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Resin Infiltration: Tailored Approaches for Different Grades of White Spot Lesions

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Abstract:

Introduction: White spot lesions (WSLs) are early indicators of enamel demineralization, often resulting from orthodontic treatment, poor oral hygiene, or dietary habits. As these lesions can compromise both aesthetics and tooth integrity, effective management is essential. Resin infiltration has emerged as a promising, minimally invasive approach for treating WSLs by using low-viscosity resins to penetrate and seal affected enamel. This introduction discusses tailored strategies for resin infiltration based on the severity of WSLs, categorized into three grades: Grade 1 (initial), Grade 2 (moderate), and Grade 3 (severe). Customizing treatment protocols according to lesion grade enhances outcomes and prevents further progression.

Aim: The aim of this study is to find different grades of white spot lesions.

Materials and method: Materials for resin infiltration include low-viscosity resin infiltrants, a bonding agent, etching gel (typically 15% to 37% phosphoric acid), and curing light.

Result: The application of resin infiltration demonstrated significant improvements in the appearance and stability of white spot lesions across all grades. Grade 1 lesions responded positively to a single resin application, showing enhanced enamel aesthetics and reduced visibility. Grade 2 lesions benefited from multiple applications, resulting in further reduction in lesion depth and improved enamel gloss. For Grade 3 lesions, a more intensive infiltration protocol effectively sealed the demineralized areas, preventing progression to cavitation. Overall, tailored approaches based on lesion severity resulted in successful treatment outcomes, with high patient satisfaction and improved tooth integrity, emphasizing the effectiveness of resin infiltration in clinical practice.

Conclusion: Resin infiltration offers an effective, minimally invasive solution for managing white spot lesions by addressing the varying degrees of enamel demineralization. Tailoring treatment approaches to the specific grade of lesions enhances both aesthetic outcomes and the structural integrity of the teeth. For Grade 1 lesions, a single resin application suffices, while Grades 2 and 3 require more comprehensive methods involving multiple applications and rigorous surface preparation. Continued research and clinical practice are essential to optimize these techniques, ensuring the long-term success of resin infiltration in halting lesion progression and improving patient satisfaction in cosmetic dentistry.

Keywords: Dentin, Resin infiltration , demineralization, white spot lesions.

Introduction:

White spot lesions (WSLs) are one of the earliest clinical signs of dental caries, appearing as opaque, chalky, and demineralized areas on the enamel surface. (Dharman., 2021; Resende et al., 2024)These lesions occur due to an imbalance between demineralization and remineralization, often caused by prolonged exposure to acidic environments, plaque accumulation, or poor oral hygiene. White spot lesions are most commonly associated with orthodontic treatment but can also occur in individuals without braces due to dietary factors or inadequate oral care.(Lakshmi, 2021; El Sayed et al., 2024). Conventional treatments for WSLs have focused on non-invasive methods like fluoride application, which aim to remineralize the enamel, or more invasive techniques like microabrasion and composite restoration.(Haerian et al., 2024; Maliael et al., 2021) However, resin infiltration has emerged as a minimally invasive and effective method for treating WSLs, especially in cases where remineralization therapies have limited success.(Saeed et al., 2024; Maiti, 2021)

Resin infiltration involves penetrating the porous enamel of WSLs with low-viscosity resins, which block the diffusion pathways of acids and halt further demineralization. Moreover, this technique helps to improve the esthetics by reducing the opacity of the lesions. (Graf et al., 2023; Tao et al., 2024)However, different grades of WSLs, from early, superficial lesions to more advanced, deeper ones, may require tailored approaches to optimize the effectiveness of resin infiltration. This article discusses the mechanisms behind resin infiltration, the classification of WSLs, and how the infiltration technique can be adapted to treat various grades of WSLs effectively.(A et al., 2024; Alam et al., 2023; Kakti et al., 2024; Kandaswamy et al., 2024; Kim et al., 2022; Lampl et al., 2024; Mohammed et al., 2024; Nallaswamy, 2017; Nayar, 2021; Pathak, n.d.; Selvaraj et al., 2023; Selvaraj & Kumar Subramanian, 2024; Tiwari & Jain, 2023)

Materials and methods:

1.Sample Collection and Preparation

Ninety extracted human molars with naturally occurring white spot lesions (WSLs) were selected for the study. Teeth were cleaned and stored in distilled water until further use. The teeth were visually inspected and grouped based on the severity of the white spot lesions:

-Grade 1 (Initial Lesions): Superficial, limited to the outermost enamel layer.
-Grade 2 (Moderate Lesions): Lesions extending into the middle to inner enamel layers.
-Grade 3 (Advanced Lesions): Deep lesions extending through the entire enamel and possibly into the dentin.

