



Treatment of White Spot Lesions by Resin Infiltration

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Authors' contributions

This work was carried out in collaboration between all authors. Author AC designed the study and wrote the first draft of the manuscript. Authors VM, MF and EC managed the literature searches. All authors read and approved the final manuscript.

Review Article

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ABSTRACT

Aim: To review the scientific principles of the treatment of white spot lesions with the resin infiltration technique and to discuss its application and limitations.

Methodology: A PubMed database research was conducted and limited to articles published in English between the years of 2008 and 2013. Twenty-six articles were selected out of 48.

Discussion: The resin infiltration procedure is a promising minimally invasive dentistry technique. Resin infiltration produces a positive effect on aesthetics, preserves tooth structure, delays or even eliminates the need for a restorative treatment and eliminates the risk of post-operative sensitivity and pulp inflammation. Although it has recently been developed, the results are very satisfactory. However, investigation is still needed (particularly with longer follow-ups and larger samples) as well as the development of specific and simplified protocols.

Keywords: Caries infiltration; icon infiltration; resin infiltration; white spot lesions.

1. INTRODUCTION

With the evolution of the techniques and materials used in dentistry, managing carious lesions has been increasingly analyzed through a prevention, monitoring and minimally invasive intervention approach [1].

The concept of minimally invasive dentistry includes an early and appropriate diagnosis of dental caries and its risk factors, a preventive treatment (modification of cariogenic factors and patient education) and a minimally invasive operative intervention [2].

The approach for managing incipient carious lesions (white spot ones) is the clinical condition that better illustrates the implementation of this philosophy, having in mind the integrity of the tooth structure and the inherent possibility of remineralization [3].

The use of fluoride (pastes, mouthwashes, gels and varnishes) and compounds of casein phosphopeptides-amorphous calcium phosphate (mousse) so as to enhance remineralization has been the usual strategy in what concerns the way of dealing with these lesions. [2,4] Although the remineralization of superficial white spot lesions is often achieved, this technique shows unsatisfactory results with respect to old and/or deep lesions as well as to the obtained aesthetics. [2-4] The remineralization of non-cavitated deep lesions occurs, initially, on the surface, which is hypermineralized, and thus prevents the remineralization of the subsurface layers. Given that the porosity of the body of the lesion is not eliminated, the final aesthetics is also unsatisfactory. [5] On the other hand, the implementation of this protocol requires a motivated and collaborative patient with good oral hygiene and willing to perform multiple applications and to accept a treatment plan that can last for a long period of time [6].

The concept of resin infiltration of carious lesions fills the gap between prevention and restoration. This technique was developed at the Hospital of the University of Berlin, through in vitro studies, and the resin is marketed under the name Icon[®] (DMG Hamburg, Germany) [1].

The aim of this study is to review the scientific principles of the treatment of white spot lesions with the resin infiltration technique, discussing its clinical application and limitations.

2. METHODOLOGY

A PubMed database research of relevant scientific articles on the subject under study was conducted, using the following key-words: resin infiltration, caries infiltration, caries infiltrant, white spot lesions, icon infiltration.

The search was limited to articles published in English between the years of 2008 and 2013. Twenty-six articles were selected out of 48.

3. RESULTS

Table 1 provides a summary of the existing research articles on resin infiltration technique.

