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Case Reports

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Patient history or etiology. Orthodontic treatment with fixed brackets.

Affected tooth/teeth. One or more teeth depending on the oral hygiene.

Localization. Typical around brackets. Mostly cervical.

Border. Well-demarcated.

Cariogenic white spot lesions.
Dental history and visual diagnosis.

Dental caries is one of the most prevalent diseases in the world and by far the most prevalent disease of the oral cavity. It is caused by the metabolic activity of the oral biofilm, which is triggered by the frequent intake of fermentable carbohydrates such as sugars. Characteristic for caries is a loss of minerals of the affected dental hard tissues. In younger patients, caries mostly starts in the dental enamel. The early and medium stages of the disease are characterized by an increased porosity of the affected enamel, which clinically appears as a white chalky spot due to increased light scattering between the crystals and the pores. In later stages the porous enamel breaks down and forms characteristic cavities.

Dental caries is a dynamic disease in which phases of mineral loss and mineral gain alternate. If mineral loss outbalances mineral gain, the diseases progresses and the lesions are called »active«. If, however mineral gain predominates, lesions may arrest. Mineral gain is usually confined to the outermost 30-200 µm in the so-called surface layer of the lesion, whereas the lesion body remains porous. Therefore, even arrested lesions still look opaque and often are hard to discriminate from active lesions.

Caries lesions only form in tooth surfaces where dental plaque is allowed to grow for longer periods, the so-called predilection sites. As most of these sites are hidden, initial caries usually is not an esthetic problem. However, during treatment with orthodontic brackets caries lesions may also form in buccal free smooth surfaces. After debonding of brackets, these lesions usually can be arrested quite easily by brushing and fluoride application. However, the unaesthetic appearance of the whitish spots often persists or even gets worse due to inclusion of food stains in the surface layer, which makes the lesions look brownish.

Caries infiltration originally was developed to arrest non-cavitated caries lesions. One positive side-effect of the treatment is that the whitishe color of enamel lesions disappears during and after infiltration as the infiltrated resin reduces the light scattering between the enamel crystals. In this way lesions can be camouflaged and an esthetic improvement can be achieved quite easily with only minimal substance loss.

Prof. Dr. Sebastian Paris
Camouflage of a fluorotic change in the enamel with superimposed post-orthodontic decalcifications.

Prof. Dr. Michael Knösel

A 16-year-old patient presented with a request for visual improvement of the anterior esthetics impaired by irregularly distributed whitish enamel spots. A treatment performed elsewhere with fixed orthodontic devices (multi-bracket (MB) devices) was completed roughly one year before; in the course of this treatment four premolars were removed and the gaps closed. The subsequent retention of the final result was performed with fixed retainers in the upper and lower jaws, which were in situ at the time of presentation.

In a visual and tactile examination the whitish opaque spots were diagnosed, because of their striated appearance without sharply defined edges, as fluorotic change in the enamel, visible in a varied distribution on all present teeth, and, in the case of the premolars in particular, very clearly including the occlusal surfaces. Furthermore, under closer examination and after drying, it was possible to identify a border around the area that was previously covered by the bracket bases of the MB device, in particular on the maxillary canines and lateral and central incisors. Moreover, striated changes could also be seen underneath the former bracket bases. The suspicion that the patient has an enamel fluorosis with superimposed post-orthodontic decalcifications is consistent with the information provided by the patient in relation to a worsening of the spotting during the MB treatment.

The patient had previously found information on potential forms of treatment on the Internet and volunteered a strong desire for infiltration treatment to improve the dentofacial esthetics. Together with the patient, the scope of the treatment was determined: treatment of the changes in enamel in the esthetically relevant areas of teeth 15-25 (with teeth 14/24 missing) and 33-43. For successful treatment of pronounced fluorotic enamel changes and also deep WSL, the literature describes micro-abrasive slurries comprising roughly 15% HCl/pumice powder (acid-pumice technique) [1-4].

Because using an infiltration technique exclusively was deemed difficult given the initial situation (enamel fluorosis with superimposed post-orthodontic decalcifications, and some micro-cracked enamel structures as on tooth 12), it was decided to proceed with a combined method to improve the result of the fluorosis infiltration:

The HCl acid gel contained in the infiltration kit and pumice powder (Ernst Hinrichs Dental, Goslar) were used to prepare a slurry to selectively pre-treat areas with deep fluorotic changes. This was done by carefully working on the affected teeth 15-25 and 33-43 with a polishing cup and the slurry at a low rotational speed.

Applying a rubber dam, in particular in the area of the lower incisors, often prevents conditioning and infiltration of the areas near the gingiva; this measure was therefore deliberately avoided. After the gel was rinsed away, drying was performed in each case with the ethanol contained in the kit. Drying with ethanol is vital for achieving the capillary effect required for infiltration; it also makes it possible to assess the esthetic result that can be expected. This assessment was performed together with the patient; in this case, the HCl steps were repeated five times to prepare the enamel surfaces sufficiently to achieve the desired esthetic result.

This was followed by infiltration; the infiltrant was left for three minutes and subsequently light-polymerized. A second infiltrant application was performed, which is recommended with a reaction time of one minute to compensate for the composite polymerization shrinkage, followed by further light-curing and polishing of the infiltrated enamel areas. After infiltration, a significant masking was apparent, deemed highly satisfactory by the patient, of both the fluorotic enamel areas and the enamel areas decalcified by the orthodontic treatment.
White spot lesions are early signs of demineralization under an apparently intact enamel surface layer. These early enamel lesions show a whitish appearance as a result of an increased porosity within the lesion due to mineral loss [1]. In case of poor oral hygiene or salivary hypofunction even on buccal surfaces of the teeth a plaque accumulation can result in white spot lesions [2]. Especially in patients that underwent orthodontic treatment with brackets white spot lesions can occur due to the difficulties to clean the area adjacent to the bracket. Several clinical studies show a high prevalence of white spot lesions after bracket removal [3, 4]. With preventive strategies like improvement of the oral hygiene and topical fluoride application there is a good chance of arresting early lesions. Though the caries progression may be stopped the whitish appearance often remains as the remineralization is superficial and there is still a porous lesion body underneath [2]. In addition to that stains can be incorporated into the lesion with the result of a brownish appearance of the lesion (brown spots) which often leads to even more esthetic deficiencies. That is why the dentist may become confronted with the patients desire to rehabilitate esthetics.

Treating non-cavitated white spot lesions may include tooth bleaching, micro-abrasion, composite fillings or even prosthetic restorations like veneers or combinations of these treatments [5]. All these options are quite invasive implying tooth structure loss. As a micro-invasive alternative caries infiltration (Icon) can be applied to prevent further caries progression. It imbeds the adjunctive effect of masking the whitish appearance of the lesion.

With the infiltrant the porosities in the lesion body are occluded. Therefore, this treatment may be used not only to arrest enamel lesions but also to improve the esthetic appearance of buccal white spots. **Clinical case report**

A 19 year-old male patient complained about the appearance of his upper front teeth due to whitish lesions on the vestibular surfaces. He had an orthodontic treatment with brackets during adolescence and when the brackets were removed the white spot lesions became apparent. In order to fulfill the patient’s desire of an esthetic improvement we suggested an Icon treatment to mask the lesions.

**Key Learnings**
- Icon infiltration treatment can get satisfactory esthetic results on the patients suffering from both post-orthodontic decalcifications and fluorosis.
- Icon-Dry can predict the esthetic result after Icon-infiltration. This assessment should be performed together with the patient.

**References**
When Icon-Dry is applied, the lesions disappear for the Fig. 7: removed with water spray for 30 seconds and the surface is dried.

been treated with a composite filling. After 2 minutes the etching gel is Application of the Icon-Etch for Fig. 6: the liquid dam was applied. Furthermore any contact of the material with the gingiva should be avoided. In this case the cavitation involves dentin, the filling should be performed before the Icon treatment as the hydrochloric acid of the Icon-Etch might lead to a decrease of shear bond strength of the adhesive to dentin [7].

Conclusion With Icon white spot lesions can be masked effectively. It is micro-invasive to the treated enamel surfaces, prevents further demineralization and is easy in handling and application. In case of white spot lesions occurring next to cavitated lesions Icon can successfully be combined with a conventional filling of the cavitated lesion.

Key Learnings
- Infiltration treatment can be combined with direct composite restoration when both white spots and cavitated caries lesion exist on enamel.
- When the cavitated lesion is restricted to enamel the infiltrant even enhances the shear bond strength of the adhesive.
- When the cavitation involves dentin, the filling should be performed before the Icon treatment as the hydrochloric acid of the Icon-Etch might lead to a decrease of shear bond strength of the adhesive to dentin.

Discussion

The manifestation of white spot lesions after bracket removal is a common side effect due to the impeded oral hygiene adjacent to the bracket during orthodontic treatment [3, 4, 6]. As esthetic demands of the patients arise dentists do not only have to take care of preventing a further progression of the lesions but also have to deal with the patient’s wishes of masking these lesions which can be esthetic compromising. In contrast to other treatment options like composite filling, micro-abrasion or bleaching, Icon offers a micro-invasive treatment tool without drilling that can not only stop the lesions progression but also can mask the whitish appearance of the white spot lesions. In case of adjacent cavitated lesions Icon can be successfully combined with a conventional filling in this area. When the cavitation is restricted to enamel the infiltrant even enhances the shear bond strength of the adhesive [7]. Filling procedure and infiltration can be combined in one step. When the cavitation involves dentin the filling should be performed before the Icon treatment as the hydrochloric acid of the Icon-Etch might lead to a decrease of shear bond strength of the adhesive to dentin [8].