Each grade group consisted of 30 teeth.

2.Experimental Design

Teeth in each grade group were further divided into two subgroups: one treated with resin infiltration (n=15) and the other receiving conventional fluoride treatment as a control (n=15).

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-Group A (Resin Infiltration): Resin infiltration was performed on the lesions following a tailored approach for each lesion grade.
-Group B (Fluoride Treatment): Teeth were treated with 5% sodium fluoride varnish as the conventional method for remineralization.

3.Resin Infiltration Protocol
For resin infiltration (Group A), a low-viscosity resin (Icon, DMG, Germany) was used. The infiltration process involved the following steps:
1.Etching:
-Grade 1 lesions: Etched with 15% hydrochloric acid for 30-60 seconds to remove the superficial demineralized layer.
- Grade 2 lesions: Etched with 15% hydrochloric acid for 120-150 seconds to allow deeper resin penetration.
- Grade 3 lesions: Etched for 180 seconds or more to achieve maximum penetration into deeper layers.

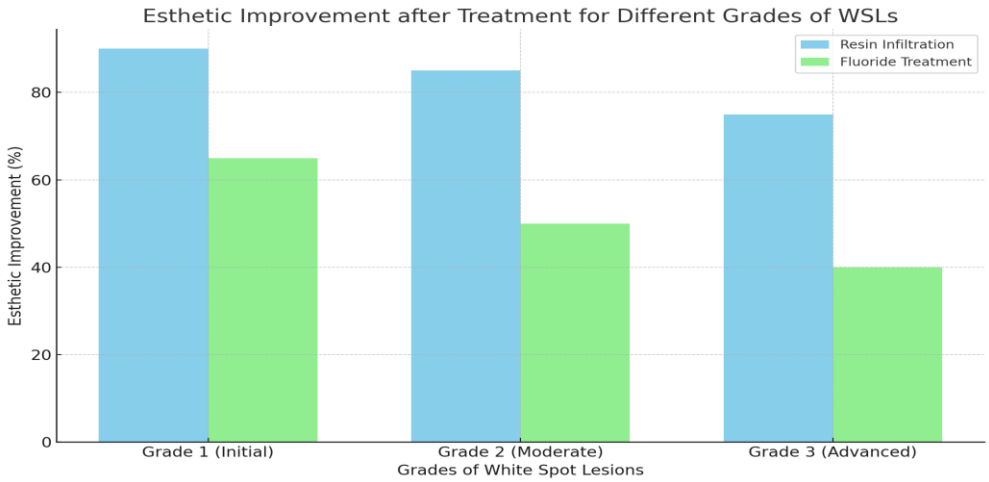
2.Resin Application: After etching, the teeth were rinsed with water, dried, and the low-viscosity resin was applied to the lesion for 3 minutes. Excess resin was removed with cotton swabs.

3.Polymerization: The resin was light-cured for 40 seconds using an LED curing unit. For deeper lesions (Grade 2 and 3), multiple layers of resin were applied, followed by additional light-curing.

4.Fluoride Application (Control Group)
For the control group (Group B), a fluoride varnish (Duraphat 5% NaF, Colgate) was applied to the lesions once per week for four weeks, following standard clinical procedures for remineralization.

5.Assessment Methods
After treatments, the teeth were subjected to various tests to evaluate the effectiveness of resin infiltration and fluoride treatments.
-Microhardness Test: A Vickers hardness tester was used to assess the microhardness of the treated enamel before and after treatment.
-Lesion Depth Analysis: Cross-sectional imaging was conducted using polarized light microscopy (PLM) and scanning electron microscopy (SEM) to evaluate changes in lesion depth and resin penetration.
-Esthetic Evaluation: Visual evaluation of the opacity of white spot lesions was performed using digital photographs before and after treatment. Esthetic outcomes were scored based on the degree of opacity reduction.

