

Impact of Fluoride-Free Dentifrices on White Spot Lesions in Patients Undergoing Orthodontic Treatment

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ABSTRACT

White spot lesions are a clinically significant complication of fixed orthodontic treatment, arising from enamel demineralization associated with dental plaque accumulation around orthodontic brackets. Fluoride-free dentifrices have attracted interest as alternative oral-care products because of their potential to support enamel protection through nonfluoride mechanisms. However, their comparative effectiveness in preventing white spot lesions requires careful assessment of clinical outcomes, product composition, patient adherence, and the quality of available evidence. This review examines the conceptual basis for using fluoride-free dentifrices during orthodontic treatment, emphasizing enamel demineralization and remineralization, plaque-related risk, and the distinction between preventing new lesions and managing established lesions. The supplied literature provides important background on dental hard-tissue changes, diagnostic assessment, and oral health-related quality of life, while a directly relevant systematic review by Bhate et al. (2026) provides the central reference for the review question. The available reference information does not provide sufficient trial-level data to establish the superiority of a particular fluoride-free formulation or to quantify its preventive effect. Accordingly, this article presents a critical, evidence-oriented synthesis rather than a new systematic review or an independently conducted clinical trial. It highlights the need for standardized lesion assessment, clearly defined comparators, adequate follow-up, and transparent reporting of adverse outcomes and adherence. Fluoride-free dentifrices should be evaluated according to demonstrated clinical effectiveness rather than product claims alone, and their use should be considered in the context of individualized caries-risk assessment and established preventive care.

Keywords: Fluoride-free dentifrices, white spot lesions, fixed orthodontic treatment, enamel demineralization, remineralization, dental plaque, orthodontic brackets, preventive dentistry, clinical evidence.

INTRODUCTION

1.1 Problem statement

Fixed orthodontic appliances improve dental alignment and occlusal relationships, but brackets, archwires, and associated components create plaque-retentive areas that complicate oral hygiene. When plaque accumulates around bracket margins, bacterial metabolism and local acid production can shift the balance between enamel mineral loss and mineral recovery. Repeated periods of demineralization may produce opaque white areas that become visible after appliance removal. These white spot lesions can compromise the aesthetic outcome of otherwise successful orthodontic treatment.

The clinical challenge is not simply to remove plaque but to maintain a favorable mineral balance throughout treatment. Preventive approaches must therefore

consider oral hygiene, dietary exposures, salivary conditions, the properties of dentifrices, and individual susceptibility. Research on tooth surface changes and their clinical assessment emphasizes that hard-tissue alterations require appropriate diagnosis and interpretation rather than reliance on appearance alone (Kelleher and Bishop, 1999; Wetselaar et al., 2020).

1.2 Research relevance

Fluoride-free dentifrices represent a heterogeneous category rather than a single intervention. Different products may contain calcium-phosphate compounds, hydroxyapatite, other mineral-based ingredients, or agents intended to influence plaque control. Their mechanisms and clinical effects cannot be assumed to be equivalent. A formulation that improves laboratory measures of mineral deposition may not necessarily prevent clinically detectable lesions under the complex conditions of fixed orthodontic treatment.

Bhate et al. (2026) directly address the topic through a systematic review of randomized controlled trials examining nonfluoridated dentifrices in fixed orthodontic patients. This work provides a relevant starting point for evaluating whether nonfluoridated products offer measurable preventive benefits. Nevertheless, interpretation requires attention to the included trials, comparator products, outcomes, and uncertainty surrounding effect estimates.

1.3 Objectives, scope, and significance

This review aims to examine the theoretical basis of fluoride-free dentifrice use, assess the relevance and limitations of the supplied literature, identify methodological requirements for valid comparisons, and outline implications for clinical practice and future research. The supplied references include several publications on tooth wear and oral health-related quality of life that provide contextual information but do not directly establish the efficacy of fluoride-free dentifrices against orthodontic white spot lesions.

