Review Article

Properties, Success, and Applications of Resin Infiltration for Minimal Invasive Restoration: A Scoping Review

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Abstract

To treat smooth surface and proximal non-cavitated caries lesions, a modified and commercially developed German technique called "resin infiltration" has been used to infiltrate the porosities of enamel lesions with a low-viscosity resin, establishing a diffusion barrier within the lesion without selecting any material on the enamel surface. Thus, resin infiltration can delay the time for restoration placement. Hydrochloric acid erodes the lesion surface, and a low-viscosity resin is infused into the intercrystalline spaces of hypocalcified or demineralized enamel from the back. Previously filled with air (RI = 1.00) or water (RI = 1.33), the porous enamel now has a resinous material infiltrating it, which has a refractive index (RI) (1.52) closer to hydroxyapatite (1.62). The Icon-Infiltrant (DMG America) is a highly fluid, unfilled resin with a high penetration coefficient that will be carried into the porosities of the lesion by capillary action, and once there, it will be light cured, occluding the microporosities, and stopping the demineralization process. Resin infiltration is a non-surgical, effective, and permanent therapy option. Patients may get therapy in as little as a few minutes without needing a local anesthetic or removing healthy tooth structure, and they can anticipate permanent, irreversible effects.

Keywords: Resin infiltration, ICON, Minimally invasive dentistry, Success.

Introduction

The traditional, therapeutic treatment approach to dental caries has given rise to a more protective, non-invasion, or minimally invasive procedure in past years [1-3]. Explaining the caries process better starts calling for management strategies that focus on prevention, risk reduction, and early detection of caries lesions to avoid invasive treatment whenever possible while employing the least invasive methods when necessary. Non-cavitated caries lesions, also known as early caries lesions, have been managed in various noninvasive ways. Therapeutic sealants for occlusal lesions or remineralization with fluoride or casein phosphopeptide amorphous calcium phosphate are two examples. Experiments with caries infiltration with resorcinol-formaldehyde resin by Doméjean *et al*. support yet another noninvasive alternative treatment [4]. For the treatment of caries lesions that aren't cavity-like, the Germans refined and marketed a technique called "resin infiltration" (RI), in which a low-viscosity resin is injected into the lesion's porous enamel. The potential caries-inhibiting effect of RI depends on the occlusion of the pores within the body of the caries lesion, in contrast to the sealing of caries lesions, which relies on the external occlusion of the lesion with the sealant material. Amelogenesis imperfecta, hypo mineralization of the molar incisors, fluorosis, and white spots have also been proposed as indications for RI [5].

Carious lesions in enamel are characterized by mineral loss within the lesion's body, leading to increased visual enamel opacity due to a change in the refractive index of the affected area. Non-surgical options for treating enamel carious lesions, such as remineralization with fluoride and casein phosphopeptide-amorphous calcium phosphate or applying therapeutic sealants for occlusal lesions, have garnered considerable interest. Remineralization of

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superficial white spot lesions is facilitated by fluoride and casein phosphopeptide-amorphous calcium phosphate. However, many patients drop out of treatment before it's over because it requires them to change their harmful habits and comply with the treatment [6].

To slow the spread of non-cavitated enamel caries, sealants have been used clinically. Acids and dissolved minerals can diffuse through the enamel caries' porous body. Based on their findings, Doméjean *et al*. propose that resorcinol-formaldehyde resin infiltration of these pores to halt carious lesions offers a potential alternative strategy for superficial sealing [4]. To treat smooth surface and proximal non-cavitated caries lesions, a modified and commercially developed German technique called "resin infiltration" has been used to infiltrate the porosities of enamel lesions with a low-viscosity resin, establishing a diffusion barrier within the lesion without selecting any material on the enamel surface. Thus, resin infiltration can delay the time for restoration placement [7].

Materials and Methods

This scoping review was conducted using the current available literature, which was retreieved from the databases such as Pubmed, Medline, ScienceDirect and Web of Science. Keywords were used such as ‘properties’, ‘success’, ‘resin infiltration’, ‘minimal invasive’ **(Table 1)**.