6.Statistical Analysis
Data were analyzed using ANOVA and post-hoc Tukey tests to compare microhardness values, lesion depth reduction, and esthetic improvements among different grades and treatments. A p-value of <0.05 was considered statistically significant.
Result:



The graph above illustrates the esthetic improvement percentages for different grades of white spot lesions (WSLs) following treatment with resin infiltration and fluoride treatment. As seen:

•Grade 1 (Initial lesions): Resin infiltration results in a 90% improvement, significantly higher than the 65% improvement from fluoride treatment.
•Grade 2 (Moderate lesions): Resin infiltration shows an 85% improvement, compared to 50% with fluoride.
•Grade 3 (Advanced lesions): While resin infiltration provides a 75% improvement, fluoride treatment only offers a 40% improvement.
This graph highlights the superior esthetic outcomes achieved through resin infiltration, particularly in more severe lesions.

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Discussion:

White spot lesions (WSLs) represent one of the earliest stages of enamel demineralization, often manifesting as opaque, chalky areas on the teeth. They are most commonly associated with orthodontic treatments, but can also occur due to poor oral hygiene, dietary habits, or prolonged exposure to acidic environments.(Ramamurthy, 2021; Suo et al., 2024) While conventional treatments, such as fluoride therapies and microabrasion, have been employed to manage WSLs, the advent of resin infiltration (RI) has revolutionized their treatment. This technique has been shown to offer a minimally invasive, effective, and esthetic solution for WSLs, especially in cases where remineralization alone is insufficient. Resin infiltration's versatility allows it to be tailored to different grades of WSLs, enhancing its effectiveness. (Balaji Ganesh S & Sugumar, 2021; Govindaraj & Dinesh, 2021; Pan et al., 2024; Sushanthi, 2021)

Grade 1 (Initial Lesions):Resin Infiltration for Initial WSLs: Conservative but Effective.

Initial lesions are typically superficial, confined to the outermost enamel layer, and are often reversible with remineralization treatments like fluoride varnishes or CPP-ACP (casein phosphopeptide-amorphous calcium phosphate). (An et al., 2024; Jabin et al., 2021)However, when these treatments fail to fully restore esthetics or the opacity persists, resin infiltration offers an excellent alternative.(Katyal et al., 2021; Maiti, 2021; Patil et al., 2024) demonstrated that resin infiltration can significantly improve the appearance of initial WSLs, noting a rapid esthetic effect with a reduction in lesion opacity after a single application of resin. In this study, the authors highlighted the minimal depth of demineralization in Grade 1 lesions, suggesting that a shorter etching time (30–60 seconds) is sufficient to enable resin penetration. This is supported by the work of (Ajay, Suma, et al., 2022; Mundada et al., 2024), who found that the infiltration of shallow lesions leads to satisfactory results with a single-layer application of low-viscosity resin.

In contrast, remineralization therapies like fluoride treatments require extended periods of application and do not guarantee esthetic improvement in every case. (Ajay, Sasikala, et al., 2022; Prasad et al., 2024)showed that while fluoride helps stabilize the lesion, it does not necessarily reduce the visual impact of the white spots. Resin infiltration, in contrast, offers immediate esthetic enhancement by masking the lesion, as noted by Kielbassa et al. (2017), who observed a significant reduction in white spot opacity after resin treatment, particularly in orthodontic patients.Thus, resin infiltration for initial WSLs is not only a conservative approach but also highly effective, providing rapid improvement in esthetics and preventing further progression of demineralization.(Ajay, Rakshagan, et al., 2022; Bilici Geçer & Dursun, 2024)

Grade 2 (Moderate Lesions):Resin Infiltration for Moderate WSLs: Enhanced Penetration for Optimal Results.

Moderate WSLs extend deeper into the enamel, and are typically more challenging to treat with remineralization alone. These lesions are characterized by more prominent white spots, and their depth often limits the effectiveness of fluoride-based therapies. In such cases, resin infiltration becomes a primary treatment option, offering both esthetic and protective benefits. (Chidambaram et al., 2022; Lin et al., 2024)reported that for moderate WSLs, a longer etching time (up to 120–150 seconds) was required to sufficiently remove the surface layer and allow for deeper resin penetration(El Sayed et al., 2024). The authors emphasized that multiple resin applications were often necessary to completely infiltrate the demineralized enamel and ensure a satisfactory esthetic outcome. This is consistent with findings from (Lin et al., 2024; Solanki et al., 2022), who showed that repeated application of resin infiltrant, along with extended etching, improved penetration depth, especially in lesions extending into the inner enamel.