The central research question is: How effectively do fluoride-free dentifrices prevent white spot lesions during fixed orthodontic treatment compared with appropriate alternative dentifrices and preventive approaches? The answer must distinguish direct clinical evidence from indirect biological reasoning and avoid treating the absence of sufficient evidence as proof of ineffectiveness.

LITERATURE REVIEW

2.1 Enamel demineralization and the biological basis of white spot lesions

Enamel is a mineralized tissue whose integrity depends on the balance between mineral dissolution and mineral recovery. During fixed orthodontic treatment, plaque accumulation around brackets can expose enamel to repeated acidic conditions. If mineral loss exceeds recovery over time, subsurface porosity develops and alters the optical properties of enamel, producing the characteristic white appearance.

This process should be distinguished from erosive tooth wear. Erosion involves chemical dissolution associated with nonbacterial acids, while attrition and abrasion involve mechanical loss of dental hard tissue. Addy and Shellis (2006), Carvalho et al. (2014), and Leven and Ashley (2023) provide context for understanding different forms of tooth surface damage and their preventive implications. However, these publications should not be interpreted as direct evidence that a particular fluoride-free dentifrice prevents orthodontic white spot lesions.

The distinction matters because different mechanisms require different preventive strategies. A product that

helps protect against erosive tissue loss may not necessarily control plaque-associated demineralization around orthodontic brackets. Likewise, evidence of reduced surface wear cannot automatically be translated into evidence of fewer white spot lesions.

2.2 Fluoride-free dentifrices and proposed mechanisms

Fluoride-free dentifrices may use different strategies to support enamel protection. Depending on the formulation, these can include supplying calcium- and phosphate-containing materials, depositing mineral-like particles on enamel, supporting surface remineralization, or contributing to oral cleanliness through the dentifrice base and brushing process. The presence of a proposed mechanism, however, does not establish clinical effectiveness.

Three levels of evidence should be distinguished. First, laboratory studies may demonstrate changes in mineral deposition, surface hardness, or enamel characteristics under controlled conditions. Second, clinical studies may measure changes in lesion appearance, fluorescence, or mineral-related indicators. Third, prevention trials should determine whether the product reduces the development or progression of clinically relevant lesions during actual orthodontic treatment. Evidence at one level cannot automatically substitute for evidence at another.

Bhate et al. (2026) is particularly relevant because it specifically examines nonfluoridated dentifrices in fixed orthodontic patients through a systematic review of randomized controlled trials. The full trial-level findings and effect estimates are not reproduced in the supplied reference information, so no specific magnitude of benefit or ranking among formulations can be responsibly asserted here.

2.3 Diagnostic assessment and outcome selection

Valid comparisons depend on consistent lesion diagnosis. Wetselaar et al. (2020) and Wetselaar et al. (2023) discuss diagnostic frameworks for tooth wear, illustrating the wider importance of explicit definitions and standardized clinical assessment. These publications concern tooth wear rather than orthodontic white spot lesions, so their diagnostic systems should not be applied directly to the latter. Their broader methodological relevance is that clinical outcomes require operational definitions, examiner consistency, and appropriate interpretation.

For white spot lesion studies, outcomes may include the number of newly developed lesions, lesion severity, changes in lesion area, or changes in optical or fluorescence-based measurements. These endpoints are related but not interchangeable. A reduction in lesion severity does not necessarily demonstrate prevention of lesion occurrence, while a change in an instrument-based measurement does not always indicate a clinically meaningful aesthetic improvement.

2.4 Patient experience and clinical significance

Clinical success should not be judged exclusively by instrumental measurements. Dental appearance can influence patient satisfaction and perceived oral health, although the supplied publications on quality of life predominantly concern tooth wear. Al-Omiri et al. (2006), Li and Bernabé (2016), Papagianni et al. (2013), and Mehta et al. (2020) address the relationship between tooth wear and aspects of daily living or oral health-related quality of life. Their findings provide contextual support for considering patient-centered outcomes, not direct proof of the impact of orthodontic white spot lesions.

For orthodontic research, patient-reported aesthetic concerns, satisfaction, and treatment experience may complement clinical assessments. Nevertheless, these outcomes should be measured with validated instruments and interpreted separately from biological endpoints.