Table 1. Inclusion and exclusion criteria

№	Inclusion criteria	Exclusion criteria
1.	Case-control and randomized control studies	Systematic reviews or meta-analyses or expert opinions or narrative reviews
2.	Published between 2010 and 2022	Out of the specified time range
3.	Studies including Resin infiltration	Irrigants other than Resin infiltration
4.	English language of publication	Language other than English
7.	In vivo (humans)	In vitro

Results and Discussion

Properties

Hydrochloric acid erodes the lesion surface, and a low-viscosity resin is infused into the intercrystalline spaces of hypocalcified or demineralized enamel from the back. Previously filled with air (RI = 1.00) or water (RI = 1.33), the porous enamel now has a resinous material infiltrating it, which has a refractive index (RI) (1.52) closer to hydroxyapatite (1.62). The affected enamel's optical characteristics are thus altered, making it appear to be the same as the sound enamel around it. In vitro experiments have demonstrated that the low-viscosity resin can permeate porous enamel affected by caries or hypomineralization. Resin infiltration with a color mask has also been shown to be effective in preventing artificial caries models. Some clinical studies also demonstrated promising cosmetic outcomes. However, there is a shortage of data regarding the technique's clinical efficacy in hiding white spots on the enamel [8].

Advantages

Resin infiltration's benefits are plain to see. No needles or drills are required. No discomfort is associated with the procedure, and a single office visit is needed to complete the course of treatment. Resin infiltration is a highly effective method for restoring lesions, saving healthy tooth structure, avoiding the need for local anesthesia, improving the patient's overall experience, and reducing the overall cost of treatment. Pros of using resin infiltration technology clinical dentistry continues to concentrate on making decisions linked to caries. Traditional core skills, such as manual dexterity and technical competence, have less to offer to oral health than many clinicians have been accustomed to thinking. However, most dentistry is still re-dentistry (with continued restorative procedures necessary within the patient's life span). As can be seen from the above analysis, the resin infiltration method offers several benefits [9].
Among them are:

- The demineralization of enamel can be stabilized mechanically.
- Permanent occlusion of superficial micropores and cavities
- Permanent obturation of porous, deeply demineralized areas
- The arrest of lesion progress
- Minimized risk of secondary caries
- Delayed restorative intervention
- No risk of postoperative sensitivity and pulpal inflammation
- Reduced risk of gingivitis and periodontitis
- The improved esthetic outcome when used to preserve sound hard substance (protecting both the same and the adjacent tooth) [10]

Therefore, a longitudinal clinical risk assessment should be devised to differentiate between progressing and remineralized lesions since this will affect clinical decision-making. Within the framework of minimal intervention dentistry, the infiltration approach seems appropriate for initial treatment selection requirements; simultaneously, even for later stages of the caries process (in case remineralization with fluorides is not considered a practical approach), this concept should be an alternative to any cavity preparation, thereby delaying (if not avoiding) sacrifice of sound structures. It is advised that a rubber dam be used in conjunction with the resin infiltration method for safety reasons and to guarantee dryness. Finally, resin infiltrants may be used in tandem with traditional resin restorations in the event of more complicated treatment scenarios, hence aiding in the preservation of dental hard tissues [11].

In Vivo Studies Proving the Concept of Resin Infiltration

Hydrochloric acid erodes the lesion surface, and a low-viscosity resin is infused into the intercrystalline spaces of hypocalcified or demineralized enamel from the back. Previously filled with air (RI = 1.00) or water (RI = 1.33), the porous enamel now has a resinous material infiltrating it, which has a refractive index (RI) (1.52) closer to hydroxyapatite (1.62). The affected enamel's optical characteristics are thus altered, making it appear to be the same as the sound enamel around it [12]. In vitro experiments have demonstrated that the low-viscosity resin can permeate porous enamel affected by caries or hypomineralization. Resin infiltration with a color mask has also effectively prevented artificial caries models. Some clinical studies also demonstrated promising cosmetic outcomes. However, there is a shortage of data regarding the technique's clinical efficacy in hiding white spots on the enamel [9, 13].

Procedure

Because of the similarity between the interproximal and smooth surface lesion locations, each treatment technique is identical. Here, we'll start with proximal surfaces and their treatment. Success relies heavily on separating the interproximal area and isolating the area to be treated. Orthodontic separators are an efficient means of accomplishing this task. This may be inserted as early as 15 minutes before treatment or as late as one week beforehand. The teeth should be spaced out by 50-80 micrometers before placing the green separating wedge. When the teeth are properly isolated, the orthodontic separator can be taken out of the way and the green separating wedge can be placed interproximally. The interproximal lesion can now be seen with the naked eye [14]. The wedge is positioned at a right angle to avoid damaging the gingival tissues. Apply light, even pressure until you feel the first sign of resistance. You can get the most space by waiting a few seconds with the wedge in place and then slowly moving it forward. Your patient will initially feel the pressure, but the pressure anesthesia will take effect shortly after and completely remove the feeling. Applying a local anesthetic to the skin can help your patient feel at ease during treatment. After the area has been prepared by isolating it, resin infiltration requires three basic steps: etching, drying, and infiltrating [15, 16].