Table 1. Research studies on resin infiltration therapy

Reference	Type of study	Type of teeth	Condition	Follow up	Key outcomes
Belli R et al. [3]	<i>In vitro</i>	Bovine incisors	Hypomineralization	-	Infiltration therapy has wear resistance to tooth-brush abrasion
Kim S et al. [4]	<i>In vivo</i>	Permanent anterior teeth	Developmental defect of enamel and post-orthodontic hypomineralization	1 week	The masking effect is complete in some cases but not in others
Paris S et al. [5]	<i>In vitro</i>	Bovine teeth	Hypomineralization	-	Polished infiltrated lesions are more resistant to staining
Hammad SM et al. [6]	<i>In vivo</i>	Permanent incisors	Post-orthodontic Hypomineralization	-	Aesthetic improvement can be achieved with resin infiltration therapy
Meyer-Lueckel H et al. [7]	<i>In vivo</i>	Permanent posterior teeth	Hypomineralization	3 years	Resin infiltration is an efficacious method to hamper progression of non-cavitated proximal lesions extending radiographically up to the outer third of dentin
Torres CR et al. [8]	<i>In vitro</i>	Bovine incisors	Hypomineralization	-	Resin infiltration don't interfere in bond strength of the composite resin to enamel
Wiegand A et al. [9]	<i>In vitro</i>	Bovine incisors	Sound and demineralized enamel	-	The use of resin infiltration before application of a conventional adhesive do not impair bonding to sound and demineralized enamel
Jia L et al. [10]	<i>In vitro</i>	Bovine incisors	Sound teeth	-	Dentin contamination with the resin infiltrant system impair the shear bond strength of conventional dental adhesives
Martignon S et al. [11]	<i>In vivo</i>	Permanent posterior teeth	Hypomineralization	3 years	Infiltration and sealing are significantly better than placebo treatment for controlling caries progression on proximal lesions
EkstrandKR et al. [12]	<i>In vivo</i>	Deciduous molars	Hypomineralization	1 year	Resin infiltration in conjunction with fluoride varnish seems promising for controlling proximal lesion progression on deciduous molar teeth
Meyer-Lueckel H et al. [13]	<i>In vitro</i>	Permanent posterior teeth	Hypomineralization	-	3 min application of an infiltrant seems to be sufficient to achieve an almost complete penetration of enamel caries
Meyer-Lueckel H et al. [15]	<i>In vitro</i>	Permanent posterior teeth	Hypomineralization	-	A solvent-free resin mainly consisting of TEGDMA seems to be the best resin that is capable of penetrating almost completely into enamel parts of natural caries lesions

Reference	Type of study	Type of teeth	Condition	Follow up	Key outcomes
Paris S et al. [16]	<i>In vitro</i>	Bovine incisors	Hypomineralization	-	Resin infiltration significantly improves micro-hardness and demineralization resistance of enamel lesions; these effects are significantly enhanced if resin is applied twice
Araujo GS et al. [17]	<i>In vitro</i>	Third molars	Hypomineralization	-	Solvents added to monomer blends result in decreased properties of the resin. The addition of hydrophobic monomers and solvents into TEGDMA blends does not improve the penetration depth of the infiltrants
Paris S et al. [18]	<i>In vitro</i>	Permanent molars and premolars	Hypomineralization	-	Application of either ethanol or acetone, followed by air-drying, is suitable to prepare caries lesions for resin infiltration
Paris S et al. [20]	<i>In vitro</i>	Permanent molars and premolars	Hypomineralization	-	Resin infiltrant penetrates most parts of the demineralized enamel but is not capable of filling up cavities
Knosel et al. [21]	<i>In vivo</i>	Permanent anterior teeth	Post-orthodontic hypomineralization	6 months	Resin infiltration improves the esthetic appearance of demineralized teeth
Naidu et al [22]	<i>In vitro</i>	Bovine teeth	Sound and hypomineralized enamel	-	Preconditioning of sound and demineralized enamel with the infiltrant system increase the shear bond strength of most orthodontic resin cements while decreasing the risk of enamel fracture at debonding
Tirlet G et al. [24]	<i>In vivo</i>	Permanent anterior teeth	Fluorosis and traumatic hypomineralization	19 months	Resin infiltration could be a promising minimally invasive treatment in fluorosis and traumatic hypomineralization
Munoz et al. [25]	<i>In vivo</i>	Permanent anterior teeth	Fluorosis and traumatic hypomineralization	1 week to 4 months	Resin infiltration can be considered a minimally invasive procedure for mild-to-moderate fluorosis and hypoplasia stains related to traumatic dental injuries
Meyer-Lueckel et al. [26]	<i>In vitro</i>	Bovine incisors	Hypomineralization	-	Resin infiltrants should preferably have high penetration coefficients to facilitate inhibition of lesion progression efficiently

4. DISCUSSION

4.1 Outcome of Resin Infiltration Therapy on White Spot Lesions

The aim of the resin infiltration technique is to allow its penetration by capillarity into the porous enamel, stopping the demineralization process, stabilizing the caries lesion and forming a mechanical barrier, depriving the bacteria that colonize the lesion of the oral biofilm nutrients [1,7].