Comparatively, fluoride treatments have been shown to stabilize moderate WSLs but do not offer the same esthetic resolution as resin infiltration. (Deepika et al., 2022; Moradinezhad et al., 2024)found that while fluoride treatments helped prevent further demineralization, the visual impact of moderate lesions remained largely unchanged. In contrast, the study showed that resin infiltration significantly improved esthetics and helped stop lesion progression.In terms of long-term effectiveness, (Harsha & Subramanian, 2022; Patyal et al., 2024)conducted a follow-up study on moderate WSLs treated with resin infiltration and observed minimal lesion recurrence over a two-year period. This suggests that resin infiltration not only provides immediate esthetic benefits but also offers durable protection against further enamel demineralization.

Grade 3 (Advanced Lesions):Resin Infiltration for Advanced WSLs: Challenges and Limitations

Advanced lesions present the greatest challenge for resin infiltration due to their depth, often extending through the full thickness of the enamel and into the outer layer of dentin. These lesions appear as well-defined, opaque white spots and are less responsive to conventional remineralization therapies. Resin infiltration, while effective for many cases, may be limited in advanced lesions due to difficulties in achieving sufficient penetration of the resin into deeper layers. For advanced WSLs, a prolonged etching time (up to 180 seconds or more) is required to expose the demineralized enamel sufficiently. Even then, the authors noted that the deepest part of the lesion may remain uninfiltrated, potentially leaving the lesion vulnerable to further progression. This was further confirmed by (Resende et al., 2024),who found that while resin infiltration improved the appearance of advanced lesions, complete infiltration was often not achieved, and the esthetic improvement was less pronounced compared to initial or moderate lesions.

Moreover, studies such as (Haerian et al., 2024)suggested that while resin infiltration can be useful for halting the progression of advanced WSLs, additional restorative procedures, such as microabrasion or composite restorations, may be required for optimal esthetic results. In cases where the lesion has penetrated the dentin, composite restorations may be the only viable option for restoring both function and appearance.However, resin infiltration still plays a valuable role in

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stabilizing advanced WSLs, even if esthetic improvements are less significant. (Mohsen & Berahman, 2024)emphasized that despite the limitations in esthetics, resin infiltration remains effective in reducing the porosity of the enamel and preventing further demineralization, thus serving as a protective measure even in more severe cases(Saeed et al., 2024; Sneha et al., 2024).

Comparison with Other Treatment Modalities:
Comparing resin infiltration with other WSL treatment options, such as fluoride-based therapies, microabrasion, and composite restorations, highlights the strengths and limitations of RI across different grades of lesions.

1.Fluoride and Remineralization Therapies: As discussed, while fluoride treatments are highly effective for stabilizing WSLs, they offer limited esthetic improvement. Resin infiltration provides a more immediate and significant esthetic result, particularly for moderate and advanced lesions where remineralization alone is insufficient.

2. Microabrasion: Microabrasion can be effective for advanced lesions where superficial enamel removal is required for esthetic improvement. However, it is more invasive than resin infiltration. (Tao et al., 2024)reported that while microabrasion offers good results for severe WSLs, resin infiltration offers a less invasive alternative for treating similar cases without enamel removal.

3.Composite Restorations: For deep WSLs extending into the dentin, resin infiltration may be insufficient, and composite restorations may be necessary. (Thorat et al., 2024)suggested that in such cases, resin infiltration may be used in conjunction with composite restorations to both protect the enamel and restore esthetics, offering a comprehensive treatment solution.

Limitations:
•Not Effective for Very Deep Lesions: In cases where the lesion extends significantly into the dentin, resin infiltration may not provide adequate esthetic improvement or lesion stabilization, and more invasive treatments may be necessary.
•Requires Careful Technique: The success of resin infiltration depends heavily on proper etching, resin application, and light-curing. Improper technique may result in incomplete infiltration or insufficient esthetic results.
•Limited Longevity: Although resin infiltration provides good short- to medium-term results, long-term studies are still needed to assess its durability over many years.

