

**RESIN INFILTRATION THERAPY: A MICRO-INVASIVE APPROACH  
TO TREAT WHITE SPOT LESIONS IN DENTISTRY**

An Undergraduate Research Scholars Thesis

by

DANIELLE ALLEN, COURTNEY FINE, and MALORIE NEWTON

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Approved by Research Advisors:

Faizan Kabani, Ph.D.  
Kathleen Muzzin, RDH, MS  
Kayla Reed, RDH, MS

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# TABLE OF CONTENTS

	Page
ABSTRACT.....	1
ACKNOWLEDGMENTS .....	3
KEY WORDS.....	4
INTRODUCTION .....	5
SECTION	
I.    MECHANISM OF ACTION.....	6
Objective 1 .....	6
II.   CLINICAL BENEFITS AND PRACTICAL IMPLICATIONS .....	10
Objective 2 .....	10
III.  IMPLEMENTATION INTO DENTAL PRACTICE.....	15
Objective 3 .....	15
CONCLUSION.....	16
REFERENCES .....	17

## **ABSTRACT**

Resin Infiltration Therapy:  
A Micro-invasive Approach to Treat White Spot Lesions in Dentistry

Danielle Allen, Courtney Fine, and Malorie Newton  
Caruth School of Dental Hygiene  
Texas A&M University

Research Advisors: Faizan Kabani, Ph.D., Kathleen Muzzin, RDH, MS,  
and Kayla Reed, RDH, MS  
Caruth School of Dental Hygiene  
Texas A&M University

Esthetic dentistry is on the rise and new treatments are evolving for treating white spot lesions. Resin infiltration is a micro-invasive procedure used to treat demineralized white spot lesions on the enamel surface. This technique involves placing a low viscosity resin with the active ingredient, triethylene glycol dimethacrylate (TEGDMA) on the lesion. Resin infiltration aids in protecting the enamel from further demineralization while preserving its natural appearance. Resin infiltration with TEGDMA penetrates the hypomineralized enamel, masks the white spot lesion, and decreases the visible differences between the white spot lesion and sound enamel. This treatment was previously used to treat interproximal incipient carious lesions; however, it is now being marketed for esthetic purposes. Studies have found that resin infiltration using TEGDMA is effective in treating mild to moderate fluorosis and white spot lesions that may be seen post orthodontic treatment. For example, an in-vitro study by Subramaniam et al. shows resin infiltration's ability to occlude enamel micro-porosities and mask white spot lesions. Furthermore, in 2019, Garg, et al. analyzed three cases of mild to moderate fluorosis treated with resin infiltration using TEGDMA. In this study, 18 fluorosed spots were measured using visual

assessment with digital photographs, a colorimeter and spectrophotometer at different stages.

Results of this study showed that 78% (n=14) of the fluorosed lesions treated with resin infiltration using TEGDMA demonstrated a significant improvement ( $p < 0.001$ ) indicating successful masking of demineralized areas. Resin infiltration provides a micro-invasive treatment for masking white spot lesions, which has the ability to bridge the gap between preventive and restorative therapy.

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## KEY WORDS

TEGDMA    Triethylene Glycol Dimethacrylate

RS         Resins, Synthetic

TD         Tooth Discoloration

E          Esthetics

DC         Dental Caries

## INTRODUCTION

Resin infiltration therapy is a micro-invasive approach to treating white spot lesions that provides therapeutic and esthetic results, while minimizing the extent of invasive surgical interventions such as veneers and crowns.<sup>1</sup> This treatment technique is designed to be an alternative option to other esthetic treatments. Research has been conducted to determine the therapeutic effectiveness of resin infiltration using the active ingredient triethylene glycol dimethacrylate (TEGDMA) and has been compared to the current gold standard of invasive restorations, such as veneers and crowns.<sup>1</sup> In addition to being micro-invasive, resin infiltration also has the ability to remineralize a demineralized white spot lesions, while reinstating the esthetic appearance and natural hardness of the tooth.<sup>1</sup> Research on this topic supports the current National Dental Hygiene Research Agenda priority area of Oral Health Care - New Therapies and Prevention Modalities. Currently, white spot lesions are being treated with topical fluoride and invasive restorations.<sup>2</sup> The purpose of this narrative review is multifold; first to be discussed is the mechanism of action resin infiltration using TEGDMA plays in restoring white spot lesions. Second, the clinical benefits and practical implications of resin infiltration using TEGDMA will be highlighted. Third, the explanation of how resin infiltration therapy can be implemented into professional dental practices will be discussed. This narrative review will also address how dental hygienists can use resin infiltration therapy in clinical practice.

