Clinical efficacy of caries infiltration technique: systematic search of the literature

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Abstract

Aim: The aim of this paper is to review the available literature explaining the scientific basis and the principles of the resin infiltration concept.

Materials and Method: A systematic search was conducted in MEDLINE, EBSCO and Google Scholar database. Key words used for conducting search were "Resin" and "caries infiltration technique". Retrieved titles and abstracts were screened for relevancy and suitability. As many full text of selected articles were retrieved as possible. These full text articles were reviewed thoroughly.

Result Resin-infiltration technique is based on the penetration of low-viscosity light-curing resins, so called infiltrants, into the pores on demineralised enamel surfaces to treat initial carious and white spot lesion. That way, diffusion pathways for cariogenic acids are occluded, resulting in a reduction or even arrest of lesion progression with extended novel indication for fluorosis and traumatic hypo-mineralized lesions.

Conclusion: Based on available laboratory and clinical studies, it seems convincing that resin infiltration of enamel lesions could reduce (or even stop) the progress of white spot lesions and close the therapeutic gap between noninvasive and invasive treatment options that significantly postpone the first invasive intervention.

Keywords: Caries, White spot lesion, Dental etching, Caries infiltration resin, Caries infiltration, Proximal caries infiltration

Introduction

During the last decades, caries has been seen as a continuum of disease from subclinical demineralization to gross cavitated lesions. The detection and assessment of carious lesions has become more difficult tasks, and now a wider range of care options are available.(1)

It is now widely accepted that, throughout the day, the tooth surface is in a continuous state of demineralization and remineralization as part of a natural physiological process. Under acidic challenge, when demineralization predominates over remineralization, caries will progress, but perhaps more importantly, when remineralization predominates over demineralization, the lesion can be reversed or arrested.(2) Depending on the stage in the caries process and the rate of progression of the disease, a range of therapeutic procedures might be applied to favor remineralization. The detection of carious lesions at an early stage is necessary in order to implement preventive and interceptive treatment strategies.(3)

Restorative treatment is based upon the results of a clinical examination and is ideally part of a comprehensive treatment plan. The restorative treatment plan must be prepared in conjunction with an individually-tailored preventive program.(4)

Infiltration Concept: A new treatment concept introduced into the field of dentistry in 2008 for treating white spot lesions.(5) It is an alternative therapeutic approach to prevent the further progression of enamel lesions. The aim of this treatment is to occlude the porosities within the body of the white spot lesion with a low viscosity light-cured resin that has been optimized for penetration into the porous enamel. Infiltrants are light-curable resins that were developed for penetration into the porosities of a lesion, with low viscosity, low contact angles to the enamel, and a high surface tension. All of these properties are important for complete penetration into the porosity.(6) Before the infiltration of the resin, the enamel is conditioned using 15% hydrochloric acid gel. The infiltrant (resin) penetrates into the lesion driven by a capillary force. The resin material was developed after several pilot studies done at the University of Kiel, Germany, that developed the infiltrant, for which they had experimented with various mixtures of resin materials such as TEGDMA, BisGMA and ethanol using various mixing ratios. A mixture of highest penetration coefficient was preferred as an infiltrant,(7) so as to create a diffusion barrier within the lesion and not on the lesion surface.(8)

Materials and Method

Data sources: The review of literature was done electronically as well as manually. For electronic search, various scientific journals and web-based search engine - Medline and Pubmed, Google Scholar were searched for literature, related to caries infiltration published either in English or with an English abstract in any other language publications from 2007 to the present December 2014. Further, Medline and Pubmed, Google Scholar were searched using authors name and the related articles link for key publications. Articles were manually retrieved from BB Dikshit Library of All India Institute of Medical Sciences, New Delhi, India and National Medical Library, New Delhi. Relevant Cross references of the relevant articles were also retrieved.

The shortlisted studies were screened and independently categorized. Any kind of disagreement between the authors regarding article and data extraction was sorted. In reading the articles, the reference lists were checked to identify any other articles that may have been relevant to the research question or provided additional information.

Table 1 shows the key words and their combinations used in the literature search.

Table 1: Literature search strategy

Key word- "caries infiltration", "icon caries infiltration", "caries infiltration technique", "caries infiltration resin", "proximal caries infiltration"	167
Duplicate articles removed	86
Search limited to humans	59
Relevant articles at title stage	24
Relevant articles at abstract stage	15
Relevant articles at full stage	15
Articles included in study	10

Inclusion and exclusion criteria: We included randomized and quasi-randomized controlled trials on the efficacy of icon caries infiltatrion in any clinical dental application to summarize the results. In vitro studies, case series, case reports, editorials, review articles and commentaries were read to identify potential evidences and reported in discussion.