References

Introduction

White spot lesions (WSL) are non-cavitated caries lesions that are often observed in the esthetical visible area [2,7]. During orthodontic treatment with fixed elements (brackets) plaque retention is increased resulting in a higher risk for new WSL [16]. In a study on premolars being referred for extraction it could be shown that the development of WSL occurs within 4 weeks under fixed, but non-cemented orthodontic bands [12]. Due to the design of orthodontic appliances biofilm is frequently not sufficiently removed by oral hygiene measures. It is, thus, no surprise that after orthodontic treatment rapid debonding may be required unless oral hygiene is crucial [16]. However, if WSL are detected after an orthodontic treatment it seems to be related to the type of lesion whether a complete remineralization can be achieved [12]. On the one hand, slightly visible, initial WSL often completely remineralize in saliva, since fixed elements – increasing the plaque retention – have been removed. The remineralizing effect can be increased by the additional use of fluoride e.g. in form of fluoride varnish [12,17]. On the other hand, clearly visible, severe WSL cannot be visually masked by saliva and fluoride alone. They remain visible for life. However, if WSL are detected after an orthodontic treatment rapid debonding may be required unless oral hygiene and fluoride regimens are followed accurately [12] whereas after orthodontic treatment the appearance of the WSL should be masked.

CASE 1.3

Masking and arresting of caries during treatment with brackets.

Prof. Dr. Hendrik Meyer-Lückel, Dr. Richard Johannes Wierichs, Fidaa Shikh Ali

To prevent caries lesions during orthodontic treatment an optimal oral hygiene is crucial [16]. However, if WSL are detected after an orthodontic treatment it seems to be related to the type of lesion whether a complete remineralization can be achieved [12]. On the one hand, slightly visible, initial WSL often completely remineralize in saliva, since fixed elements – increasing the plaque retention – have been removed. The remineralizing effect can be increased by the additional use of fluoride e.g. in form of fluoride varnish [12,17]. On the other hand, clearly visible, severe WSL cannot be visually masked by saliva and fluoride alone. They remain visible for life. Thus, for severe WSL more invasive treatments are indicated. During orthodontic treatment rapid debonding may be required unless oral hygiene and fluoride regimens are followed accurately [12] whereas after orthodontic treatment the appearance of the WSL should be masked.

Caries infiltration is one method to mask initial non-cavitated lesions. By infiltrating the lesion microporosities of the carious enamel are obturated. Thus, the caries progression is arrested. Furthermore, due to the similar refractive index of the infiltrant (RI of infiltrant 1.52) compared with apatite (RI=1.62), light scattering is reduced and visual color differences to enamel are decreased directly after application. Thus, the visual appearance of the lesion is changed positively and the WSL appears less white than before; in other word the lesion is masked [10,14].

In several studies on WSL – being diagnosed after orthodontic treatment with fixed elements – a positive masking effect after the infiltration was observed [3, 4, 5, 6, 8, 9]. Furthermore, the masking effect was classified as satisfactory (although not complete) in further studies [4, 5, 8, 11]. Interestingly, the time between debonding and infiltration seems to play an important role in order to allow an effective masking of WSL [9]. The shorter the time after debonding the better the masking effect. This observation was supported in a second non-controlled study [13]. In this study the masking effect of caries infiltration was examined during the treatment with fixed orthodontic elements. Immediately after the detection of a WSL the bracket was removed, the WSL was infiltrated and the bracket was rebonded. During the subsequent 10-month follow-up 92.5 % of the infiltrated WSL showed no further worsening.

On the basis of the previous studies the success of the masking effect seems to depend on the time between detection of the WSL, debonding and infiltration. Shorter time periods between debonding and infiltration seem to mask WSL more effectively. This raises the question if the esthetic outcome can be optimized by infiltrating WSL during the orthodontic treatment. Moreover, infiltration during orthodontic treatment arrests the lesion progress at an earlier point in time.

Case report

A 15-year-old female patient complained of white spots in the esthetical visible area. The lesions were observed after a 24-month orthodontic treatment with fixed elements. The patient’s main concern was to stop lesion progression with a minimal-invasive treatment without interrupting the orthodontic treatment. The patient was in good general health. ICDAS criteria were used for the visual-tactile assessment of the WSL [11]. Furthermore, photo documentation was performed to assess the severity of the lesions [19]. The clinical examination revealed an ICDAS level of 2 for six teeth, two of these being active lesions. The patient was asked to participate in a monocentric, controlled, randomized split-mouth study. After informed consent teeth with WSL were randomly divided into two groups. Without removing the brackets, teeth in the control group (teeth 13, 21, 23) were treated with a fluoride varnish (Tiefenfluorid®, Humanchemie, Alfeld/Leine) and those in the test group (teeth 12, 11, 22) were infiltrated with a low-viscosity polymer (Icon-Infiltrant, DMG, Hamburg) and subsequently fluoridated in the same way as the control group.

Fig. 1: Situation before treatment.

Fig. 2: One week after treatment.

Fig. 3: Directly after removal of the brackets.

Fig. 4: One week after removal of the brackets and after infiltration of the control teeth.
The visual appearance of WSL were improved by caries infiltration. The patient reported no significant adverse event after infiltration. FIG. 1: Situation before treatment. FIG. 2: Situation one week after treatment. FIG. 3: Situation one week after debridging. FIG. 4: Situation one week after debridging and infiltration of the teeth in the control group. FIG. 5, 7, 9: Test teeth 11, 12, 22 before treatment. FIG. 6, 10: Test teeth 11, 12, 22 one week after treatment. FIG. 11, 13, 15: Control teeth 13, 21, 23 before treatment. FIG. 12, 14, 16: Control teeth 13, 21, 23 one week after treatment.

Key Learnings
- Shorter time periods between deboning and infiltration seem to mask WSL more effectively.
- Infiltration can be performed during orthodontic treatment and can arrest lesion progression at an earlier point in time.

References
Post-orthodontic decalcifications or white spot lesions are a significant aesthetic challenge. They have been reported at incidences as high as 73% - 95% [1, 2]. The prevalence of white spot lesions is so high due to several factors. Oral hygiene for patients with orthodontic appliances, bands and brackets is a challenge. Besides maneuvering around and cleaning between orthodontic hardware, it provides an increase in surface area for plaque and biofilm to accumulate. Add to this a teenaged patient, the most common recipient of orthodontic treatment, who may present with a lack of motivation to maintain oral hygiene and a high caries risk scenario ensues. White spot lesions can develop in as little as one month [3, 4, 5]. The lesions are often detected after debonding. Patients, parents, orthodontists and general dentists all have the same perception; that the appearance of white spot lesions is highly undesirable [6]. Studies show that resin infiltration (Icon DMG) proves to be most effective at masking smooth surface lesions [8]. Furthermore the colour stability of caries infiltrated resin infiltration (Icon DMG) proves to be most effective at masking the appearance of white spot lesions is highly undesirable [6]. Studies show that resin infiltration of demineralized enamel does not affect the bond strength of orthodontic brackets [13].

Case Study
Post-orthodontic white spot lesions treated with resin infiltration (Icon DMG).

- Pre-operative photograph.
- Dry field is essential for success. Rubber dam is placed to isolate the field and should be inverted, or ideally ligated, to prevent leakage or saliva contamination.
- Prophylaxis with non-fluoridated pumice is completed; teeth are rinsed, then dried. Icon-Etch (hydrochloric acid) is applied, etch should extend approximately 2 mm around the edges of the lesion and be placed for 2 minutes. Once in place the etch gel should be agitated with an instrument as it will buffer shortly after contact with the surface of the tooth. Etching process was repeated a second time for this case. For long standing white spot lesions the Icon-Etch step may be repeated.

- Rinse for 30 seconds and dry completely with oil free air. Application of Icon-Dry (99% ethanol) to the dried surface. Icon-Dry can indicate the final result after infiltration. Since the result was satisfactory, the ethanol was left on the surface for 30s to promote a thorough desiccation of the enamel, followed by air-drying.

- Application of Icon-Infiltrant by twisting the syringe. At this point remove direct overhead light source to avoid premature curing of the infiltrant. Continue «feeding» infiltrant to lesion for 3 minutes.

- Remove any excess material and light cure. Repeat the infiltration process with a new vestibular tip for 1 minute. Remove excess again and light cure. Final polish with Shofu OneGloss.

- Micro-invasive treatment of post orthodontic white spot lesions can be completed in approximately 15 minutes chair time per tooth without mechanical removal of tooth structure or use of local anaesthetic. Excellent immediate post-operative results followed by long lasting beauty and stability.

Key Learnings
- Recognize the aetiology and prevalence of post orthodontic decalcification/white spot lesions.
- Understand the success and effectiveness treatment of post orthodontic decalcification/white spot lesions with resin infiltration.
- Follow the clinical procedure of micro-invasive resin infiltration of smooth surface lesions.

References
Fluoride has an important and determinant role in dental caries prevention. However, excess and constant exposure to this chemical element during enamel formation may result in fluorosis, and its severity is directly related to the amount of fluoride which the patient contacted during enamel formation/maturation. [1,3]

Clinically, mild dental fluorosis is characterized by a diffuse whitish opaque appearance caused by a porous/hypominerализed subsurface enamel with an intact surface layer. In cases in which higher concentrations or prolonged fluoride exposure occurred, moderate and more severe fluorosis present a clinical aspect ranging from more extensive and opaque whitish or brownish stained enamel to pitted enamel lesions that occur pre- or post-eruptively due to deeper defects in enamel formation/mineralization. [1,6]

Of all permanent teeth, the anterior teeth are more likely to be affected by fluorosis, since the period of development and maturation of these teeth coincides with the beginning of exposure to fluoride during the second and third year of life. [1,3]

The alteration in esthetic perception caused by fluorosis, according to its severity, can generate frustration, embarrassment and concern when smiling, as well as potential impact in quality of life of adults and children. [4,6] More recently, resin infiltration has emerged as a viable alternative for esthetic treatment of lesions classified as mild to moderate. [2,5,7]

In milder fluorosis, the shallower subsurface porosities are usually adequately infiltrated and the esthetic results commonly pleasant. In moderate or severe fluorosis, an initial mechanical wear of the surface of the affected enamel might be required before resin infiltration, that is followed by increments of composite resins, as illustrated in some clinical cases presented in this book.