## SECTION I

### MECHANISM OF ACTION

#### Objective 1

##### *Etiology and Treatment of White Spot Lesions*

White spot lesions may be the first sign of a subsurface enamel porosity due to demineralization.<sup>2</sup> The etiology of white spot discoloration of the enamel can occur as a result of several intrinsic and extrinsic factors.<sup>1</sup> Traumatic hypocalcification and fluorosis are examples of pre-eruptive conditions due to disturbances that take place during enamel development, which can intrinsically contribute to white spot lesions.<sup>1</sup> Post-eruptive demineralization plays a role in extrinsic discoloration of the enamel, and the etiology can be traced back to four co-existing factors; these include 1) biofilm accumulation on the enamel, 2) consumption of fermentable carbohydrates that release acidic byproducts in the oral environment, 3) a susceptible tooth surface, such as subjection to orthodontic brackets, that allow bacteria to accumulate in confined crevices, and 4) the length of time bacteria remain on the teeth.<sup>1,3</sup> The prolonged biofilm accumulation allows the acidic byproducts from the bacteria to create micro-porosities within the enamel surface, which results in the development of white spot lesions.<sup>3</sup> Early lesions can be arrested and reversed by re-mineralization.<sup>4</sup> When the acid challenge is removed, saliva becomes saturated in calcium and phosphate which allows the ions to be absorbed back into the demineralized area, resulting in net mineral gain and repair of the enamel's hydroxyapatite structure.<sup>4</sup> However, if a white spot lesion is left untreated, it reaches the clinical end point of cavitation, which requires a more invasive approach, i.e. restoring with a crown or veneer.<sup>4</sup>



Non-invasive strategies are available to arrest white spot lesions; these include control of diet; biofilm; and mineralization, such as direct application of sodium fluoride.<sup>2</sup> Although dietary control is effective for preventative measures, it does not directly arrest white spot lesions.<sup>2</sup> Fluoride has been shown to reduce caries in both permanent and primary dentitions.<sup>2</sup> At-home methods of delivering fluoride to susceptible tooth surfaces include dentifrice containing fluoride and oral rinses containing fluoride.<sup>2</sup> Professionally applied methods of fluoride include: gels, varnishes, and silver diamine fluoride (SDF) products.<sup>2</sup>

Micro-invasive strategies such as pit and fissure sealants and the technique of resin infiltration have been used to arrest early cavitated lesions.<sup>2</sup> Pit and fissure sealants are applied onto phosphoric acid-etched enamel.<sup>5</sup> Low viscosity resins, such as those used in resin infiltration, permeate or infiltrate into hydrochloric acid-etched white spot enamel lesions by capillary action.<sup>5</sup> Sealants act as a barrier between the susceptible tooth surface and acid production, therefore preventing mineral loss from tooth tissues.<sup>2</sup> Resin infiltration masks the demineralized area by penetrating into the enamel and obstructing the diffusion pathways for acids and dissolved minerals from bacteria.<sup>6</sup> Resin infiltration also treats white spot lesions by permeating the pores of the tooth, which replaces lost tooth structure and stops caries progression.<sup>7</sup>