Study selection, data extraction and quality assessment: A total of 167 articles were retrieved from the various databases. After removing duplicates, we limited the search to articles in English and to studies that involved human subjects. We selected 59 citations and searched for relevance (determined by title), which resulted in 24 articles. We reviewed the abstracts of these articles for relevance, which resulted in 10 articles that were finally included as a part of the systematic review. Articles were reviewed at each stage independently and discrepancies were solved by consensus. Two of the authors screened (M.C, K.S) the shortlisted studies and independently categorized and extracted data from the full text of the articles. Any kind of disagreement between the authors regarding article screening and data extraction was sorted by the other two authors (N.R, O.S). The abstraction sheets for annotated author/date, population, age, sex, geographic location, intervention or test treatment (number of subjects), control treatment (number of subjects), outcome, conclusion, and classification of recommendations was prepared. The abstraction sheets were reviewed thoroughly to determine relevance.

Results

Clinical Procedure: A single package consists of an Infiltrant which is a composed of the resin tetraethylene glycol dimethacrylate for infiltration, additives and initiator, an acid conditioner to etch the enamel surface made of 15% hydrochloric acid(as opposed to 37% phosphoric acid in sealants) as an etching material, and ethanol(used as a drying agent). It works on the principle of the light-scattering phenomenon.[9]

The objective of resin infiltration is to halt progression of small proximal carious lesions by surrounding them with polymerized unfilled resin.[4]
This technique uses a specialized matrix interproximally in order to:

1. Treat the surface of non-cavitated caries lesions with hydrochloric acid
2. Desiccate the surface with air then ethanol
3. Infiltrate, via capillary action over several minutes and two applications, an unfilled "fluid" resin to the extent of the dentino-enamel junction or slightly beyond
4. Polymerize the resin with light

A different version of the product is available to repair early carious lesions in the form of white spots gingival to orthodontic brackets (after removal of brackets) when plaque removal was less than ideal.[10,11]

Recommendations

Resin infiltration has been introduced as a treatment option for small interproximal carious lesions in permanent (and, in some circumstances, primary) teeth.[12]

After the advent of bonding agents and development of sealants, some studies on infiltration of early carious lesions were conducted. However, the research on these kinds of studies is very limited. The total treatment time per tooth is about 15 minutes. Treated teeth may become desiccated during treatment and may appear lighter than adjacent teeth immediately after the procedure. There is no discomfort associated with this potential outcome and patients should be counseled to rinse and hydrate the tooth (or teeth) for several hours after the procedure. The final shade result will be harmonious with adjacent teeth. The specially designed screw-type syringes with luer-lock tips ensure gentle and slow extrusion of the materials, and they can be operated with one hand. Conveniently, adjacent surfaces can be treated at the same time. The technique proscribed by the manufacturer, including the use of a rubber dam, must be strictly followed.[13]

The Table 2 summarizes the findings of the clinical studies.

Table 2: Clinical studies

Author, Year	Duration	Study Design	Study Population	Control	Intervention	Outcome	Authors Conclusion
Bakhshande HA, Ekstrand K (2014) (14)	2-3 years	Split-mouth design study	50 children aged between 5 and 8 years with three occlusal lesions each	One lesion was varnished with duraphat (F).	One lesion was infiltrated with icon and varnished with duraphat (I+F) One lesion was sealed with delton and varnished with duraphat (S+F),	Radiographic progression.	Infiltration and sealing occlusal surfaces with initial caries lesions on primary molar teeth showed a high efficacy in arresting caries progression, significant for the "I+F" or borderline significant for the "S+F" compared with the F group.
Knosel M, Eckstein A, Helms HJ (2013) (15)	6 months	Simple randomized, split-mouth, controlled	21subjects with 231 non-cavitated, unrestored white spot lesions after multi bracket treatment were recruited	108 teeth in 20 subjects with no treatment	White spot lesion infiltration of the 111 anterior teeth was performed with low-viscosity light-cured resin after enamel conditioning with a 15% HCL gel	Color and lightness of the white spot lesions and the sound adjacent enamel were assessed with a spectrophotometer before infiltration and after 1 day, 1 week, 4 weeks, 3 months, and 6 months	The results showed sufficient durability of resin infiltration over 6 months. It also improved the esthetic appearance of demineralized teeth
Altarabulsi MB, Alkilzy M, Splieth CH (2013) (16)		Quasi randomized	50 children, adolescents, and young adults		The infiltration material Icon on non-cavitated proximal lesions in permanent and primary teeth	The applicability was evaluated using two questionnaires filled out by clinicians and patients assessing the comfort, complexity, time, and difficulties of the application in comparison to a filling.	Resin infiltration of initial non-cavitated proximal lesion showed good clinical applicability for clinicians and very high acceptance by patients