Prof. Dr. Leandro Augusto Hilgert

References
Effective and predictable masking of mild to moderate fluorosis with in-office bleaching prior to resin infiltration.

PD. Dr. Michael Wicht, Christoph Schoppmeier

The prevalence of dental fluorosis varies significantly among different countries depending on the level of water fluoridation and the use of fluoridated products in patients' early childhood. In Germany, the prevalence is estimated around 10-15% [1] with most of the alterations being mild to moderate expressed as whitish opacities either localized or widely spread over the enamel surface. Recently, no strong evidence regarding the masking effect of whitish discoloration with resin infiltration was reported in a systematic review disregarding the origin of the alteration [2]. However, case reports [1, 7] and excellent clinical results achieved in our dental school support the theory that resin infiltration is a treatment alternative to direct and indirect composite or ceramic restorations. In-office or home bleaching with hydrogen or carbamide peroxide has also been reported to improve the overall aesthetic appearance of fluoridated products in patients' early childhood. In Germany, countries depending on the level of water fluoridation and the use of fluoridated products, the prevalence of dental fluorosis varies significantly among different countries. According to Perdigao [5], the combination of both, home bleaching and subsequent resin infiltration led to impecable clinical results in mild to moderate dental fluorosis. The following two clinical cases visualise the treatment protocol and clinical results up to 6 months follow-up.

Cases

Two female patients (24 and 27 yrs.) exhibiting mild (case 1) and moderate (case 2) dental fluorosis particularly on their upper front teeth. Both patients applied for inclusion in the above-mentioned clinical trial and were proven to meet the inclusion criteria. Based on positive results mostly published in case reports, we hypothesised that in-office bleaching prior to resin infiltration improves the quantifiable and self-assessed aesthetic effect in mild to moderate dental fluorosis. 26 patients were included in a RCT. The test group received an in-office light enhanced power bleaching with 25% hydrogen peroxide (Zoom, Philips, NL); the control group was pre-treated accordingly using an ACP gel (Relief Oral Care Gel, Philips, NL) instead of the active substance. After two weeks both groups were infiltrated (Icon, DMG, Germany). Digital images were taken at every appointment and after 1, 3 and 6 months respectively. Statistical analyses (mixed linear model) revealed that resin infiltration alone leads to a significant masking of discoloured enamel opacities most likely connected with dental fluorosis. In-office bleaching with 25% H2O2 following Icon infiltration treatment significantly improves Delta E values and the self estimated appearance after 6 months. The following two clinical cases visualise the treatment protocol and clinical results up to 6 months follow-up.

Fig. 1: Base status. Case 1.

Fig. 2: Base status. Case 2.

Fig. 3: Close up case one 21-23. Marked opacities in the incisal region become more pronounced after desiccation.

Fig. 4: In-office bleaching (case one). Patients were prepared for in-office bleaching using the Zoom kit (Philips, NL). Liquid dam is thoroughly applied along the gingival margin in both, the bleaching and infiltration procedure. Every patient in the test group received 3 cycles of light enhanced power bleaching each cycle lasting for 15 minutes.

Fig. 5 and 6: Bleaching results. After bleaching teeth are obviously brighter in both cases. Patients preferred that bleached look, however Delta E values do not decrease significantly. These patient-centered findings are not in line with our personal observations. It appears that not only the sound but also the fluorotic enamel appears brighter after bleaching leading to an overall lighter appearance than the baseline status.

Fig. 7: Close up case one 21-23. After bleaching the teeth appear brighter including the discoloured areas. The contrast is not levelled out but rather more pronounced most probably enhanced by desiccation directly after treatment.

Fig. 8: Case 1 before infiltration. In-office bleaching we waited for 2 weeks before the infiltration procedure. After rehydration the teeth appear more uniform yet brighter in colour. The treatment protocol intended application of hydrochloric acid for 6 minutes (three rounds, 2 minutes each) and 10 minutes of infiltration and one additional minute after the initial infiltrating procedure. The prolonged etching and infiltration increases the probability to sufficiently remove the intact surface layer and allows the infiltrant to homogeneously fill up deeper porosities. Apart from these modifications the infiltration process was performed as recommended by the manufacturer.
Icon resin infiltration.

Gabriela Caldeira Andrade Americano, Prof. Dr. Vera Mendes Soviero

References

Key Learnings
- Patients who feel impaired by mild to moderate fluorosis have many treatment options to choose from. With direct composite restorations or veneers on the rather invasive and the latter definitely on the costlier side, resin infiltration can be a good alternative to mask the blemishes and providing a more uniform appearance. In some cases, treatment with resin composites can correct or improve enamel imperfections, but this procedure also ends up in a loss of tooth tissue. Infiltrant resin has masked white spot lesions [8, 9], because this resin has a refractive index similar toapatite crystals. Thereby, light refraction and, consequently, the colour differences of enamel are reduced. As the fluorotic enamel is porous [11], the same as the white spot lesions, the resin infiltration can be a good alternative to mask the blemishes. This paper aims to describe a case report about the use of infiltrant resin (Icon, DMG, Hamburg, Germany) to mask diffuse opacities in permanent anterior teeth.

Case Report
The patient male, 12 years old, has been assisted at the Paediatric Dentistry clinic of the Rio de Janeiro State University, Rio de Janeiro, Brazil.

Abstract
Aesthetic problems due to Fluorosis can occur in children and adolescents. The aim was to describe a case report about the use of infiltrant resin to mask diffuse opacities. A male patient aged 12 years attended the Paediatric Dentistry clinic of the Rio de Janeiro State University, Rio de Janeiro, Brazil. Through a clinical exam, it was diagnosed that incisors had fluorosis. The teeth 12, 11, 21 and 22 were treated with infiltrant resin (Icon, DMG, Hamburg, Germany). All procedures were done in accordance with manufacturer instructions. Furthermore, Icon-Etch and Icon-Dry were applied three times in order to enhance the masking of the defects. The immediate result as well as 1 week and 4 months after the treatment were satisfactory. The use of infiltrant resin (Icon) can mask diffuse opacities improving the esthetics without a significant loss of tooth tissue.

Introduction
Aesthetic problems due to enamel developmental defects can occur in children and adolescents. Fluorosis is a defect of enamel mineralization, characterized by porosity of the enamel subsurface [1]. Clinically, fluorosis can be seen as slight accentuation of the perikymata, diffused opacities with a opaque white appearance or chalky white enamel with some yellow to brown staining and pitting [2]. There are several treatment options for aesthetic problems due to fluorosis, such as bleaching, microabrasion and restorative techniques. Bleaching therapy has been reported by being able to mask the blemishes and providing a more uniform appearance [3, 4]. Microabrasion works well for shallow defects, but it can result in some reduction of enamel [5, 6]. Treatment with resin composites can correct or improve enamel imperfections [7], however this

CASE 2.2

Fig. 1-2: Through a clinical exam, it was diagnosed that all of permanent anterior teeth, which were erupted, had fluorosis. However, the teeth 11 and 21 were more severely affected according to Thylstrup and Fejerskov index [12].
Discussion
Whenever an aesthetic procedure is recommended, it should be based on patient’s demand. Aesthetic perception is very much subjective and individual. An enamel defect can be an aesthetic problem for dentists, but not for patients. Furthermore, it can be argued that girls may be more concerned with their appearance than boys [8]. In the present case, the patient was a boy and felt really upset about the appearance of his teeth. Thus, the decision to treat the upper incisors aesthetically came from the patient himself. It is necessary, once the material penetrates into the enamel [9], the removal of the excess material with gauzes also retains the surface shape [15]. In contrast to the bleaching therapy, which can reduce the microhardness of demineralized enamel surfaces [16], the infiltrant resin can strengthen the enamel structure mechanically [17].

Key Learnings
- The polishing of treated areas enhances the color stability of the masking probably due to reduction of the roughness.
- In contrast to the bleaching therapy, which can reduce the microhardness of demineralized enamel surfaces [16], the infiltrant resin can strengthen the enamel structure mechanically [17].
- The use of infiltrant resin (Icon) can mask diffuse opacities improving the esthetics without a significant loss of tooth tissue.

Key Learnings
- The polishing of treated areas enhances the color stability of the masking probably due to reduction of the roughness.
- In contrast to the bleaching therapy, which can reduce the microhardness of demineralized enamel surfaces [16], the infiltrant resin can strengthen the enamel structure mechanically [17].
- The use of infiltrant resin (Icon) can mask diffuse opacities improving the esthetics without a significant loss of tooth tissue.

References
Association of resin infiltration and composite resin on the treatment of severe dental fluorosis.

Prof. Dr. Leandro Augusto Hilgert, Marília Bizinoto Silva Duarte

Enamel developmental defects may negatively affect esthetics and patients’ self-esteem [1]. This is particularly true for young patients. For these cases, treatments should be able to present an acceptable esthetic result without compromising much tooth structure (being minimally invasive). Resin infiltration has been shown to be a microinvasive treatment for white spot lesions, slight to moderate fluorosis and some other types of opacities [2, 3]. However, in more severe cases, in which tooth substance loss is already present and/or opacities are too opaque and deep, a combination of resin infiltration and composite resins may be an effective, fast and minimally invasive approach to improve esthetics (»deep infiltration«) [4]. Fluorosis is characterized by hypomineralization of the enamel [5]. In less severe cases the subsurface hypomineralized enamel may be resin infiltrated only in a true microinvasive treatment approach. The aim of this case report is to present a severe case of fluorosis in which due to enamel loss and deep opacities an association of resin infiltration and composite resin restorations was used on the treatment a young patient.