Depth of resin penetration could be a key determining factor for the creation of a diffusion barrier and the success of resin infiltration.<sup>8</sup> A study conducted by Paris et. al in 2014 classified extracted human teeth according to International Caries Detection and Assessment System (ICDAS).<sup>9</sup> Half of each tooth was etched with 37% phosphoric acid, the etchant used to prepare the tooth surface for sealants. The other half was etched with 15% hydrochloric acid, the etchant used to prepare a demineralized lesion for resin infiltration.<sup>9</sup> They found that etching with

15% hydrochloric acid gel for 2 minutes eroded the surface layer ( $\leq 50 \mu\text{m}$  thickness) sufficiently, resulting in an almost complete penetration of the resin.<sup>9</sup> In contrast, 37% phosphoric acid eroded less of the surface layer and resulted in reduced penetration depths.<sup>9</sup> Resin infiltration has also been shown to penetrate deeper with the use of 15% hydrochloric acid to etch, when compared to treatments using fluoride or casein phosphopeptide with the use 37% phosphoric acid.<sup>10</sup>

In the past, resin infiltration has been used to arrest incipient carious lesions.<sup>11</sup> Due to the lack of opaque filler, the treatment was not seen on radiographs.<sup>11</sup> Resin infiltration is now being marketed and used for esthetic purposes in the treatment of mild to moderate fluorosis and white spot lesions.<sup>11</sup> Resin infiltration using TEGDMA increases the esthetic appearance of the natural tooth in patients with mild to moderate fluorosis. TEGDMA is infiltrated into the hypomineralized enamel, which masks the white discoloration; producing a more uniform appearance of the visible enamel. A study has reported that resin infiltration using TEGDMA does not cause post-operative sensitivity or pulpal inflammation.<sup>1</sup> When the dentinal tubules are filled with the resin infiltrate, marginal gaps and leakage seem to no longer be present, which effectively seals the tooth and reduces sensitivity.<sup>12</sup>

Hygienists can perform resin infiltration treatment on patients in the dental office. The steps for resin infiltration are in order as follows: isolate the teeth with a gingival barrier; 15% hydrochloric acid gel is applied to the area of demineralization for two minutes to etch the surface; a 99% ethanol solution is applied for thirty seconds to dry the surface and improve penetration; TEGDMA is applied onto the tooth with a micro-brush for three minutes; excess resin is removed with a cotton roll; light cure for 20 seconds; repeat steps 4-6 to further occlude any microscopic gaps; finish, if needed, and polish; lastly, an application of 5% sodium fluoride

varnish is recommended to remineralize any areas that may have been demineralized by the hydrochloric acid gel.<sup>1</sup>

## SECTION II

### CLINICAL BENEFITS AND PRACTICAL IMPLICATIONS

#### Objective 2

##### *Clinical Studies Showing Reinstatement of the Tooth*

There is an increasing demand for minimally invasive esthetic treatment options without the use of anesthesia or moderate removal of enamel.<sup>1</sup> Resin infiltration not only restores the appearance of the white spot lesion esthetically, but it also fills micro-porosites and brings the tooth's fluorescence, hardness, and texture back to that of sound enamel.<sup>1,13,14</sup> An *in vitro* study by Markowitz and Carey (2018) used a fluorescent camera to assess the brightness intensity on ten extracted caries free third molars.<sup>13</sup> The fluorescent camera demonstrated resin infiltration's ability to fill micro-porosities and mask white spot discoloration.<sup>13</sup> In this study, a 1mm x 4mm area on the facial surface was treated with lactic acid for two weeks to create a demineralized white spot lesion.<sup>13</sup> Half of the lesion was then treated with resin infiltration and the other half was untouched.<sup>13</sup> The results of the study were able to compare the mean brightness intensity readings of intact enamel prior to treatment, after demineralization, and after resin infiltration treatment.<sup>13</sup> Prior to resin infiltration, the brightness intensity value of intact enamel was 159.6.<sup>13</sup> After the enamel was etched with lactic acid, the artificial white spot lesion had a value of 123.4.<sup>13</sup> Lastly, after resin infiltration therapy, the brightness intensity value was brought back up to that of intact enamel with a reading of 160.9.<sup>13</sup> This study suggests that resin infiltration has the ability to restore enamel to its original state and may improve the appearance of white spot lesions.<sup>13</sup>