Etchant

A screw-style syringe dispenses Icon-Etch (DMG America), which is 15% hydrochloric acid. These syringes come with disposable, single-use applicator tips. Connect the foil-shaped end of the applicator to the Icon-Etch syringe (DMG America). One side of the foil is white, while the other is green. The Icon-Etch is dispensed through perforations on the foil's green, "active" side (DMG America). The etchant is dispensed by inserting the syringe inter proximally and twisting the plunger. Soft tissue should be protected from the Icon-Etch (DMG America). Two full minutes are spent with the lesion in contact with the Icon-Etch (DMG America). Maximal etching can occur if you agitate the Icon-Etch (DMG America) while in contact with the proximal surface. You should wait 2 minutes, rinse for 30 seconds, and let dry in the air. The Icon-Infiltrant can't reach the lesion's core unless the surface layer is eroded first (DMG America) [17, 18].

Drying Agent

After 30 seconds, a 99% ethanol solution is removed from the Icon-Dry (DMG America) treatment. Once the area is clean, it is dried with oil-free air. This permits the infiltrant to be removed by capillary action since the lesion and tubules have been fully desiccated [19].

Infiltration

The Icon-Infiltrant (DMG America) is a highly fluid, unfilled resin with a high penetration coefficient that will be carried into the porosities of the lesion by capillary action, and once there, it will be light cured, occluding the microporosities, and stopping the demineralization process. Due to its extreme sensitivity to light, the icon-infiltrant must be protected from direct sunlight by being moved out of its path. An applicator tip can be affixed to the Icon-Infiltrant (DMG America) syringe, and the product can then be applied by twisting the needle [20, 21]. Sprinkle on some Icon-Infiltrant (DMG America) every so often, and let it work its magic for three minutes. This makes sure there's enough resin reaching the injury site. Lightly cure for 40 seconds after the excess has been removed. Use a fresh applicator tip to start the infiltration process again if necessary. Light cure for 1 minute and 40 seconds after the lot has been removed twice [22, 23].

Finish

Excess infiltrant material is removed using floss and hand instruments for the final finish. Not only Icon can treat interproximal lesions, but it can also effectively cover up a wide variety of other dental flaws, such as white spots on the smooth surface, post-orthodontic white spot lesions, brown spots, hypo mineralization associated with molar incisor hypo-mineralization, and fluorosis-related lesions. Reduced light scattering conceals the discolored appearance. The Icon-Infiltrant has a similar refractive index as enamel. Therefore the lesion may be effectively "erased" with excellent cosmetic results [24, 25]. This refractive index property has the remarkable advantage of virtually eliminating smooth-surface lesions after treatment. This is not a concern for our smooth-surface lesions, but it does affect our interproximal lesions. When applied to smooth surfaces, resin infiltration reduces or eliminates the visibility of the white spot, brown spot, or fluorosis lesion. This method of treating soft surface lesions is innovative without the need for anesthetics or removing any tooth structure [26, 27].

The technique is very similar to interproximal use, with the apparent difference being the distance between the two. **Figure 1** depict the penetration of Icon resin to treat a case

of hypo-mineralization and create a smooth surface. Hypo-mineralization of the flat surfaces of the incisor teeth was present pre-operatively, as seen in **Figure 2** shows it is necessary to thoroughly clean the tooth or teeth treated using pumice or a non-fluoridated prophylaxis paste or rubbing the tooth with a diamond bur softly. **Figure 3** shows that Icon-Etch treats the lesion's outer surface (DMG America) [4, 28, 29]. The accompanying syringe is applied to the lesion and a 2-mm physical barrier. **Figure 4** After the prescribed amount of time has passed; the hydrochloric acid is removed, washed, and dried. During this time, agitating the acid can prevent it from being buffered and produce better results. The Icon kit includes a syringe filled with the ethanol drying agent Icon-Dry (DMG America), applied as directed **(Figure 5)**. As a precaution against the Icon-Infiltrant curing too quickly, turn off any overhead lights (DMG America). Place a vestibular tip on the Icon-Infiltrant syringe and apply it by twisting the needle. Allow 3 minutes of quiet time, and then peek at the finished product before curing it with light. If further concealment is needed, Icon-Infiltrant may be continuously injected into the lesion. Light cure after you're happy with the effect, then infiltrate for another 60 seconds with a fresh vestibular tip. **Figure 6** depicts the scene immediately after surgery, and **Figure 7** illustrates the position two weeks later. Infiltration with Icon resin is a groundbreaking minimally invasive option for this child's hypo-mineralization lesions. Excellent outcomes were achieved [30-32].