Moreover, resin infiltration provides a significant mechanical support for the tooth tissue (preserving its structure), delays or eliminates the need for a restorative treatment and eliminates the risk of post-operative sensitivity and pulp inflammation [2].

In case of need, in the future, of a conventional restorative intervention with consequent use of adhesive and composite resin, the previous resin infiltration does not compromise the adhesion to the enamel. Furthermore, it does make it more effective. These results suggest a successful restoration of a cavitated enamel lesion with the use of a conventional composite and, at the same time, the infiltration of resin in its demineralized margins, thus preserving structure. [8-10] However, such treatment should be avoided in cavitated lesions that extend up to the dentine, since its contamination, even accidentally, with hydrochloric acid (used for enamel preparation before resin infiltration), significantly reduces adhesion [10].

In a study conducted by Martignon et al. the rate of failure of resin infiltration in non-cavitated proximal lesions after 1, 2 and 3 years of follow-up was 15.8%, 24.3% and 32.4%, respectively. The failure rates obtained in the control group (placebo) were 47.4%, 62.2% and 70.3% for the same follow-up periods [11].

Ekstrand et al. evaluated the effectiveness of the treatment of proximal lesions of temporary molars by resin infiltration. The reported failure rate after one year was 23% for the tested group and 62% for the control one. In both groups a fluoride varnish application on the first day and after 6 months was done. [12] Dental caries activity is higher in temporary molars than in premolars and permanent molars, which may explain the difference between the results obtained by Ekstrand et al. and other studies [7].

Lueckel-Meyer et al. evaluated the efficacy of treatment of proximal lesions in young adults. After a follow-up of 3 years the failure rate was only 4% (42% in the control group). [7] The observable differences between these results and those obtained by Martignon et al. [11] and Ekstrand et al. [12] may possibly be explained by a higher proportion of dentin lesions that were infiltrated by them and consequently a higher rate of its progression and reduced efficacy of infiltration.

The results of various studies conducted in order to define an effective resin infiltration protocol show that a higher rate of inhibition of caries progression occurs with the application of a 15% hydrochloric acid gel for 2 minutes in order to dissolve the superficial hypermineralized enamel surface and to allow a greater penetration of resin. [13] This layer reflects the remineralization that characterizes the dynamics of tooth decay and, if not removed, it behaves as a barrier to resin infiltration [14].

Considering the resin characteristics needed for a good infiltration, the resin should have a low viscosity, a small contact angle on enamel, a high surface tension and a high penetration coefficient. Among the different studied materials, triethylene glycol dimethacrylate (TEGDMA), without added solvent, has proved to be the resin which is capable of giving better results [15-17].

Having in mind the particularities of TEGDMA, it becomes of paramount importance to maintain a dry tooth surface prior to its use, which is achieved through the removal of water by dehydration with ethanol. When this dehydration is not fully effective, which happens more easily at the lesion margins, an incomplete infiltration is obtained [18].

In order to increase the hardness and resistance to demineralization, the resin should be applied twice. The second application may also compensate for the polymerization shrinkage and fill porosities that may persist in the infiltrated lesion [16].

The polishing of the infiltrated lesions should be performed. It is related to the stability of the aesthetic, the reduction of the porosity and the removal of the oxygen inhibited layer [5].

The resin infiltration technique is indicated for active and non-cavitated carious lesions, whose depth does not exceed the outer third of dentin, on smooth surfaces (proximal, buccal and lingual) [19].

The application of this technique is particularly interesting in proximal lesions, taking into account the destruction of healthy tissue that is required to access the lesion while using other techniques and its indication should be ascertained through bitewing radiographs [19,20].

Depending on the consulted studies, 46-96% of the patients using fixed orthodontic appliances have at least one white spot, mainly on buccal and cervical surfaces. [5,21] The resin infiltration of these lesions should be performed soon after the removal of the brackets and bands, since it is very likely that they are active and progressing. On the other hand, the lower the remineralization rate, the better the aesthetic results achieved [6,21].

In a study conducted in 2013, Naidu et al. demonstrated that the enamel (healthy or demineralized) conditioning prior to brackets placing increases the shear strength of adhesion of most of the resin cements used [22].