A study by Taher et al. (2012) evaluated resin infiltration therapy's ability to restore the micro-hardness and texture of demineralized enamel.<sup>14</sup> The researchers measured the hardness of twenty caries free extracted premolars using the Vicker's surface hardness test before and after treatment with resin infiltration.<sup>14</sup> They reported that the premolars treated with resin infiltration had approximately the same micro-hardness as sound enamel.<sup>14</sup> In regards to texture, the researchers used scanning electron microscopy magnification to examine micro-porosities in enamel.<sup>14</sup> They found that the micro-porosities appeared occluded and the enamel surface was smooth following resin infiltration using TEGDMA.<sup>14</sup> This study demonstrates resin infiltrations ability to bring both the hardness and texture back to that of sound enamel.<sup>14</sup>

One of the most common and beneficial uses of resin infiltration using TEGDMA is on teeth following orthodontic treatment. Patients with fixed orthodontic brackets are at higher risk for experiencing demineralization which results in white spot lesions.<sup>3</sup> These lesions may appear as irregular milky white opacities on the surface of enamel.<sup>3,15</sup> This is especially evident in orthodontic patients with poor oral hygiene practices.<sup>3</sup> In general, white spot lesions are commonly seen on the facial surfaces of enamel.<sup>3</sup> A concern with the formation of white spot lesions on the anterior teeth is that they are visualized more frequently by both the patient and those the patients' interact with.<sup>3</sup> Post-orthodontic treatment of resin infiltration using TEGDMA aims to improve the esthetic outcome by masking the white spot lesions to match the adjacent enamel.<sup>1</sup> An added benefit for patients who seek therapeutic treatment through resin infiltration is that it can be achieved in a single visit and with low risk of postoperative sensitivity or inflammation.<sup>1</sup> This micro-invasive treatment aims to penetrate deep into porous, demineralized enamel and preserve the tooth structure simultaneously.<sup>1</sup>

In 2019, Garg, et al. analyzed three different cases of mild to moderate fluorosis treated with resin infiltration using TEGDMA.<sup>16</sup> In this study, 18 fluorosed spots were measured using visual assessment with digital photographs, a colorimeter and spectrophotometer.<sup>16</sup> These tools were used at four different stages: pre-operative, post-bleaching prior to resin infiltration, post-infiltration, and at a 12-month follow-up to measure the effects of resin infiltration on fluorosis.<sup>16</sup> Of the three patients who presented with mild to moderate fluorosis, two patients presented with well-defined white spot lesions and a few light brown spots.<sup>16</sup> The third patient presented with diffuse white spot lesions and brown spots.<sup>16</sup> Results of the study demonstrated that nearly 78% (n=14) of the 18 fluorosed lesions treated with the resin infiltration using TEGDMA, were within an acceptable range ( $p < 0.001$ ).<sup>16</sup> The other twenty two percent (n=4) were found to be unacceptable as the white spot lesions were not completely masked at the post-infiltration stage. However, at the 12-month stage, three of those four lesions improved and were found to be in the acceptable range.<sup>16</sup> This study found an 88% success rate of masking white spot lesions at 12 months using resin infiltration, suggesting it may maintain the esthetic appearance for at least 12 months.<sup>16</sup> In the conclusion of this study, the number of acceptable masked white spot lesions were statistically significant ( $p < 0.001$ ).<sup>16</sup> Patients in this study also reported an increase in self-esteem and confidence.<sup>16</sup>