Case report

A young female patient presenting a severe case of fluorosis reached the University clinic seeking for esthetic treatment. During anamnesis it was revealed that the child was shy and afraid of smiling, and episodes of bullying at school have already happened due to the enamel development defects. However, there was a concern by the child and her mother on the possible complexity, costs and invasiveness of the necessary treatment approach. Intra oral examination showed a fluorosis graded as TF6, presenting regions of white opacities as well as some enamel pitting with substantial amount of enamel loss. Transillumination suggested areas of deeper hypomineralization (where light transmittance was blocked) as well as some areas with more shallow lesions. Proposed treatment plan was resin infiltration and small additions of composite resin. Patient and mother were explained on the treatment steps and the possible need for some localized wear of the enamel on the regions that already presented enamel pitting and discoloration and on the areas with deeper opacities.

Fig. 1: Base status.

Fig. 2-4: Figures 1, 2 and 3 present different views of the clinical case in which the patient presents fluorosis (TF6). Observe that there are areas with diffuse and slight white opacities, areas with very opaque white opacities and areas that already present enamel loss and some discoloration. In Figure 4 transillumination was performed to check light transmittance through the enamel, that may be a useful diagnostic tool since the deeper the enamel hypomineralization, the more light is blocked. Some areas of the affected anterior teeth area were suggested to present deeper lesions, that may impair a more complete resin infiltration without some previous wear of the enamel.

Fig. 2-5: After isolation of the operatory field using lip retractors and a liquid dam to protect soft tissues (Fig. 5), Icon-Etch (hydrochloric acid) was applied on the surfaces for 2 mins (Fig. 6) aiming to remove the enamel surface layer and create access to the subsurface hypomineralized enamel (porous area). In Figure 7 it is possible to observe the matt appearance after the acid etching. In Figure 8, a drop of Icon-Dry (alcohol) was applied on the etched surfaces. After a few seconds, it is possible to see that some areas around the enamel pitting kept very white and opaque. This »optical test« after etching may be useful to indicate areas in which a more pronounced enamel wear is needed to create access to the hypomineralized layer. This extra step may be performed with repeated acid etchings or, in deeper lesions, with air abrasion or rotary instruments.

Fig. 6-8:
Localized enamel wear and acid etching. It possible to see that there are superficial part of the more affected enamel and areas of discoloration which enamel pitting was already present) (Fig. 9). Then, Icon-Etch was dropped onto the surfaces (Fig. 12). Observe the more uniform aspect of fluorosis or other enamel defects that are nonresponsive to resin infiltration only. The localized wear performed with abrasive instruments removes the highly affected enamel and exposes the underlying porosities that are, then, able to be adequately infiltrated (technique known as «deep infiltration»). The advantage of infiltrating the (still porous) subsurface enamel before covering it with composites is that a uniform substrate is achieved, avoiding the need to use opaque dentin shades, that in thin thicknesses either do not mask de whitish underlying enamel or do not present the expected life-like esthetics and translucency of the enamel. Learning from cases like this on limitations of using resin infiltration alone, but its usefulness when associated with localized preparations and composite resin restorations allow the dentist to have new treatment possibilities that aim on a highly esthetic outcome with a minimally invasive approach.

**Key Learnings**

1. Severe fluorosis or other very opaque (deep) enamel defects might require a previous enamel wear to allow underlying hypomineralized enamel to be adequately infiltrated.
2. «Deep infiltration» promotes a uniform substrate that eases obtaining nice esthetic results with thin (and conservative) increments of body and enamel shades of composite resin.
3. Bonding to composites after resin infiltration does not require an additional adhesive step. If after the infiltrant final light-curing there is no contamination of the operator field, composite increments may be directly applied onto the infiltrated surfaces.

**References**

Fluorosis infiltration – Case study of a young patient.

As part of a routine examination our patient reported an increasing urge to do something about the white spots on her anterior teeth (Fig. 1). After weighing various therapy options, it was jointly decided that infiltration was the treatment of choice [1].

In numerous studies there is evidence of almost optimal matching of infiltrated (orthodontic) white spot lesions to the shade of the natural tooth enamel [2, 3, 4, 5]. In terms of the localization, form, and patient’s history, the white spots on the labial surfaces of teeth 11 and 21 are classified as fluorosis with severity 0.5 (community fluorosis index according to Dean). Masking of the white spots using infiltration is based solely on altering the refractive index near the whitish opacities. Healthy enamel has a refractive index (RI) of 1.62. The different refractive means that unwanted shade changes in the form of uneven shading on the infiltrated (orthodontic) white spot lesions to the shade of the natural tooth enamel [2, 3, 4, 5].

Key Learnings

• Icon-Infiltrant can penetrate into porosities in fluorosis white spots and thereby minimizes the difference of refractive index between the health enamel and fluorosis white spots.
• The number of etch times will be decided according to the assessing in Icon-Dry step. When the expected result is not achieved, the white spot need to be etched and dried again before infiltration step.
• Icon infiltration is a promising and micro invasive treatment for the patient impaired by fluorosis white spots.

The success of the infiltration is highly dependent on the level of fluorosis damage. With very mild to moderate fluorosis, the infiltration technique has been successfully used in vitro as an intervention for fluorosis [9]. Nevertheless we decided to use infiltration because it is the least invasive treatment option in this case. If the infiltration was not successful, it would not prevent a more invasive treatment method. A combination of the infiltration with composite treatment is definitely possible. This is because even with simultaneous composite treatment of enamel surfaces affected by caries no additional adhesive is required for the enamel. Only once dentin is involved, appropriate adhesives have to be used [10]. Therefore, there is nothing preventing an invasive composite treatment subsequent to successful infiltration (successful from an esthetic perspective). What is noteworthy is that the infiltrated teeth can be bleached with standard methods. The results are comparable with the effects that can be achieved with non-infiltrated teeth. This means that unwanted shade changes in the form of uneven shading of the teeth are of no concern [11, 12].

Fig. 1: Frontal view of the white spots 11, 21.

Fig. 2: Firstly, the teeth should be cleaned or (as in our case) a professional dental cleaning should be done. A protection of the mucous membranes using a dental dam is performed.

Fig. 3: After application of a dental dam, the entire labial surfaces were etched for two minutes with Icon-Etch. The procedure was repeated because the initial result was not satisfactory. During the drying with alcohol, there is a preview of the color change. The result was unsatisfactory, which in this case led to three times etching.

Fig. 4: After thorough spraying the acid off, the Icon-Dry was then applied and left on for three minutes, the excess was removed, and this was followed by light curing. This procedure was repeated with the option of shortening the application time (one minute).

Fig. 5: After polishing, the treatment was complete and the patient was impressed by the final result.

The appearance after three months.

Fig. 6-7: The white spots on the labial surfaces of teeth 11 and 21 are classified as fluorosis with severity 0.5 (community fluorosis index according to Dean). Masking of the white spots using infiltration is based solely on altering the refractive index near the whitish opacities. Healthy enamel has a refractive index (RI) of 1.62. The different refractive means that unwanted shade changes in the form of uneven shading on the infiltrated (orthodontic) white spot lesions to the shade of the natural tooth enamel [2, 3, 4, 5].

Fig. 8: The option of shortening the application time (one minute).

Fig. 9: The Icon-Infiltrant was then applied and left on for three minutes, the excess was removed, and this was followed by light curing. This procedure was repeated with the option of shortening the application time (one minute).

Fig. 10: After polishing, the treatment was complete and the patient was impressed by the final result.

The appearance after three months.
Dental fluorosis is caused by ingestion of excess amounts of fluoride, mainly through water, and leads to esthetic alterations of teeth. Fluorosis is prevalent in countries which lack moderated community water supplies and people usually drink ground water having fluoride more than the stipulated limit of 1 ppm. Dental manifestation of fluorosis may vary from non-pitted white opacities/ brown stains covering partial or complete tooth surface (s) to pitted tooth surfaces. Conventionally dentists have been treating these non-pitted fluorosis lesions by bleaching, micro-abrasion, composite veneering while on the other end laminates/ crowns are frequently given for pitted fluorosis teeth. However recently a novel micro-invasive resin infiltration technique is introduced which has shown promising results for the treatment of demineralized white spot lesions, in terms of, both stopping the progress of these lesions and improving the esthetics [1].

Later the technique was tried by many dentists worldwide for other hypomineralized lesions, including fluorosis, hypomineralized developmental defects, Molar-Incisor hypomineralization cases, trauma induced mineralization defects etc. [2, 3].

Clinical case
The present clinical case is of a patient who was having chalky white opaque areas covering the whole tooth/ teeth due to fluorosis. It was decided to treat the lesion using micro-invasive resin infiltration procedure, using vestibular Icon kit (DMG, Germany) for which the informed consent was sought from the patient. The vestibular Icon kit contain three syringes, along with applicator tips for facial surfaces, each to be used in the three step procedure for application of resin infiltration; namely 1. Etching: Icon-Etch which is composed of 15 % Hydrochloric acid, 2. Drying agent: Icon-Dry, composed of Ethanol, 3. Infiltrant: Icon-Infiltrant, composed of Infiltrant having very low viscosity resin allowing it to infiltrate in the body of lesion.

The tooth represented in this clinical case is #12, which was isolated with rubber dam and the white opacity covering the whole tooth is visible in the pre-operative clinical picture (Fig. 1). This was followed by application of Icon-Etch for 2 minutes (Fig. 2).