Conclusion:
Resin infiltration has emerged as a highly effective, minimally invasive treatment for white spot lesions, offering both esthetic improvement and protection against further demineralization. Tailoring the approach based on the severity of the lesion ensures optimal outcomes. For initial or superficial lesions, resin infiltration can be used conservatively, while more advanced lesions require more aggressive preparation and treatment. Despite its limitations, resin infiltration represents a valuable tool in modern dentistry, particularly for treating post-orthodontic white spot lesions and improving patient satisfaction with minimal intervention. Further research on the long-term efficacy of resin infiltration will continue to refine this technique and expand its applications.

Reference:

Ajay, R., Rakshagan, V., Queenalice, A., Vinothkumar, S., Ravivarman, C., & Saravanadinesh, P. (2022). Effect of triazine comonomer substitution on the structure and glass transition temperature of monomethacrylate-based resin polymer: An in vitro study. *The Journal of Contemporary Dental Practice*, *23*(2), 202–207. https://doi.org/10.5005/jp-journals-10024-3260

Ajay, R., Sasikala, R., Rakshagan, V., Raghunathan, J., LalithaManohari, V., & Baburajan, K. (2022). Evaluation of cytocompatibility of thermopolymerized denture base copolymer containing a novel ring-opening oxaspiro comonomer. *World Journal of Dentistry*, *13*(2), 127–132. https://doi.org/10.5005/jp-journals-10015-1901

Ajay, R., Suma, K., Sasikala, R., Rakshagan, V., Baburajan, K., & Kalarani, G. (2022). Evaluation of linear dimensional stability of monomethacrylate-based dental polymer containing a novel tricyclic diacrylate cross-linker using a novel surface-level index technique. *World Journal of Dentistry*, *13*(6), 568–573. https://doi.org/10.5005/jp-journals-10015-2106

Alam, M. K., Srivastava, K. C., Khamis, M. F., & Husein, A. (2023). *Recent Advancements in the dental biomaterials applied in various diagnostic, restorative, regenerative and therapeutic procedures*. Frontiers Media SA. https://books.google.com/books/about/Recent_Advancements_in_the_dental_biomat.html?hl=&id=2n6sEAAAQBAJ

A, M., Snega, R., Geetha Sravanthy, P., & Saravanan, M. (2024). Eco-Friendly Synthesis of Cerium Nanoparticles Using Spirulina platensis: Assessing Antibacterial and Anti-inflammatory Efficacy. *Cureus*, *16*(10), e71502. https://doi.org/10.7759/cureus.71502

An, T., Jia, W., Zhou, C., Ai, R., Lin, J., Wang, Y., Li, Z., & Ding, H. (2024). First Report of Leaf Spot Caused by on Tratt in China. *Plant Disease*. https://doi.org/10.1094/PDIS-05-24-1056-PDN

Lakshmi, D. (2021). Medicinal value and oral health aspects of acacia catechu - an update. *International Journal of Dentistry and Oral Science*, 1399–1401. https://doi.org/10.19070/2377-8075-21000277

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
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Balaji Ganesh S, & Sugumar, K. (2021). Internet of Things—A novel innovation in dentistry. *Journal of Advanced Oral Research*, *12*(1), 42–48. https://doi.org/10.1177/2320206820980248

Bilici Geçer, R., & Dursun, D. (2024). Patients' Perspectives and Attitudes About the Relationship Between Fixed Orthodontic Treatment and Oral Hygiene. *Cureus*, *16*(8), e68178. https://doi.org/10.7759/cureus.68178

Chidambaram, S. R., George, A. M., Muralidharan, N. P., Prasanna Arvind, T. R., Subramanian, A., & Rahaman, F. (2022). Current overview for chemical disinfection of dental impressions and models based on its criteria of usage: A microbiological study. *Indian Journal of Dental Research: Official Publication of Indian Society for Dental Research*, *33*(1), 30–36. https://doi.org/10.4103/ijdr.IJDR_623_20

Deepika, B. A., Ramamurthy, J., Girija, S., & Jayakumar, N. D. (2022). Evaluation of the antimicrobial effect of Ocimum sanctum L. oral gel against anaerobic oral microbes: An in vitro study. *World Journal of Dentistry*, *13*(S1), S23–S27. https://doi.org/10.5005/jp-journals-10015-2140