Resin infiltration using TEGDMA presents with practical implications. For example, ten to fourteen days prior to treatment, external bleaching is suggested to optimize an esthetic appearance.<sup>17</sup> Clinicians should adhere to the protocol stated by the manufacturer, which includes protection of the gingiva and maintaining a dry field.<sup>1</sup> If the dry field is compromised, the probability of failure is increased.<sup>1</sup> In comparison to more invasive treatments such as veneers, resin infiltration removes minimal amounts of enamel and studies have shown that this

therapeutic treatment has not been associated with postoperative sensitivity or pulpal inflammation.<sup>1</sup> One limitation of resin infiltration is that optimal results are not permanent, therefore bleaching is recommended every 12-18 months to maintain esthetic appearance.<sup>17</sup> If a demineralized white spot lesion has been previously treated with resin infiltration, it may present with resistance to the etch, making it more difficult to remove the surface enamel which would require additional etchant steps for the resin to be able penetrate the lesion.<sup>15</sup> This can make the procedure more time consuming for the patient and may also lead to a poor outcome. For the infiltration to succeed, it is important that the etchant penetrates the surface for a full thirty seconds as it is intended to do, to achieve the best long-term outcome clinically and esthetically.<sup>1</sup> Furthermore, another potential limitation that may improve the penetration of the etch if a patient has been previously treated with resin infiltration, is the use of a medium-grit disk.<sup>15</sup> The disk may be used to gently remove the surface enamel, allowing the etch to penetrate deeper into the surface, as etch may not be sufficient in itself for some cases.<sup>15</sup> Though the procedure as a whole is very micro-invasive, the disk does have the potential to irreversibly remove a thin layer of enamel and should be addressed and thoroughly explained to the patient prior to use.<sup>15</sup> Lastly, there is a difference in treating primary versus permanent teeth with resin infiltration, due to the differences in components and structure.<sup>11</sup> Resin infiltration has a universal application given by the manufacturer and uses the same steps for permanent and primary teeth, which have different compositions of minerals, shape of the contact areas, and different thickness of enamel.<sup>11</sup> Primary enamel is less mineralized and more porous than permanent enamel, and as a result, the resin has been shown to have a greater diffusion coefficient when applied to primary enamel.<sup>1</sup> Paris et al. conducted a study with resin infiltration in 2007, using confocal microscopic images to measure the lesion and penetration depths; primary teeth were shown to exhibit better

penetration of resin infiltration using TEGDMA than permanent teeth after a one minute application.<sup>1,18</sup> Being a universal application, it may be difficult to successfully treat a wide variety of cases depending on the age and the tooth's stage of development.



## SECTION III

### IMPLEMENTATION INTO DENTAL PRACTICE

#### Objective 3

##### *Maintaining Esthetics*

Patients who are unaware of the micro-invasive treatment using resin infiltration often believe that bleaching or veneers are the best treatment option to enhance esthetic appearance of their teeth.<sup>2</sup> These treatments can be expensive and time-consuming and that may put the tooth's enamel at risk of increased demineralization, sensitivity, and inflammation.<sup>2</sup> Although bleaching is a suggestion prior to resin infiltration to maximize esthetic appearance, there has been no reported cases of sensitivity.<sup>16</sup> Continuous bleaching post resin infiltration is recommended every 12 to 18 months to maintain esthetic appearance.<sup>17</sup>

## CONCLUSION

In conclusion, resin infiltration using TEGDMA is an alternative treatment option for white spot lesions following fixed orthodontic therapy and mild to moderate fluorosis.<sup>8</sup> This technique allows for a more conservative approach to enhance esthetics of white spot lesions, while bringing the demineralized lesion back to the natural hardness, texture, and fluorescence of intact enamel. Infiltration technology can be used to treat white spot lesions without removing tooth structure, thus protecting and preserving the hard tissue surrounding the lesion.<sup>8</sup> Furthermore, it has been shown that patients are more compliant, as it requires no anesthesia and the treatment duration is sustainable.<sup>8</sup> In Texas, dentists must still diagnose and develop the esthetic treatment plan, but the application of TEGDMA can be performed by a licensed dental hygienist. The mechanism of action resin infiltration using TEGDMA plays in masking white spot lesions, the clinical benefits and potential limitations of resin infiltration using TEGDMA and how resin infiltration can be implemented into dental practices have been discussed and systematically reviewed. Resin infiltration provides dental hygienists with the opportunity to bridge the gap between preventive and restorative treatments.

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