2.5 Research gaps and theoretical positioning

The principal gap is the need to determine whether specific fluoride-free formulations produce reliable preventive benefits under routine orthodontic conditions. Important questions include whether effects differ by formulation, baseline caries risk, oral hygiene, treatment duration, adherence, and the preventive measures used alongside the dentifrice.

The evidence must also distinguish superiority from noninferiority and equivalence. A product that performs similarly to a comparator in a small or imprecise trial cannot automatically be declared equivalent. Such conclusions require suitable study designs and prespecified statistical criteria. The present review therefore adopts a risk-based, comparative framework in which product composition, biological plausibility, clinical outcomes, and certainty of evidence are assessed separately.

METHODOLOGY

3.1 Review design

This article uses a structured narrative review approach based exclusively on the references supplied by the user. It does not claim to be a newly conducted systematic review, meta-analysis, or clinical trial. No new database searches, independent screening procedures, or statistical analyses are reported. This distinction is important because a publishable systematic review requires a reproducible search strategy, documented eligibility criteria, study selection, data extraction, and a formal assessment of methodological quality.

The literature was conceptually organized into four

domains: biological mechanisms of dental hard-tissue change; diagnostic and outcome assessment; patient-centered implications; and direct evidence concerning nonfluoridated dentifrices in fixed orthodontic patients. Bhate et al. (2026) was identified as the most directly relevant supplied reference for the central question.

3.2 Eligibility and relevance framework

The references were assessed according to their relevance to the research question rather than treated as equally applicable evidence. Publications specifically addressing nonfluoridated dentifrices in fixed orthodontic patients are directly relevant. Publications concerning general tooth wear, erosion, diagnosis, or quality of life are indirect sources that can clarify terminology and broader clinical considerations but cannot independently establish preventive efficacy against orthodontic white spot lesions.

No supplied reference was excluded from the final reference list. Instead, its evidential role was distinguished in the synthesis. This approach preserves the requested bibliography while avoiding the methodological error of presenting indirect evidence as though it were derived from orthodontic prevention trials.

3.3 Comparative assessment framework

The comparison was structured around five dimensions.

First, intervention characteristics include the active ingredients, concentration where applicable, formulation, and recommended use. The term fluoride-free alone does not adequately describe a product or predict its effectiveness.

Second, comparators must be clearly defined. Comparisons against fluoride-containing dentifrices, another fluoride-free product, or routine oral hygiene without a specified alternative address different clinical questions. Comparator selection affects how results should be interpreted.

Third, clinical outcomes should distinguish incident lesions, lesion progression, lesion severity, and changes in instrumental measurements. The timing of baseline and follow-up assessments must also be considered.

Fourth, implementation factors include brushing frequency, adherence, dietary exposure, plaque control, baseline susceptibility, and concurrent preventive care. These factors may influence outcomes independently of the dentifrice.

Fifth, certainty and applicability depend on sample size, randomization, allocation procedures, examiner blinding, follow-up duration, missing data, and consistency across trials. Where such information is unavailable, the appropriate conclusion is uncertainty rather than an assumed positive or negative effect.

3.4 Analytical procedure

The synthesis used a qualitative comparison of the conceptual and clinical relevance of the supplied references. No pooled effect size, statistical significance test, or numerical efficacy estimate was calculated because trial-level data were not supplied. Hypothetical clinical situations are used only to illustrate how findings should be interpreted; they are not presented as observations from actual patients.

The main methodological limitation is that the reference list is weighted toward tooth wear and related outcomes rather than the specific prevention of orthodontic white spot lesions. Consequently, the conclusions are framed as an evidence-oriented clinical interpretation, not as a definitive estimate of comparative efficacy.

RESULTS

4.1 Evidence relevance and interpretation

The synthesis identified an important distinction between literature that explains dental hard-tissue changes and literature that directly evaluates fluoride-free dentifrices for orthodontic lesion prevention. The supplied references on tooth wear, erosion, diagnostic classification, and quality of life contribute background knowledge, but they do not provide a sufficient basis for estimating the preventive effectiveness of nonfluoridated dentifrices during fixed orthodontic treatment.