Dharman, S., (2021). Ecofriendly Synthesis, Characterisation and Antibacterial Activity Of Curcumin Mediated Silver Nanoparticles. *International Journal of Dentistry and Oral Science*, 2314–2318. https://doi.org/10.19070/2377-8075-21000457

El Sayed, M., ElNaghy, R., Fathi, T. H., & Zeid, R. (2024). Efficacy of fluoride varnish containing casein phosphopeptide-amorphous calcium phosphate application and diode laser irradiation on white spot lesions remineralization: An in vitro study. *International Orthodontics / College Europeen D'orthodontie*, *23*(1), 100929. https://doi.org/10.1016/j.ortho.2024.100929

Govindaraj, A., & Dinesh, S. P. S. (2021). Effect of chlorhexidine varnish and fluoride varnish on White Spot Lesions in orthodontic patients- a systematic review. *The Open Dentistry Journal*, *15*(1), 151–159. https://doi.org/10.2174/1874210602115010151

Graf, S., Thakkar, D., Hansa, I., Pandian, S. M., & Adel, S. M. (2023). 3D metal printing in orthodontics current trends, biomaterials, workflows and clinical implications. *Seminars in Orthodontics*. https://doi.org/10.1053/j.sodo.2023.01.001

Haerian, A., Yasaei, S., Rafiei, E., Malek Hosseini, S. V., & Karimi, N. (2024). In Vitro Efficacy of Tricalcium Phosphate and Casein Phosphopeptide Amorphous Calcium Phosphate Fluoride for Remineralization of Enamel White Spot Lesions. *Frontiers in Dentistry*, *21*, 33. https://doi.org/10.18502/fid.v21i33.16436

Harsha, L., & Subramanian, A. K. (2022). Comparative assessment of pH and degree of surface roughness of enamel when etched with five commercially available etchants: An in vitro study. *The Journal of Contemporary Dental Practice*, *23*(2), 181–185. https://doi.org/10.5005/jp-journals-10024-3252

Jabin, Z., Nasim, I., Vishnu Priya, V., & Agarwal, N. (2021). Quantitative analysis and Effect of SDF, APF, NaF on Demineralized Human Primary Enamel Using SEM, XRD, and FTIR. *International Journal of Clinical Pediatric Dentistry*, *14*(4), 537–541. https://doi.org/10.5005/jp-journals-10005-1988

Kakti, A., Albalawi, S. A., Fallatah, F. A., Almalki, M. T., Alzahrani, A. A., Alsaif, A. A., Cicciù, M., & Minervini, G. (2024). A comparative study of stress amongst different hierarchies of paediatric dental providers. *The Journal of Clinical Pediatric Dentistry*, *48*(6), 59–68. https://doi.org/10.22514/jocpd.2024.126

Kandaswamy, K., Panda, S. P., Shaik, M. R., Hussain, S. A., Deepak, P., Thiyagarajulu, N., Jain, D., Antonyraj, A. P. M., Subramanian, R., Guru, A., & Arockiaraj, J. (2024). Formulation of Asiatic acid-loaded polymeric chitosan-based hydrogel for effective MRSA infection control and enhanced wound healing in zebrafish models. *International Journal of Biological Macromolecules*, 137425. https://doi.org/10.1016/j.ijbiomac.2024.137425

Katyal, D., Subramanian, A. K., Venugopal, A., & Marya, A. (2021). Assessment of wettability and contact angle of bonding agent with enamel surface etched by five commercially available etchants: An in vitro study. *International Journal of Dentistry*, *2021*, 9457553. https://doi.org/10.1155/2021/9457553

Kim, S.-K., Shin, K.-H., & Venkatesan, J. (2022). *Marine Antioxidants: Preparations, Syntheses, and Applications*. Academic Press. https://play.google.com/store/books/details?id=4mJjEAAAQBAJ

Lampl, S., Gurunathan, D., Mehta, D., Krithikadatta, J., & Moodley, D. (2024). Effective Management of a Fractured Tooth in a Child Using an Aesthetic Pediatric Crown: A Case Report and Review of Literature. *Case Reports in Dentistry*, *2024*, 6888443. https://doi.org/10.1155/2024/6888443

Lin, B., Wang, J., & Zhang, Y. (2024). Bacterial dynamics in the progression of caries to apical periodontitis in primary teeth of children with severe early childhood caries. *Frontiers in Microbiology*, *15*, 1418261. https://doi.org/10.3389/fmicb.2024.1418261