Icon-Etch was washed off for 30 seconds and tooth was dried with oil free air. Etching was repeated again for 2 more minutes. Next the drying agent (Icon-Dry) was applied for 30 seconds (Fig. 3), then evaporated leaving the accentuated pores making it easy for infiltrant to seep in. Lastly the infiltrant was applied (Fig. 4) and was left in place for 3 minutes followed by light curing the infiltrant for 40 seconds (Fig. 5) and a repetition of infiltrant application for 1 more minute. Immediate improvement in esthetics and good patient satisfaction was observed (Fig. 6).

Key Learnings
- It can be concluded that resin infiltration can be used for non-pitted white opacities which are due to fluorosis.
- In fact literature suggests that resin infiltration can be used for any kind of hypomineralization defects, however variations in the etching times and number of infiltrant applications are required, which depends on the depth of the lesion and should be judged clinically on case to case [4, 5, 6].

References
Resin infiltration as a micro invasive treatment for fluorosis.

Prof. Dr. Leandro Augusto Hilgert, Marilia Biznito Silva Duarte

Fluorosis is observed, clinically, from mild diffuse white opacities on the enamel to severe whitish/brownish staining and enamel surface malformation. Those conditions may compromise esthetics according to its severity. For light to moderate fluorosis, the most common cases, there are reports that resin infiltration may successfully mask the opacities with esthetics with very low enamel wear. The aim of this case report is to present a step by step description of the resin infiltration technique as a microinvasive alternative for the esthetic treatment of fluorosis. Considerations on how to diagnose depth of the opacities and on how many times to etch the enamel to improve results predictability are presented. Main features of the resin infiltration technique and other established esthetic treatments for fluorosis are discussed.

Introduction
Fluorosis is characterized by subsurface enamel hypomineralization (porosities) caused by excessive fluoride intake during enamel development [1, 2]. In mild to moderate cases of fluorosis, the lower refractive index (RI) of the porosities contents gives the enamel a diffuse whitish appearance that, for some patients (according to fluorosis severity), may be aesthetically unpleasant. Many treatment options are available for fluorosis as: (a) bleaching, that can possibly reduce the contrast between whitish opacities and sound enamel; (b) microabrasion, in which the surface and subsurface of the affected enamel are worn out by a combination of acids and abrasives, exposing the underlying sound enamel; (c) macroabrasion, where a preparation is performed on the affected fluorotic areas followed by a restoration; and, (d) resin infiltration, a technique that involves a very mild wear of the surface enamel, exposing the porous subsurface that is subsequently infiltrated by a low-viscosity resin that has a RI more similar to sound enamel [3, 4]. Usually, bleaching alone is not capable of providing a complete optical blending of the fluorotic to the sound enamel. Micro and macroabrasion techniques are effective, but require a more invasive approach, removing the whole affected enamel. Resin infiltration appears as a suitable alternative that combines good results with a very low invasiveness. The aim of this case report is to describe in details the resin infiltration protocol on the esthetic treatment of a mild to moderate fluorosis case.

Case Report
A 26-year old female patient presenting mild to moderate fluorosis looked for esthetic treatment. Her main complaint regarded the whitish diffuse opacities that affected her smile.

Fluorosis is observed, clinically, from mild diffuse white opacities on the enamel to severe whitish/brownish staining and enamel surface malformation. Those conditions may compromise esthetics according to its severity. For light to moderate fluorosis, the most common cases, there are reports that resin infiltration may successfully mas...
Resin infiltration is a technique based on the acid dissolution of the enamel. Therefore, the optical appearance of the infiltrated enamel will be different from the original enamel. For the infiltration process to be effective the first step is to diagnose the primary lesion (less invasive treatment and may require some localized tooth preparations). Shallow to medium depth lesions, as those depicted in the case report, that clinically do not block the light passage during transillumination (see Fig. 3) have usually a favorable prognosis for resin infiltration.

Discussion

An ideal esthetic treatment is the one that can please the demands of the patient, that require very little wear of sound enamel (low biological cost), that can be simply and quickly executed and that should be able to offer treatment options that present efficacy, low invasiveness and durability.

Resin infiltration is a technique based on the acid dissolution of the well-mineralized surface layer of the enamel (with a thickness of around 30-40 μm) [6], exposing the porous hypomineralized enamel of the subsurface. After thorough drying, a low-viscosity resin is infiltrated into the porosities of the enamel by capillary forces filling the spaces with a material that has a closer refractive index to sound enamel. Therefore, the optical appearance of the infiltrated enamel blends with the sound enamel, significantly improving the esthetic harmony of the smile [7, 9].

For the infiltration process to be effective the first step is to diagnose the kind of white opacity. Deeper lesions, that are very opaque to microabrasion is a more invasive alternative, requiring much more enamel wear to present pleasant results. The color stability of the resin infiltrated enamel has been tested in vitro [8] in clinical studies [11] and presented in numerous case reports [4, 12-15]. So far results are positive and very promising. This hybrid structure of enamel/infiltrant (the infiltrated enamel) can be successfully daily submitted to the polishing of oral hygiene and able to be polished by the dentist in routine clinical sessions.

Next, another fundamental step for a successful resin infiltration is the complete removal of the well-mineralized surface layer therefore exposing the porous subsurface. If an adequate access for the resin to infiltrate the porosities is not achieved, the technique will not present the best results. A very effective way of testing if the surface layer was removed after the acid etching step is observing what happens when a drop of ethanol is applied on the etched enamel. If the optical result already looks good, surface layer was properly removed.

It is imperative for the dentist to realize that the main difference from resin infiltration to microabrasion is that in the first method the porous enamel is preserved and infiltrated while the later method is based on the complete removal of the affected enamel. That is why the technique is indicated for lesions no deeper than 0.3 mm (300 to 300 μm) [16]. Therefore, it is clear that microabrasion is a more invasive alternative, requiring much more enamel wear to present pleasant results.

Based on the substantial amount of available scientific evidence, clinical reports and our clinical experience of almost eight years conducting resin infiltration treatments, this approach has become our standard of care in treating light to moderate fluorosis. It is normal to observe a shiny and irregular appearance due to excess of the infiltrant covering the surface. These material is easily removed with polishing instruments as abrasive disks, spirals or rubber cups.

Conclusion

Resin infiltration seems to be a successful microinvasive treatment for the esthetic treatment of light to moderate fluorosis.

Key Learnings

• Resin infiltration is a microinvasive approach for the treatment of slight to moderate fluorosis;
• Additional acid etchings may be necessary to improve resin infiltration. Observing the visual aspect when applying Icon-Dry may be a good way of determining the need for repeating the etching step;
• Removal of Icon-Infiltrant excess before light-curing and adequate finishing and polishing after light-curing are important steps to promote a nice surface texture.

References

Case Report: Masking of fluorosis by resin infiltration.

A 19-year-old patient presented in the university outpatient clinic requesting treatment of whitish spots on her teeth, which she found esthetically disturbing. According to the patient, the spots had already been visible since her adult teeth came through. For this reason, composite fillings had already been placed on the anterior incisors. After a visual-tactile examination, the discolorations were diagnosed as dental fluorosis. Whitish opaque discolorations of the tooth enamel, which are also brownish opaque in severe forms, are characteristic of dental fluorosis cases. These discolorations are mostly located outside the traditional caries predilection sites. The whitish changes often affect several teeth, are poorly defined, are more clearly visible when the teeth are dried and are accentuated on the perikymata. Also characteristic is so-called «snow capping», a whitish discoloration of the incisal third of the teeth (Fig. 1).

Various therapy options were discussed with the patient, including bleaching, resin infiltration, microabrasion and composite restorations, while the associated necessity for tooth structure removal, the predictability of the esthetic result, the long-term prognosis and the costs were weighed against each other. The patient opted for resin infiltration due to the relatively low tooth structure removal, good predictability and manageable costs. For a better estimate of the esthetic result, the most severely affected tooth (13) was treated first. In the present case, there was no isolation with rubber dam because desiccation and protection of the soft tissue could be guaranteed by an adequate distance to the gingiva.

For a better estimate of the esthetic result, the most severely affected tooth (13) was treated first. In the present case, there was no isolation with rubber dam because desiccation and protection of the soft tissue could be guaranteed by an adequate distance to the gingiva.

Key Learnings

- When Icon-Dry was applied to the lesion, the lesion was masked and appeared less whitish opaque due to the penetration of the ethanol into the lesion’s porosities. This effect should be observed in the first 2-5 seconds after application of the ethanol. If this effect comes slower, it most often indicates that the lesion should be etched again.
- Polishing after infiltration treatment is very important to remove the oxygen inhibition layer on the resin.
- When several lesions need to be treated, it will be better to treat one of the lesions first to make sure Icon infiltration treatment works well on this patient and also give the patient more confidence to perform following treatment.

Fig. 4: The color change is slower, this most often indicates that the surface layer has not been eroded completely. In this case, the lesion should be etched again. In the present case, the lesion was etched again for 2 minutes, the etching gel subsequently sprayed off, the lesion dried with compressed air and ethanol applied once again.

Fig. 5: At this juncture, an instant (< 2 seconds) disappearance of the lesion’s opacity could now be observed, which indicates adequate removal of the surface layer. In preparation for the subsequent infiltration, the ethanol was vaporized with compressed air and ethanol applied once again.

Fig. 6-7: If the color change is slower, it most often indicates that the lesion should be etched again. When Icon-Dry was applied to the lesion, the lesion was masked and appeared less whitish opaque due to the penetration of the ethanol into the lesion’s porosities. This effect should be observed in the first 2-5 seconds after application of the ethanol. If this effect comes slower, it most often indicates that the lesion should be etched again.