The most directly relevant reference is the systematic review by Bhate et al. (2026), which specifically addresses nonfluoridated dentifrices in fixed orthodontic patients. Its topic and review design make it central to the research question. Nevertheless, because the supplied citation does not include the review's detailed results, trial characteristics, pooled estimates, or certainty assessments, this article cannot responsibly report a numerical reduction in white spot lesions or identify a superior product.

4.2 Comparative outcome considerations

A valid comparison must distinguish prevention from treatment. Preventing new lesions requires assessment of lesion incidence during orthodontic treatment, whereas treating existing lesions requires evaluation of their subsequent appearance, severity, or structural characteristics. Combining these outcomes can obscure clinically important differences.

Similarly, findings based on laboratory measures should not be interpreted as equivalent to reductions in clinically visible lesions. A hypothetical product may improve an enamel surface measurement without demonstrating a meaningful reduction in lesion occurrence. Conversely, a

clinical trial may detect fewer new lesions but remain inconclusive because of a small sample or substantial loss to follow-up.

4.3 Factors affecting real-world performance

Product performance is likely to be influenced by adherence, brushing quality, plaque accumulation, dietary habits, baseline caries risk, and concurrent preventive care. These variables should be documented and, where appropriate, controlled in comparative studies. Without such information, an observed difference between groups cannot necessarily be attributed exclusively to dentifrice composition.

4.4 Overall interpretation

The principal finding of this evidence-oriented synthesis is methodological rather than quantitative: the supplied material supports a rationale for evaluating fluoride-free dentifrices, but it does not independently establish their comparative clinical effectiveness. The direct systematic review by Bhate et al. (2026) warrants detailed examination of its full results before definitive conclusions are drawn. Claims of superiority, equivalence, or reliable prevention should therefore remain conditional on the actual clinical evidence.

DISCUSSION

5.1 Interpretation of the evidence

The central issue in evaluating fluoride-free dentifrices is whether a plausible biological mechanism translates into a measurable clinical benefit. Mineral-containing formulations may be designed to support enamel surface protection or mineral recovery, but effectiveness depends on formulation-specific properties, conditions of use, and the outcome being measured. It is therefore inappropriate to treat all nonfluoridated products as a single therapeutic class.

Bhate et al. (2026) provides the most directly relevant evidence source among the references supplied because it specifically evaluates nonfluoridated dentifrices in fixed orthodontic patients. However, the citation alone cannot establish the direction or magnitude of its findings. A rigorous interpretation would require examination of the included randomized trials, the nature of their interventions and comparators, risk-of-bias assessments, and consistency of results. This limitation prevents the present article from asserting that fluoride-free dentifrices are either superior or inferior to other preventive approaches.

The broader literature reinforces the importance of maintaining distinctions between different dental conditions. Addy and Shellis (2006) discuss interactions among attrition, abrasion, and erosion, while Carvalho et al. (2014) and Leven and Ashley (2023) address erosive tooth wear and its prevention. These works are useful for differentiating forms of hard-tissue damage, but they do not directly answer whether a

nonfluoridated dentifrice prevents plaque-associated white spot lesions around orthodontic brackets.

5.2 Clinical implications

For clinicians, the practical priority is to select preventive care according to the patient's clinical risk and the strength of the available evidence. Fixed orthodontic appliances complicate plaque removal, making oral hygiene instruction, monitoring, and appropriate preventive planning important throughout treatment. A fluoride-free dentifrice should not be assumed to provide equivalent protection merely because it contains ingredients associated with enamel mineralization.

Patients who prefer nonfluoridated products may require a careful discussion of the reasons for that preference, the evidence available for the specific formulation, and their individual susceptibility to caries. Any decision should distinguish a patient's preference from a demonstrated clinical outcome. Where caries risk is elevated, clinicians should not allow an unverified product claim to displace established preventive measures without an appropriate assessment.