Figure 1. Initial pre-operative situation smooth surface molar incisor hypo-mineralization lesions

Figure 2. Abrasion with a diamond bur

Figure 3. Icon-Etch DMG

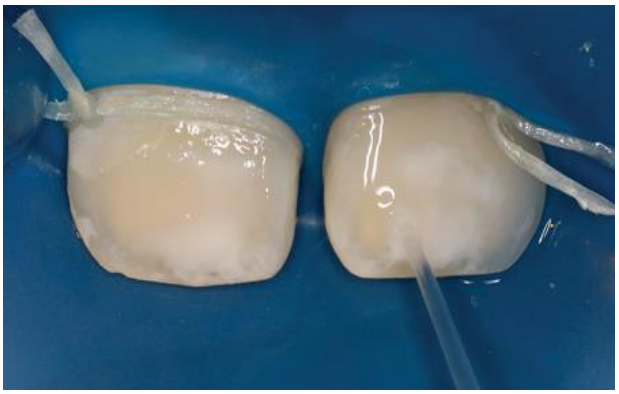

Figure 4. Icon-Dry DMG

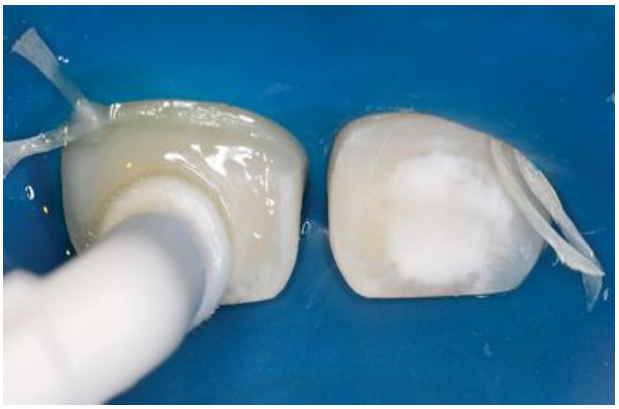

Figure 5. Icon-Infiltrant DMG.

Figure 6. Immediate post-operative situation.

Figure 7. Two-week follow-up.

There are three main requirements for a dental procedure to be successful. Choosing the right patient is the first and most important step, followed by making an accurate diagnosis and learning and mastering the necessary procedures. The total time for resin infiltration therapy, from beginning to end, is roughly 15-30 minutes. Due to the high concentration of hydrochloric acid (15%) in the etchant, accidental contact with soft tissue should be avoided, and protection should be used. The resin infiltrant is a hydrophobic material that requires an absolutely dry field. Patient selection is crucial for success given these two prerequisites. The patient must be cooperative enough to sit still during the infiltration procedure while a rubber dam or other isolation device is in place. For treatment to be successful, the lesion must be correctly identified. An icon can be used in E1, E2, and D1 lesion depths due to the penetrating abilities of the Icon-Etch and Icon-Infiltrant (D1) [33, 34]. Cavitated enamel, damage to Dentin 2, and D3 lesions may necessitate restorative procedures. On display in **Figure 1** are examples of lesions that meet the criteria for Icons. The best outcomes can only be attained with a thorough focus on technique. If you want this method to work, you have to follow the manufacturer's directions. There is a tremendous body of research to back up the methodology's steps. Several studies are referenced, and the most effective practices recommended and outlined here result from these investigations, including the composition, timing, concentration, frequency, and repetition of each step [35].

Conclusion

Resin infiltration is a non-surgical, effective, and permanent therapy option. Patients may get therapy in as little as a few minutes without needing a local anesthetic or removing healthy tooth structure, and they can anticipate permanent, irreversible effects. Minimally invasive and painless treatment is an option for interproximal lesions of sufficient depth and no evident cavitation. Lesions with a smooth surface are easier to cover up or remove. The Icon-Infiltrant builds an unbreakable and robust wall.

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