Fig. 9: Even though the lesion was fully masked after a few seconds, the excess resin was only removed from the lesion surface with a foam pellet after 3 minutes. The resin then underwent light-curing for 40 seconds. To compensate for the infiltrant’s polymerization shrinkage, the resin was applied again and cured again after 1 minute (no illustration). Thanks to the oxygen inhibition of the polymerization of the resin surface layers, a thin raw unpolymerized resin layer remains on the enamel surface. This should be removed by polishing. In the current case, polishing was carried out with polishing disks (Sof-Lex, 3M Espe). The final result on tooth 13 was very satisfactory immediately after the treatment. The remaining teeth (12-23) were thus subsequently treated as described above and showed complete masking of the fluorosis immediately after treatment.
Minimally invasive aesthetic restoration for severe dental fluorosis – combination resin infiltrating with at-home bleaching.

Dr. Ryan Li

Dental fluorosis is an extremely common disorder, characterized by hypomineralization of tooth enamel caused by ingestion of excessive fluoride during enamel formation. It appears as a range of visual changes in enamel causing degrees of intrinsic tooth discoloration, and, in some cases, physical damage to the teeth. The severity of the condition is dependent on the dose, duration, and age of the individual during the exposure. The »very mild« (and most common) form of fluorosis, is characterized by small, opaque, »paper« white areas scattered irregularly over the tooth, covering less than 25 % of the tooth surface. In the »mild« form of the disease, these mottled patches can involve up to half of the surface area of the teeth. When fluorosis is moderate, all of the surfaces of the teeth are mottled and teeth may be ground down and brown stains frequently »disfigure« the teeth. Severe fluorosis is characterized by brown discolored patches or confluent pitting; brown stains are widespread and teeth often present a corroded-looking appearance.

People with fluorosis are relatively resistant to dental caries (tooth decay caused by bacteria), although they may be of cosmetic concern. In moderate to severe fluorosis, teeth are physically damaged. Traditional treatment options for dental fluorosis are porcelain laminate veneer or all-ceramic crowns, which are invasive and expensive. These treatments need normally long clinical procedure (several appointments). Combination resin infiltrating technology with at-home bleaching is a minimally invasive method for treating dental fluorosis and easy to operate. Therefore it is more acceptable for patients.

Clinical case
A 23-year-old female patient complained about severe discoloration and discrete pitting on anterior teeth and hoped to improve tooth appearance. After clinical examination, severe dental fluorosis was diagnosed. We offered a treatment protocol – minimally invasive aesthetic restoration combining resin infiltrating with at-home bleaching.

CASE 2.8
Discussion
The clinical manifestation of dental fluorosis is that dental enamel developed in the same period has chalk spots or brown spots. Severe dental fluorosis can accompany discoloration with defects. Discoloration can be treated with dental bleaching. Dental bleaching utilizes hydrogen peroxide or carbamide peroxide which can diffuse into the tooth and dissociate to produce unstable free radicals. Free radicals will attack organic pigmented molecules in the spaces between the inorganic salts in tooth enamel by attacking double bonds of chromophore molecules within tooth tissues [1, 2, 3]. The change in double-bond conjugation results in smaller, less heavily pigmented constituents, and there will be a shift in the absorption spectrum of chromophore molecules; thus, bleaching of tooth tissues occurs. Enamel micro-abrasion works with the abrasive paste which is 6.6% hydrochloric acid slurry that contains silicon carbide microparticles. Chemical corrosion and mechanical abrasion happen simultaneously in order to remove enamel defect and make enamel smooth and glossy. Compared with the invasive methods like porcelain laminate veneer and all-ceramic crown, enamel micro-abrasion can preserve more natural dental structure.

Resin infiltration technique is an alternative therapeutic approach, the principle of which is capillary siphoning, to prevent further progression of enamel lesions. This treatment aims to occlude the micro-porosities within the lesion body by infiltration with low-viscosity light-curing resins that have been optimized for rapid penetration into the porous enamel. Because the infiltrating resin’s refractive index is closer to the natural enamel, it changes the lower refractive index of decalcified enamel, and makes the teeth bright. Therefore this treatment may be used not only to arrest enamel lesions but also to improve the esthetic appearance of anterior teeth.

Conclusion
Resin infiltrating combined with at-home bleaching and micro-abrasion can treat dental fluorosis effectively. Besides, it leads to minimal invasion on the dental hard tissue and is easy to apply. It can also save time and money for the patient. In short, the infiltration technique is the first option for dental fluorosis patient.

Key Learnings
- The patient who suffers from severe fluorosis can be treated by Icon infiltration treatment effectively. It is normally combined with some of other treatments, for example: bleaching, microabrasion, composite restoration.
- Icon infiltration cannot eliminate the yellow or brown stain, therefore normally bleaching is necessary to be performed by the patient with severe fluorosis before infiltration treatment.
- Icon can provide a uniform background for the esthetic composite restoration.

References
A noninvasive approach to treating white enamel lesions.

Dr. Alexander Aresdahl

Whether a patient has brown spots, white spots or both, I always recommend teeth whitening for 2-4 weeks before Icon smooth surface is used. In a few cases, when the brown spots are superficial, a white polishing stone can be used to remove brown staining before initiating treatment.

Transillumination: A good way to determine if a white spot is treatable or not with Icon is to use a light curing LED. Illuminate the enamel by placing the LED tip on the palatal side of the tooth structure and see if the white spot is translucent or completely opaque. If the white spot is opaque then the treatment is less likely to be successful and may need substance removal and composite treatment.

Key Learnings

- Make sure to rub the Icon-Etch properly onto the enamel.
- Transillumination analysis pretreatment is a very good clinical indicator of whether you will need to remove tooth substance and use composite in addition to your treatment or if you can use Icon alone.
- For optimal aesthetics use polishing discs to polish the matte surface after the treatment.
CASE 2.10

Masking Fluorotic Lesions with Icon.

Associate Prof. Dr. Giuseppe Allocca

Fluorosis is one of the most important caries-preventive agents in dentistry [1]. Nevertheless a chronic exposure of too high fluoride intake during tooth development can lead to fluorotic spots on the tooth surface. Especially high concentrations of naturally occurring fluorides in drinking water seem to be the main cause for fluorosis [2].

Histologically, fluorotic enamel is characterized by hypomineralization, resulting in porosities of the tooth (sub-)surface [1, 3]. The appearance of these spots varies from opaque whitish to unsightly brown spots or even pitting, dependent on the duration and time point of high fluoride exposure during tooth development as well as patient related factors (e.g. patient’s age or individual response) [2].

The main consequence of dental fluorosis is compromised esthetics [3]. Especially when front teeth are affected by dental fluorosis dentists often are confronted with the patient’s demands of esthetic improvement as the appearance of these areas can be compromising. Treatment options include bleaching in case of mild forms, moderate forms of fluorosis can be treated with enamel microabrasion. Severe cases can require composite fillings or even veneers [2, 4].

Infiltration of these fluoride spots with Icon is an alternative treatment option to mask these compromising areas on the tooth surface. In young patients dentists might want to avoid dental bleaching as well as more invasive treatments. Icon is not only minimal but microinvasive and can also be applied on young teeth. The low viscosity resin of Icon occludes the lesion porosities. As a result the lesions are masked [3].

Clinical case report

An eight year old male patient with whitish and chalky spots on his upper front teeth applied to our dental office with his mother. He was suffering from his classmates’ mocking due to the appearance of his teeth 11 and 21. In addition to that his mother raised concerns about his front teeth applied to our dental office with his mother. He was suffering from his classmates’ mocking due to the appearance of his teeth 11 and 21. In addition to that his mother raised concerns about his appearance of these spots when her child gets up in the morning. After detailed examination dental fluorosis was diagnosed and it was assumed that the reduction of saliva moistening of the patient’s teeth during the night promotes the chalky effect in the morning. In order to terminate the patient’s psychological strain due to compromised esthetics we suggested an Icon treatment to mask the fluorotic lesions.

Discussion

Fluorotic spots can be a burden for patients as they often compromise esthetics. The clinical treatment goal of this kind of tooth discoloration should be achieving an acceptable esthetic result as conservatively as possible. Icon enables to mask these lesions in a microinvasive way as no mechanical enamel removal is required. The surface is just etched with the Icon-Etch to get access to the lesion. Compared to microabrasion or conventional restorative treatment options Icon is less invasive. Furthermore the treatment time is shorter compared to other treatment options which can be an advantage in children with less compliance. Though in the same way as in some bleaching and enamel microabrasion techniques it has to be considered that the treatment result is dependent on the severity of the fluorotic spots. In some cases an improvement but not a completely masking of the spots can be achieved [3].

Conclusion

Treating fluorotic spots with Icon is a microinvasive, short and painless treatment option which improves esthetics and can be applied also in young patients.

Key Learnings

• Especially with fluorosis it is often necessary to repeat the etching step several times to gain sufficient access to the lesion body.

• Icon-infiltrant can be set for 6 minutes because of severe fluorosis diagnosis.

• Icon Infiltration treatment can be also used for the permanent teeth for young children.

Fig. 1: Initial situation of the fluorotic spots before treatment with Icon. Especially the appearance of the teeth 21 and 11 were esthetically compromising.

Fig. 2: After polishing the teeth with pumice the resin barrier Opaldam Green (Ultradent*) was applied in order to isolate the working field and to protect the gingiva which is mandatory when using Icon.

Fig. 3: To condition the surface Icon-Etch was applied for 2 minutes. The etching gel was removed with water spray for 30 seconds and the surface was dried. The etching step was repeated 4 times. Especially with fluorosis it is often necessary to repeat the etching step several times to gain sufficient access to the lesion body.

Fig. 4: In the next treatment step Icon-Dry was applied for 30 seconds. Immediately after the wetting with Icon-Dry the operator gets a preview of the masking effect. If the lesions do not diminish the etching step should be repeated. After 30 seconds the surfaces were thoroughly dried with oil free and water-free air.

