38} Bioactive and antibacterial adhesives are considered useful to eliminate caries.^{35,39}

The use of adhesive systems in combination with fluoride releasing resins may reduce the caries inhibition effect. However, fluoride-releasing resin composites cannot be used without the application of the adhesive system because the bonding to dentine fails without such a system. Therefore, it becomes necessary to choose an adhesive system that reduces fluoride release as little as possible.^{2,35,40-42}

Self-etching primer (SEP) combines acid and primer in the same step, simplifies bonding procedures, reduces chair time, and avoids contamination.^{35,42,43}

Elastomeric ligatures: Fluoride-releasing elastomeric ligature ties containing tin fluoride (SnF₂) are currently available to orthodontists. An *in vitro* study has confirmed that the quantity of fluoride released initially by elastomeric ligature is high; however, levels dramatically decreased after seven days.⁴⁴ These materials may reduce salivary concentration of *Streptococcus mutans* (*S. mutans*), increase tooth resistance at 20 µm depth after a month in oral environment, and reduce decalcification during treatment.^{10,20} The use of 20 elastic modules releases 46.22 µgF/ml during the first five days, 1.42 µgF/ml after the second week, and 0.84 µgF/ml after the fourth week; recommending should be replaced monthly.⁴⁵

This does not seem to be an option with prolonged effects, but can be a preventive tool that may help to avoid problems of demineralization and dental caries during orthodontic treatment.

Discussion

Patients develop considerably more white spots lesions when they are under orthodontic treatment, which might compromise the good health and esthetic appearance of the subjects at the end of the active treatment. Furthermore, the evolution of caries occurs sooner in patients with brackets. White spots lesions can convert visible around the brackets within 30 days after bonding bracket (formation of caries

generally takes 6 months).^{5,17} Thus, prompt diagnosis allows clinicians to perform minimally invasive therapy by using diverse agents for remineralizing to prevent progression of white spot lesions. In this context; patients undergoing orthodontic treatment should be instructed perfectly for brushing with fluoride containing toothpaste and mouth rinse, and topical applications with varnish are highly recommended because several studies suggest that the enamel crown is an important reservoir for topically applied fluoride.^{9,10,18,19} It has been described that fluoride varnish applied before or at the moment of bracket bonding did not inhibit the bond strength.²⁰

On the other hand, before placing brackets, enamel has to be conditioned with conventional acid etching technique or SEPs;^{42,43} selective etch or self-etch are both good alternatives specially if the bonding systems contain fluoride to prevent undesirable formation of white spot lesions. Moreover, composite resins or glass ionomers can be used for bonding orthodontic brackets. Both materials are fabricated with different presentation of fluoride (inorganic salts, leachable glasses, fillers, or organic fluoride). Most of the fluoride is already released during the setting reaction, followed by a smaller amount of long-term fluoride release.^{8,26,27} However, GICs are more effective to release fluoride ions.²⁹⁻³¹

For these reasons, in effort to obtain the best bonding properties of composite resins and more fluoride released as GICs, RMGI cements have been developed that are suitable materials for placing brackets. Bonding brackets with PMCRs are possible; although these modified composites are non-fluoride releasing materials. Moreover, giomers are another option for bonding orthodontics brackets, because this kind of composite modified resin, fabricated with S-PRG technology, increases fluoride ions released from the particles while keeping bond strengths.³⁰

In any case, fluoride releasing materials might perform as a reservoir for ions of

fluoride from topical source. Elastomeric ligatures for tying arch wires are another orthodontic material that can release fluoride and improve the concentration of ions in the mouth and prevent decalcification.⁴⁴

After all, it is not clear whether initial burst or long-term release may be clinically more important to prevent caries, as certain remineralizing mechanisms need rather low but constantly provided quantities of fluoride. Further studies are necessary to understand the release mechanism and improve white spot lesions prevention during orthodontic active treatment.

Conclusion

According to this literature review, it can be

concluded that patients receiving fixed orthodontic treatment should be instructed in a proper brushing technique using a fluoride containing toothpaste; and high risk patients should be bonded with fluoride releasing agent. Additionally, it is recommended to apply fluoride varnish periodically during orthodontic treatment. These groups of dental materials are prescribed to prevent undesirable white spot lesions during orthodontic active treatment.

Conflict of Interests

Authors have no conflict of interest.

Acknowledgments

None.

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