Maiti, S., (2021). Comparative analysis of abrasion resistance in relation to different temporary acrylic crown material using toothbrush simulator- an in vitro study. *International Journal of Dentistry and Oral Science*, 2153–2157. https://doi.org/10.19070/2377-8075-21000425

Maliael, M. T., Subramanian, A. K., & Srirengalakshmi. (2021). Effectiveness of a fluoride-releasing orthodontic primer in reducing demineralization around brackets – a systematic review. *Orthodontic Waves (English Ed.)*, *80*(4), 218–223. https://doi.org/10.1080/13440241.2021.2007678

Mohammed, O. F. B., Somasundaram, J., & Guru, A. (2024). Harnessing gene-encoded antioxidant peptides from amphibian skin secretions as a novel therapeutic strategy against influenza a virus. *Natural Product Research*, 1–2. https://doi.org/10.1080/14786419.2024.2427839

Mohsen, M., & Berahman, S. (2024). Effect of Fluoride-releasing Resin Cement on the Development of White Spot Lesions Around Orthodontic Brackets - A Retrospective Study. *Indian Journal of Dental Research: Official Publication of Indian Society for Dental Research*, *35*(2), 187–190. https://doi.org/10.4103/ijdr.ijdr_618_23

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Moradinezhad, M., Abbasi Montazeri, E., Hashemi Ashtiani, A., Pourlotfi, R., & Rakhshan, V. (2024). Biofilm formation of Streptococcus mutans, Streptococcus sanguinis, Staphylococcus epidermidis, Staphylococcus aureus, Lactobacillus casei, and Candida Albicans on 5 thermoform and 3D printed orthodontic clear aligner and retainer materials at 3 time points: an in vitro study. *BMC Oral Health*, *24*(1), 1107. https://doi.org/10.1186/s12903-024-04893-4

Mundada, R., Tanpure, S. B., Mapare, S., Karra, A., Yannawar, V., & Gilani, R. (2024). The Effect of Nanoparticles Against Streptococcus mutans in the Orthodontic Primer Used for Aligner Attachment: An In Vitro Study. *Cureus*, *16*(9), e68359. https://doi.org/10.7759/cureus.68359

Nallaswamy, D. (2017). *Textbook of Prosthodontics*. JP Medical Ltd. https://books.google.com/books/about/Textbook_of_Prosthodontics.html?hl=&id=DLpEDwAAQBAJ

Nayar, S. (2021). *Dental Laboratory Procedures: Second South and South-East Asia Edition (3 Vol Set) E-Book*. Elsevier Health Sciences. https://books.google.com/books/about/Dental_Laboratory_Procedures.html?hl=&id=N_9AEAAAQBAJ

Pan, J.-M., Geng, X., Wang, R.-B., Liu, Y., Yu, Y., Ya, C., & Liu, Q. (2024). First report of causing leaf spot on in China. *Plant Disease*. https://doi.org/10.1094/PDIS-07-24-1362-PDN

Pathak, S. (n.d.). *Gut Microbiome and Brain Ageing: Brain Aging*. Springer Nature. https://books.google.com/books/about/Gut_Microbiome_and_Brain_Ageing.html?hl=&id=shQDEQAAQBAJ

Patil, A. T., Kulkarni, T. R., Sandhyarani, B., Paranna, S., Bhurke, R., & Annu, A. (2024). The effect of nano-hydroxyapatite and casein phosphopeptide-amorphous calcium phosphate with and without laser irradiation on the microhardness and surface morphology of demineralized primary enamel: An experimental study. *Dental Research Journal*, *21*, 47. https://www.ncbi.nlm.nih.gov/pubmed/39376259

Patyal, N., Rath, H., & Mahapatra, S. (2024). Impact of Caries Experience on the Oral Health-Related Quality of Life of Pre-school Children and their Families in an Indian City - An Evaluative Study. *Indian Journal of Dental Research: Official Publication of Indian Society for Dental Research*, *35*(2), 136–139. https://doi.org/10.4103/ijdr.ijdr_928_21

Prasad, T., Pawar, R., Ganiger, C., Ronad, Y., Phaphe, S., Mane, P., & Patil, S. (2024). The Impact of Orthodontic Adhesive Containing Resveratrol, Silver, and Zinc Oxide Nanoparticles on Shear Bond Strength: An In Vitro Study. *Cureus*, *16*(8), e68346. https://doi.org/10.7759/cureus.68346