Fig. 5: Next Icon-Infiltrant was applied and it was set for 6 minutes because of severe fluorosis diagnosis. Excess material was removed with a cotton roll and dental floss before it was light cured for 40 s. This infiltrant step was repeated letting the infiltrant set again for 3 minutes before excess removal and light curing. Polishing was performed with Flareze medium (DMG*) and Enamel Shiny Micerium polishing kit (Micerium s.r.l.). The fluorotic spots on both central front teeth are completely masked.

Fig. 6: Clinical situation 3 months after Icon treatment. The situation is stable, the lesions on the teeth 21 and 11 are completely masked.

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

References


Traumatic hypomineralisation.
Dental history and visual diagnosis.

Traumatic hypomineralization of a permanent tooth is a consequence of periodontal trauma affecting the deciduous teeth. Whatever the severity of this trauma, the appearance of sequelae is sporadic [1].

The prevalence of this hypomineralization is estimated as 5.2%. This figure is not surprising, given that one third of children suffer a traumatic episode involving their deciduous teeth before the age of 5.

The close anatomical proximity that exists between the apexes of the anterior deciduous teeth and the germs of their permanent successors, which also display delayed calcification, explains this relationship.

Traumatic hypomineralization can present a wide variety of clinical expressions differing in shape, outline, localization and even color. They are generally punctiform lesions situated on the incisal half of tooth crowns. They are often limited to one tooth, and asymmetrical with respect to the corresponding contralateral teeth. However, associated lesions can often be found on mandibular opponents.

The histopathology of traumatic hypomineralization is similar to that of WS and fluorosis. It involves also subsurface hypomineralized surface layer.

Either superficial or deep erosion-infiltration works very well to treat traumatic hypomineralisation. [2].

Dr. Jean-Pierre Attal

References
Treatment of traumatic hypomineralized teeth.

Dr. Jean-Pierre Attal

Traumatic hypomineralization of a permanent tooth is a consequence of periodontal trauma affecting the deciduous teeth. Whatever the severity of this trauma, the appearance of sequelae is sporadic [1]. The prevalence of this hypomineralization is estimated as 5.2%. This figure is not surprising, given that one third of children suffer a traumatic episode involving their deciduous teeth before the age of 5. The close anatomical proximity between the apices of the anterior deciduous teeth and the germs of their permanent successors could explain why the trauma can lead to the delayed calcification of the affected permanent tooth germs. Traumatic hypomineralization can present a wide variety of clinical expressions differing in shape, outline, localization and even color. They are generally punctiform lesions situated on the incisal half of tooth crowns. They are often limited to one tooth and asymmetrical. However, associated lesions can often be found on opposite jaw.

The histopathology of traumatic hypomineralization is similar to that of white spots and fluorosis. It involves subsurface hypomineralization under a relatively well-mineralized surface layer. The erosion/infiltration treatment works very well, either superficial or deep infiltration [2].

Clinical case report

A 25 years old lady would like to mask the two lesions on the central incisors. The diagnosis is almost easy: MIH was excluded because there are no lesions on first molars; fluorosis and incipient caries are also excluded according to clinical expressions. In the end traumatic hypomineralization was diagnosed. One hour treatment is planned to treat the two lesions.

Key Learnings

- For deep traumatic hypomineralization, you have almost always to do a deep infiltration. So you need to sandblast or to drill.
- Never infiltrate the lesion unless you have a clear modification with Icon-Dry after the rinsing of Icon-Etch.

References

Non-Invasive treatment of enamel hypomineralizations with Icon.

In daily practice, developmental enamel defects are being more frequently seen in young patients. The management of such enamel lesions depends on the type and severity of defect, and minor lesions are often treated by bleaching, microabrasion or conservative resin-based restorations. Resin infiltration was originally developed for the non-invasive treatment of initial proximal carious lesions and post-orthodontic white spot lesions, but its esthetic masking effect by taking on the appearance of the surrounding enamel has introduced new possibilities for the non-invasive esthetic management of a variety of developmental enamel defects including enamel hypomineralizations. This is of particular importance, because hypomineralized enamel is resistant to conventional acid etching, which may lead to poor micromechanical adhesion and subsequent microleakage when such lesions need to be treated with resin-based composites. On the other hand, microabrasion may lead to some tissue loss at the surface layer, which often needs to be restored with composite resin.

Icon can mask small, white developmental defects by infiltrating into the pores with a resin that has a refractive index close to that of the surrounding sound enamel. The masking effect is immediate, and in most cases dramatic. Esthetic improvements are even observed in teeth with incomplete resin penetration. The Icon system utilizes 15% hydrochloric acid to open the pores within the lesions, thereby facilitating penetration of the resin infiltrant. Even after repeated applications of hydrochloric acid, the enamel removed from the surface is almost negligible, resulting in a truly non-invasive, ultraconservative esthetic treatment.

The following case is a typical example of small, shallow hypomineralization lesions. The patient seeks esthetics, while the parents demand a non-restorative solution.

**Fig. 1**: A 9-Year-old girl with hypomineralization lesions on central and lateral incisors. The patient is more concerned with the lesions on central incisors. The parents do not prefer restorative treatment.

**Fig. 2**: View of the lesions under cross-polarization filter, which eliminates highlights that mask the opacities, and thus provide a better appreciation of the borders of the lesions.

**Fig. 3**: Isolation of affected teeth after cleaning of surfaces with fluoride free pumice and rotary rubber cup at slow speed. Before placement of the rubber dam, the gingiva should be isolated with Vaseline to ensure protection. The borders of the lesions can be better appreciated after dehydration. Tooth no 11 has well defined borders, while 21 has diffuse hypomineralizations. The lesion on 11 appears to be a deeper than its neighbor, suggesting that additional etching may be necessary.

**Fig. 4**: The hydrochloric acid gel is applied on the lesions and allowed to sit for 2 minutes.

**Fig. 5**: All tooth surfaces should be thoroughly washed with air-water spray for at least 30s and the teeth should be dried meticulously with oil-free compressed air. Icon-Dry is absolute ethanol, and is applied to dry the pores within the lesions. Icon-Dry has a second important function of providing a preview image of the final appearance after infiltration. To achieve best results, the ethanol should stay on tooth surfaces for at least 30 seconds. Here the lesion on tooth 21 appears to be masked satisfactorily, while the lesion on 11 suggests that an additional etching step will be necessary.

**Fig. 6**: This time, the Icon-Etch is applied only on tooth 11 for 2 minutes.

**Fig. 7**: Again, the tooth is rinsed for at least 30 seconds with air-water spray.

**Fig. 8**: Dry with oil-free and water-free air. There is no visible change. However, a decision can only be made after the application of Icon-Dry.

**Fig. 9**: Following a 30-second application of absolute ethanol, the lesion on tooth 11 appears to be masked well. A comparison of the first (A) and second (B) rounds of Icon-Dry applications. For each step, the upper photo shows the dried lesion and the lower one shows the dramatic masking effect created by absolute ethanol. After two rounds of etching and drying, it is evident that an additional etching step will not be required.

**Fig. 10**: Application of the Icon-Infiltrant. An ample amount of Icon-Infiltrant should be introduced onto the lesion site and should sit for 3 minutes with the operatory light turned off. Excess resin should be removed from the surface with gauze and the teeth should be exposed to curing light for 40 seconds each. Then the Icon-Infiltrant should be applied as a second layer for at least 1 minute and subsequently light-cured as with the first layer. It is always beneficial to perform a final round of light curing with the tooth surfaces covered with glycerine gel to prevent oxygen inhibited surface layer.

**Fig. 11**: Excess resin should be gently removed using slow speed disks or rubber cups, leaving a polished enamel surface.

**Fig. 12**: Immediate post-operative view showing the total masking effect. Under cross polarization, the borders of the lesions are invisible and there is excellent color match. In this patient, the esthetics was reestablished without the need to treat the laterals. A comparison of preoperative (A) and post-operative images (B) showing the masking effect achieved with a non-invasive treatment approach. For each image set, the upper photo shows the actual result, and the lower one shows the lesion under cross-polarization filter.
Resin-infiltration procedure of white spots.

Dr. Erik-Jan Muts

White spots present on the front teeth can esthetically be very unpleasant for the patient. To prevent the start of a restorative cycle, invasive treatment with composite or porcelain veneers is not advised. The removal of »healthy« enamel may weaken the tooth and may cause problems later on in life.

Using a resin-infiltration technique the porosities inside the enamel, causing the white spots, can be infiltrated and filled with resin. This way we are nowadays able to treat white spots non-invasively with very good and long lasting results.

Initial status
Britt (22 years old) was looking for minimal invasive treatment to remove the white spots on her front teeth (12, 11 and 21). I decided to make some pictures.

There was no need for bleaching prior to the treatment.

Micro-abrasion
First of all rubberdam (Opttradam, Ivoclar Vivadent) is placed to get a clear and dry work field. Rubberdam is obligatory in these kinds of cases. Next we perform micro-abrasion using a micro-abrasive paste (Opalustre, Ultradent) to clean the surface and to start opening the porosities. It is applied three times for 60 seconds each, in between excessive rinsing is important. Instead of using a special micro-abrasive paste, the 15% hydrochloric acid (Icon-Etch, DMG) can also be mixed with some pumice and rubbed with a special rubber cup using gentle forces.

Etching
Then neighbouring teeth are isolated with Teflon tape and the etching procedure with hydrochloric acid (Icon-Etch, DMG) starts. The etching is done with a rubbing motion using the special smooth surface (sponge) tip for two minutes.

After a lot of rinsing the white spots become even more visible. This means the porosities are getting better accessible. A check can be performed with the absorption of ethanol (Icon-Dry, DMG). Once the white spots disappear after application of ethanol, the enamel is ready to be infiltrated. If not, the etching procedure is repeated, with a maximum of five repetitions total.

Infiltration
After the white spots disappear with the application of ethanol (Icon-Dry, DMG), it is time to infiltrated with the methacrylate (Icon-Infiltrant, DMG). Infiltration is also done with the special smooth surface tip.