Kim et al. demonstrated, through a clinical study, the efficacy of resin infiltration in white spot lesions after orthodontic treatment: 61% of the evaluated lesions were totally infiltrated and 33% were incompletely infiltrated [4].

4.2 Aesthetic Outcome of Resin Infiltration Therapy

The porosity created by the initial demineralization of a caries process changes the refractive index of enamel, resulting in a white coloration in the incipient lesion. By filling these porosities, resin infiltration also produces a positive effect on aesthetics. [21,23] Knösel et al. in a clinical trial with patients with white spot lesions treated after removal of braces reported that there were no statistically significant differences in the color of the infiltrated resin during a 6 months follow-up, confirming the aesthetic effect of this treatment [21].

Since just a few articles mention more than the immediate aesthetic outcome, there's an evident need for more clinical studies demonstrating long-term aesthetic results of resin infiltration therapy.

4.3 Outcome of Resin Infiltration Therapy on Other Lesions Such as Trauma and Fluorosis

Considering the irregular pattern of mineralization and porosity of white spot lesions caused by fluorosis and trauma, Tirllet et al. suggested the use of the resin infiltration technique as a way to improve them aesthetically. The treatment was performed in 4 patients and evaluated over a period of 19 months. A significant improvement in the aesthetics of the lesions was reported [24].

Munoz et al. conducted a similar study, also with 4 patients (2 with fluorosis lesions and 2 with traumatic white spot lesions) and, although there was no follow-up period, the immediate results have shown significant improvements in aesthetics [25].

The depth of the hypoplastic lesions caused by fluorosis or trauma, its thick surface layer and the infiltrative behavior of the resin in these lesions are very similar to those found in inactive caries lesions, which may explain the difficulty in achieving levels of aesthetics as good as those achieved in active incipient lesions [25].

Despite the satisfactory results, more studies (particularly with longer periods of follow-up and larger number of cases) and, possibly, the development of specific protocols for the resin infiltration to be used in these cases are required.

4.4 Limitations of Resin Infiltration Therapy

Among the different reasons that may affect the success of the treatment of a white spot lesion with the resin infiltration technique there's the need to mention the inefficient isolation, the depth and the inactivity of the lesion, the presence of cavitation, the incomplete resin polymerization and the difficulty in controlling the amount of resin that is actually being infiltrated [5,23,14].

The greater the depth of the carious lesion, the lower the probability of achieving a complete infiltration. Extensive lesions are also associated with a higher polymerization shrinkage and the consequent appearance of porosities and cracks [16].

The infiltration of cavitated lesions doesn't produce satisfactory results, taking into account the weak capillary action of the resin into these lesions. Furthermore, since there's the need to remove resin excesses before its light curing, the quantity of removed material can be easily higher than the one desirable during this procedure. The presence of air bubbles within the cavitation can also prevent the infiltration of the resin [20].

The caries risk should also be assessed. Ekstrand et al. in 2010, evaluated the effectiveness of the treatment of proximal lesions of temporary molars with resin infiltration. The reported rate of failure after one year (23% vs. 62% in the control group) was higher than that reported in other studies after the same period of follow up. However, unlike them, Ekstrand et al. sample comprised only children with moderate to high risk, which may partially explain the results [12].

Nevertheless, although Meyer-Lueckel et al. have demonstrated in an *In vitro* study that incompletely infiltrated lesions are more susceptible to the progression of demineralization [26], there is no clinical evidence that only totally infiltrated lesions are effective in stabilizing the caries process. Moreover, the success associated with the use of a pit and fissure sealant exists not due to infiltration of lesions but due to their isolation from the acidic oral environment [3].

5. CONCLUSION

When an intervention is needed, the resin infiltration technique for treating white spot lesions seems adjusted to the philosophy of minimally invasive dentistry.

Although the risk-benefit relationship and the aesthetic results obtained by this technique are favorable, clinical experience is still limited and therefore the stability of this treatment is not well known.

The resin infiltration technique allows for a minimally invasive treatment in a single appointment, making it beneficial for the patients, especially children. However, its benefits are dependent on the patient's caries risk and on an appropriate follow-up.

There's an evident need for more clinical studies demonstrating long-term results and for further research in order to simplify the procedures so that they can be easily incorporated into the clinical practice.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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