Meyer-Lueckel H, Bitter K, Paris S (2012) (17)	3 years	Randomized split-mouth placebo-controlled trial	29 pairs of proximal caries lesions from 22 young adults	Placebo was used for the control group	infiltration was performed	Radiographic assessment using digital subtraction radiography	7% of treated lesions, showed progression, while in the placebo 37% lesions showed progression
Hammad SM, El Banna M, El Zayat I, Mohen MA (2012) (18)	1 Week	Quasi randomized	18 orthodontic ally treated patients were divided into two groups based on the extent of demineralization	Group 1: visible WSLs without surface disruption and group 2: WSLs showed a roughened surface but not requiring restoration.	Three successive photographs were taken for every patient; immediately after bracket removal, 1 week after oral hygiene measures and after icon material application.	Three successive photographs were taken for every patient; immediately after bracket removal, 1 week after oral hygiene measures and after Icon material application	JPEG images were imported into image analysis software (Image J version 1.33u) which presented the images into histograms of gray scale from (0 to 255)WSLs in Group 1, the means at gray scale for the initial and the final photographs were 126.091 +/- 13.452 and 221.268 +/- 9.350 For WSLs in Group 2, the means at gray scale for the initial and the final photographs were 95.585 +/- 20.973 and 155.612 +/- 31.203 respectively
Martignon S, Ekstrand KR, Gomez J, Lara JS, Cortes A (2012) (19)	3 Years	Randomized split-mouth controlled clinical trial	39 patients each with 3 proximal lesions were included	Control-Test-C (placebo).	Test-A (infiltration: icon-pre-product; DMG), Test-B (sealing: prime-bond; DENTSPLY	Primary outcome after 1, 2, and 3 yrs of radio graphically observed lesion progression was assessed using pair-wise and digital-subtraction readings	The study showed that infiltration and sealing are significantly better than placebo treatment for controlling caries progression on proximal lesions. No significant difference was seen between infiltration and sealing
Ogodescu A, Ogodescu E, Talpos S, Zetu I (2011) (20)	10 Months	Quasi randomized	12 patients with mild decalcifications prior to the orthodontic treatment were examined once each month		At aggravation of the WSLs, the brackets were taken down, the lesions were infiltrated with resin (icon) and the brackets were bonded in place.	WSLs were evaluated from intraoral photographs taken before and during the treatment.	This clinical study showed a positive evolution of the resin infiltrated WSLs during the fixed orthodontic therapy. Orthodontic-orthognathic surgery cases or patients that are refractory to oral hygiene measures

Kim S, Kim EY, Jeong TS, Kim JW (2011) (21)		Quasi randomized	Twenty teeth with a developmental defect of enamel (DDE) and 18 teeth with post-orthodontic decalcification (POD) were selected	Treated with resin infiltration to assess the effectiveness of masking white spot enamel lesions	Standardized photographs were taken before, immediately after, and 1 week after treatment	The results were classified into three groups: completely masked, partially masked, and unchanged.	Among the 20 teeth with DDE, five teeth (25%) were classified as completely masked, whereas seven (35%) and eight teeth (40%) were partially masked and unchanged, respectively. Among the 18 teeth with POD, 11 teeth (61%) were completely masked, six teeth (33%) were partially masked, and one tooth (6%) was unchanged
Paris S, Hopfenmuller W, Meyer-Lueckel H (2010) (22)	18 months	Randomized split-mouth placebo-controlled clinical trial	22 young adults, 29 pairs of interproximal lesions	A placebo treatment was performed in the control group	Lesions were infiltrated (icon, pre-product; DMG)	Radiographic assessment by digital subtraction radiography	Infiltration of interproximal caries lesions is efficacious in reducing lesion progression.
Ekstarnd KR, Bakhshande A, Martignon S (2010) (23)	1 year	Clinical split mouth study	48 subjects aged 5-8 years old having two lesions each	Only one lesion was given flouride varnish only	One lesion was infiltrated with resin followed by flouride varnish (2.26% F)	Radiographic assessment using digital subtraction radiography	Resin infiltration in conjunction with fluoride varnish seems promising for controlling proximal lesion progression on deciduous molar teeth.