Ramamurthy, J., (2021). Evaluation of antioxidant and anti inflammatory activity of grape seed oil infused with silver nanoparticles an in vitro study. *International Journal of Dentistry and Oral Science*, 3318–3322. https://doi.org/10.19070/2377-8075-21000676

Resende, L. D., Bresciani, E., Dos Santos Rocha, R., Sendyk, W. R., Kim, Y. J., & Pallos, D. (2024). Icon for the treatment of postorthodontic white spot lesions. 2-year follow-up. *The International Journal of Esthetic Dentistry*, *19*(4), 336–347. https://www.ncbi.nlm.nih.gov/pubmed/39422268

Saeed, F., Ilyas, M., & Shaheen, A. (2024). An In Vitro Study Comparing the Antibacterial and Mechanical Properties of Zinc Oxide-Based Nanofillers in Orthodontic Adhesives for White Spot Lesion Prevention in Fixed Orthodontic Therapy. *Cureus*, *16*(8), e66967. https://doi.org/10.7759/cureus.66967

Selvaraj, A., & Kumar Subramanian, A. (2024). Cone-beam computed tomography study of incisive canal and maxillary central incisors in Dravidian population. *Cureus*, *16*(7), e63707. https://doi.org/10.7759/cureus.63707

Selvaraj, A., Subramanian, A., George, A., & Shanmugam, R. (2023). A novel coating of biosynthesized silver nanoparticles on orthodontic elastomeric ligatures. *Journal of Complementary Medicine Research*, *14*(2), 184. https://doi.org/10.5455/jcmr.2023.14.02.29

Sneha, S., Anbarasu, P., Kumar, S. S., Annamalai, I., Rathi, S. S., & Priya, R. S. M. (2024). The Effect of Light-emitting Diode Light Intensities and Duration of Cure on Pulpal Wall Temperature among Different Classes of Teeth. *International Journal of Clinical Pediatric Dentistry*, *17*(4), 467–471. https://doi.org/10.5005/jp-journals-10005-2826

Solanki, L., Shantha Sundari, K. K., Muralidharan, N. P., & Jain, R. (2022). Antimicrobial effect of novel gold nanoparticle oral rinse in subjects undergoing orthodontic treatment: An ex-vivo study. *Journal of International Oral Health: JIOH*, *14*(1), 47. https://doi.org/10.4103/jioh.jioh_155_21

Maiti, S. (2021). Adhesion of microflora and the role of denitrifies in colour stability on provisional crowns: An in-vitro study. *International Journal of Dentistry and Oral Science*, 3805–3809. https://doi.org/10.19070/2377-8075-21000780

Suo, W., Li, F., Chu, H., & Zhang, Y. (2024). First Report of Causing Leaf Spot of in China. *Plant Disease*. https://doi.org/10.1094/PDIS-08-24-1600-PDN

Sushanthi, (2021). Vernonia amygdalina mediated copper nanoparticles and its characterization and antimicrobial activity - an in vitro study. *International Journal of Dentistry and Oral Science*, 3330–3334. https://doi.org/10.19070/2377-8075-21000678

Tao, B., Li, X., Zhou, S., & Yuan, G. (2024). First Report of Bacterial Leaf Spot Disease on Ginger Caused by in China. *Plant Disease*. https://doi.org/10.1094/PDIS-06-24-1254-PDN

Thorat, S. U., Balakrishnan, N., & Subramanian, A. K. (2024). Evaluating the Remineralizing Effects of Calcium Sucrose Phosphate and Casein Phosphopeptide-Amorphous Calcium Phosphate Toothpastes on Artificial Carious Lesions Using Micro-computed Tomography: An In Vitro Investigation. *Cureus*, *16*(8), e67637. https://doi.org/10.7759/cureus.67637

Tiwari, A., & Jain, R. K. (2023). Comparative evaluation of White Spot lesion incidence between NovaMin, probiotic, and fluoride containing dentifrices during orthodontic treatment using laser fluorescence - A prospective randomized controlled clinical trial. *Clinical and Investigative Orthodontics*, 1–8. https://doi.org/10.1080/27705781.2023.2190950