The possible benefit of fluoride-free formulations is best considered in terms of their demonstrated role within a broader preventive plan. For example, a patient with excellent plaque control and low baseline risk may have a different absolute risk profile from a patient with frequent plaque accumulation and previous caries. Even if a relative treatment effect were similar in both groups, their absolute benefits could differ. The available information does not permit those benefits to be quantified.

5.3 Methodological trade-offs

Research comparing dentifrices faces several design challenges. Blinding may be complicated by differences in taste, texture, or product labeling. Adherence can vary between participants, while dietary exposures and oral hygiene behaviors may change during treatment. In addition, differences in lesion scoring and follow-up periods can make study results difficult to compare.

A clinically meaningful evaluation should specify whether its primary outcome is the development of new lesions, progression of existing lesions, or improvement in lesion appearance. Studies should also report baseline risk, orthodontic treatment duration, adherence, co-interventions, adverse effects, and losses to follow-up. When outcomes are assessed visually or with instruments, examiner calibration and measurement reliability are important to reduce the possibility that apparent differences reflect inconsistent assessment.

Statistical interpretation requires similar caution. Failure to identify a statistically significant difference does not

demonstrate that two products are equivalent. Conversely, a statistically significant difference does not necessarily imply a meaningful clinical benefit. Confidence intervals, effect sizes, prespecified outcomes, and an assessment of clinical relevance are needed for sound conclusions.

5.4 Patient-centered outcomes

The aesthetic consequences of white spot lesions may influence satisfaction with orthodontic treatment. The supplied studies on tooth wear and quality of life, including Al-Omiri et al. (2006), Li and Bernabé (2016), and Papagianni et al. (2013), illustrate the relevance of considering patients' experiences alongside clinical findings. Nevertheless, these studies concern tooth wear and cannot directly establish the magnitude of quality-of-life effects attributable to orthodontic white spot lesions.

Future trials should therefore combine objective lesion assessment with validated patient-reported outcomes. This would help establish whether any reduction in lesion severity corresponds to improvements that patients can perceive and value.

5.5 Limitations and future research

The principal limitation of this review is the restricted relevance of much of the supplied bibliography to the specific research question. Several references address tooth wear rather than orthodontic white spot lesions, and the citation for Bhate et al. (2026) is not accompanied by its detailed findings. No independent search, formal risk-of-bias assessment, or quantitative synthesis was performed. Accordingly, this paper should be understood as a structured narrative analysis, not as a substitute for the cited systematic review.

Future research should directly compare well-characterized fluoride-free formulations with clearly specified control products. Trials should use standardized lesion definitions, adequate follow-up, transparent reporting, and appropriate statistical methods. They should also assess whether any observed benefit varies according to baseline risk, adherence, and concurrent preventive care. Independent replication would strengthen confidence in formulation-specific findings and help determine whether results are applicable across different orthodontic populations.

CONCLUSION

Fluoride-free dentifrices represent a diverse group of oral-care products with potentially different mechanisms of action and clinical effects. Their role in preventing white spot lesions during fixed orthodontic treatment should be determined through formulation-specific clinical evidence rather than generalized assumptions about mineral deposition or enamel protection. The biological rationale for evaluating these products is relevant, but biological plausibility alone cannot demonstrate prevention of clinically significant lesions.

The supplied literature contributes useful background on dental hard-tissue changes, diagnostic assessment, and patient-centered outcomes. However, the systematic review by Bhate et al. (2026) is the most directly relevant reference for the comparative effectiveness question. Its detailed findings must be examined before any firm conclusion can be drawn regarding superiority, equivalence, or the magnitude of benefit associated with nonfluoridated dentifrices.

Clinically, prevention should remain individualized and should incorporate plaque control, appropriate oral hygiene, dietary counseling, risk assessment, and professional monitoring. Fluoride-free products should be selected with attention to their specific evidence base and the patient's preventive needs. Future research should prioritize standardized outcomes, adequately powered randomized trials, transparent reporting, and assessment of both clinical effectiveness and patient experience. Such work would help clarify which formulations, if any, provide meaningful additional benefits during fixed orthodontic treatment.

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