Discussion

This systematic review of the literature on the icon caries infiltration technique in the treatment of initial caries lesion, concludes, with a good level of evidence,[24,25] that the sealants act by forming a superficial barrier at the surface of the tooth (and eventually wear off) against the penetration of bacteria and their by-products. The sealants only cover incipient carious lesions, while infiltration techniques works by capillary action by creating an internal barrier in the lesion by replacing lost minerals with low viscosity light-cured resin.[26] With this technique, the unique low viscosity resin is drawn deep into the pore system of a lesion like a sponge draws up liquid. The resin completely fills the pores within the tooth, replacing lost tooth structure and stopping caries progression by blocking further introduction of any nutrients into the pore system.[27] With infiltration, carious lesions are stabilized while the anatomical shape and color of the tooth are not altered at all. Filling and occluding of these pores with resin could impede lesion progression, and moreover, should prevent cavitation by strengthening the enamel structure.[28]

The durability of the result is dependent on the lesion's environment. Caries inhibition is being maintained in a weakly demineralising environment, but it is likely that in a patient at uncontrolled risk of caries, demineralisation will continue or recur at the periphery of the resin infiltrated area. The technique does not make proper management of caries risk and patient monitoring redundant. Resin infiltration seems suited particularly for proximal lesions where, when invasive treatment is chosen, the ratio of normal tissue to carious tissue leads to significant loss of healthy tissue in order to gain access to the lesion, even when applying micro-invasive methods of preparation such as sono-abrasion.[29]

It is extremely difficult for the practitioner to locate the border between the absence and presence of cavitation clinically and radiographically in the interproximal spaces between adjacent posterior teeth. Initial lesions evaluated as non-cavitated may nevertheless appear with broken-down surface layers. The technique is therefore not recommended for the management of cavitated lesions and it should be borne in mind that, if a proximal cavity has not previously been detected, infiltration may be faulty and caries inhibition may fail. Here again, the technique does not dispense with the requirement for early detection, thorough diagnosis and rigorous caries monitoring.[30]

The risk-benefit ratio of this non-invasive and aesthetic technique is favourable but clinical experience is limited. The earliest of the studies done on the concept of infiltration dated back to 1976 when Robinson et al published their work. They investigated the concept of infiltrating a carious lesion using adhesive compound called resorcinol formaldehyde.[31]

These early studies have provided the ground-work for evolution of infiltration material by helping to develop the materials and methodology for treating cavitated and non-cavitated lesions with infiltration resins. These studies have concluded that resin infiltration materials are promising in prevention and treatment of dental caries.[24,25,26,27]

These studies concluded that infiltrating material is effective in preventing the progression of the caries lesion, in comparison to no treatment. Radiographic studies have also been done to monitor the progression of the lesion. The clinical studies that were conducted using the infiltrating showed promising results. However, longer studies with more subjects are required.[21,32]

The infiltration technique has several advantages over the other techniques. First, deeper lesions can be improved by the infiltration techniques which aren't amenable to remineralization, and the esthetic improvement can be seen instantly.[33] Secondly, the infiltration is much less invasive compared to restoring the tooth. Once the resin material is infiltrated, excess material was removed from the surface of the lesion using a cotton swab and the material infiltrated, and curing was done using a ultra-violet light.[34]

Various infiltration materials (resins) showed promising results in terms of infiltration into the lesions, prevention from secondary acid attack. Although one clinical study demonstrated promising results, very few clinical studies have been done to assess the efficacy of such materials.

As discussed earlier, the infiltrating technique works on the principle of infiltration, which also requires a very dry field. Apart from keeping the environment moisture-free, additional steps must be taken to dry the lesion. This is accomplished by treating the lesion area with alcohol, which evaporates the water within the porosities which can inhibit the process of infiltration. Another disadvantage of infiltrating technique compared to the sealant material is the etching process. For infiltrating technique, the etching is accomplished with 15% hydrochloric acid, which is more corrosive compared to the 37% phosphoric acid.[35] The hydrochloric acid has to be kept away from the oral soft tissue, which requires placement of a rubber dam if done intraorally. In addition, during the etching procedures, problems arose concerning the number of etchings done on the white spot lesions. First, the infiltrating material is a very technique-sensitive material to be used in a public health setting. The materials that are typically used in such settings are easier to use; in contrast, the procedure involved with the infiltrating material must be followed carefully and every step from etching to infiltration and curing has to be done carefully and in a timely manner. The other challenges for infiltrating technique use in both public health setting and a private practice are the high cost of the material and the fact that the treatment and that the costs incurred by the treatment are not reimbursable by insurance companies. Given the need to minimize costs in public and private settings, it

is not clear that use of infiltrating technique is cost-effective in routine practice for the prevention of caries. Research is needed specifically investigate the cost-effectiveness of infiltrating technique compared to other treatments.[12,22,24]

Conclusion

Cosmetics and esthetics are current trends of our society. There is a growing demand for minimally invasive enhancement without anesthesia, drilling.[36] Caries infiltration is a clinically feasible and efficacious method for the treatment of interproximal lesions without prior temporary tooth separation.[28] It significantly increase micro-hardness and reduce mineral loss after a demineralization challenge compared with untreated lesions and allows for the recovery of natural tooth appearance. Therefore, this treatment can be regarded as an additional option for the non-operative and operative treatment measures for caries lesions.

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Conflict of Interest: Nil

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