Notice that there is no direct light on the working surface, since this may polarize the methacrylate particles preventing them to infiltrate further. Capillary forces suck the methacrylate (Icon-Infiltrant, DMG) into the enamel, filling up the porosities. This may take a while and it is advised (DMG) to wait at least 3 minutes. In my experience it might even infiltrate further while waiting longer and I would advise to wait at least 6 minutes. Polymerisation can be performed for 40 seconds after removing the excess with air.

This infiltration procedure should be repeated for 1 to 2 minutes and light cured as well. After light curing glycerine gel is applied and polymerised again for 40 seconds to remove the oxygen inhibition layer.
Minimally invasive approach in the treatment of enamel white spot lesions due to traumatic injuries of primary tooth: a clinical case.

Dr. Ali Salehi

Abstract

Hypomineralization in the permanent dentition could be a consequence of traumatic injuries of primary teeth happening at children's early years of life during learning to walk and exploring the environment. This sequela is the consequence of periodontal trauma affecting the deciduous teeth [1, 2]. The proximity of these two dentitions explains why not only a severe infection but also a slight inflammation around the periapical of a primary tooth could disturb the maturation of the ameloblasts, which leads to the appearance of post-traumatic hypomineralization.

Diagnosis is important because it will give an indication on how deep the lesion can be deeper. The severity of the opacity of the lesion can indicate whether we are facing a really deep lesion or a relative superficial one. On a microscopic scale, like any white spot lesions we are facing the enlargements of the interprismatic sheath creating the impression of gaps which are not present in healthy enamel. The presences of numerous gaps deviate the trajectory of light rays, which is responsible for the white appearance of the lesion. Erosion step before infiltration will attack the thin layer of well mineralized enamel that acts like a barrier and make the lesion accessible for the infiltration [4]. Infiltration will then be possible in the whole lesion [4]. Infiltration will then be possible in the whole lesion for post-traumatic hypomineralization.

Diagnosis is not easy as the lesion can present a wide variety of clinical expressions differing in shape, outline, localization and color. They are generally punctiforms, which are on the incisal third of tooth crowns, limited to one tooth and asymmetrical. Associated lesions can often be found on opposite jaw which is a pathognomonic sign for post-traumatic hypomineralization.

Optical microscopy, as a diagnostic tool, allows the clinician to evaluate the depth of the lesions dividing them into superficial and deep lesions. In superficial lesions, the light rays can keep their course because no gaps are present. In deep lesions, they deviate from their course due to the presence of numerous gaps. The presence of such gaps is responsible for the white appearance of the lesion. The history, shape, location, asymmetry and absence of similar lesions on the other teeth indicate the diagnosis of post-traumatic white spots. The opaque areas of the white spots indicate deeper parts of the lesion that will require a deeper treatment.

Case 1. Initial situation with large white spots on the incisal half of 11 and 22. Patient experienced trauma on primary incisors at the age of 4. The history, shape, location, asymmetry and absence of similar lesions on the other teeth indicate the diagnosis of post-traumatic white spots. The opaque areas of the white spots indicate deeper parts of the lesion that will require a deeper treatment.

Key Learnings

- With the help of Teflon it is easy to get the isolation of neighbouring teeth.
- In infiltration step, please make sure that there is no direct light on the working surface, since this may polarize the methacrylate particles preventing them to infiltrate further.
- Capillary forces suck the nano-methacrylate (Icon-Infiltrant, DMG) into the enamel, filling up the porosities. Please wait at least 3 min. or even longer to make the infiltration process complete.
- After removal of the excess with scalers and dental floss the surface is polished with rubbers. First using a brownie (Brownie, Shofu), followed by a greenie (Greenie, Shofu) and a felt disc (Flexibuff with Enamelize, Cosmedent) with aluminium oxide paste (Enamelize, Cosmedent).

Evaluation

Immediately after treatment the initial result is evaluated. The white spots on the 12, 11 and 21 are completely removed and Britt is enormously happy. During and after treatment there was no sensitivity or adverse reaction of any kind. One year later I evaluated the treatment again and the result seems to be very stable. The resin-infiltration technique is a very useful and successful technique in esthetically compromised white spot cases.

Polishing

After removal of the excess with scalers and dental floss the surface is polished with rubbers. First using a brownie (Brownie, Shofu), followed by a greenie (Greenie, Shofu) and a felt disc (Flexibuff with Enamelize, Cosmedent).

In infiltration step, please make sure that there is no direct light on the working surface, since this may polarize the methacrylate particles preventing them to infiltrate further.

Capillary forces suck the nano-methacrylate (Icon-Infiltrant, DMG) into the enamel, filling up the porosities. Please wait at least 3 min. or even longer to make the infiltration process complete.

Application of the methacrylate infiltrant (Icon-Infiltrant, DMG) with the special smooth surface (sponge) tip from DMG. Infiltrating the porosities with the infiltrant (Icon-Infiltrant, DMG). Polymerisation with glycerine gel is performed to remove the surface oxygen inhibition layer.

Infiltration will then be possible in the whole lesion for post-traumatic hypomineralization.

Diagnosis is not easy as the lesion can present a wide variety of clinical expressions differing in shape, outline, localization and color. They are generally punctiforms, which are on the incisal third of tooth crowns, limited to one tooth and asymmetrical. Associated lesions can often be found on opposite jaw which is a pathognomonic sign for post-traumatic hypomineralization.

Diagnosis is important because it will give an indication on how deep we need to go to reach the body of lesion before we infiltrate. In this case the histology is similar to white spots and fluorosis as the lesion is usually close to a well mineralized enamel surface layer [3], which is the result of post-eruptive ionic precipitation. In some cases, the lesion can be deeper. The severity of the opacity of the lesion can indicate whether we are facing a really deep lesion or a relative superficial one. On a microscopic scale, like any white spot lesions we are facing the enlargements of the interprismatic sheath creating the impression of gaps which are not present in healthy enamel. The presences of numerous gaps deviate the trajectory of light rays, which is responsible for the white appearance of the lesion. Erosion step before infiltration will attack the thin layer of well mineralized enamel that acts like a barrier and make the lesion accessible for the infiltration [4]. Infiltration will then be possible in the whole lesion to fill the gaps. The infiltrant’s reflection index is close to the one of healthy enamel, therefore the light rays will keep the same trajectory as in normal enamel, thus the white spots disappear.

However, for post-traumatic hypomineralization, the edges of the lesion can have acute or obtuse angle [3, 5].
In case of acute angles, the infiltration could be incomplete on the margins where the contours of the lesion could be still visible after treatment. We are able to eliminate the thin relatively well-mineralized surface layer by erosion, but only the central part of the lesion will be accessible to the infiltrant, while on the edges of the lesion, erosion alone cannot remove the peripheral healthy enamel, which will make resin infiltration not effective on the edges of the lesion. As a result, the center of the spot disappears while a more or less homogeneous white outline remains. This result is sometimes unsightly than the spot itself.

In order to improve the effectiveness of erosion-infiltration treatment in all situations of traumatic hypomineralization, light sandblasting can be done to increase the peripheral erosion.

Conclusion

In order to perform a treatment that can balance the effectiveness and minimal invasive approach, a proper diagnosis of the lesion prior to any kinds of treatment is important. Depending on the etiology of the lesion we can have an idea of its shape and depth. It will help us to know if the good final outcome needs a superficial or deeper erosion-infiltration treatment. The latter will always need some composite to restore its initial morphology at the end of the treatment.

**Key Learnings**

- For post-traumatic hypomineralization, the edges of the lesion can have acute or obtuse angle. In case of acute angles, the infiltration could be incomplete on the margins where the contours of the lesion could be still visible after treatment.
- A proper diagnosis of the lesion prior to any kinds of treatment is important. Depending on the etiology of the lesion we can have an idea of its shape and depth, accordingly we can decide superficial or deeper erosion-infiltration treatment should be performed.
- The combination of sandblasting, Icon infiltration and enamel composite restoration can achieve good esthetic result for traumatic white spot lesions.

**References**


Dr. Marie Clement

In everyday practice, dental surgeon, under increasing pressure from patients with esthetic concerns, is more and more often called on to treat abnormalities in tooth color.

The presence of a visible white area on the tooth surface is due solely to a defect in the enamel. This patient present a deep traumatic hypomineralization of a permanent tooth (Fig. 1-2). This is a consequence of periodontal trauma affecting the deciduous teeth. This may involve displacements of all kinds (concussion, subluxation, luxation, intrusion, extrusion, extraction). Traumatic hypomineralizations can present a wide variety of clinical expressions differing in color, shape, and outline. They are often limited to one tooth and sometimes associated lesions can often be found on mandibular opponents. Medical history is not one of the leading criteria on account of its uncertain utility (it is difficult to remember a shock that occurred several years previously). It is the elective nature of traumatic hypomineralizations rather than their clinical presentation that provides the most useful diagnostic information [1]. So the diagnosis of traumatic hypomineralization remains essentially diagnosis by exclusion (with Fluorosis, White spots and MIH).

The histopathology of traumatic hypomineralization involves subsurface hypomineralization under a relatively well-mineralized surface layer. The surface layer is the result of post-eruptive ionic recrystallization. It is due to inconsistent angles that the results of treatment of traumatic hypomineralization by erosion-infiltration are difficult to predict.

In the case of white spots involving deep lesions of the enamel superficial infiltration is not sufficient and a new technique has been developed: the deep infiltration [2].

A deep infiltration treatment is proposed to our patient. Before the treatment the patient is informed a composite resin will be probably use on the teeth to mask concavity and alteration of enamel. Even if it remains a very conservative treatment.

The concept of deep infiltration involves paying a price in the form of mild mutilation of the enamel through preparation by sandblasting or milling so as to ensure that the infiltration can spread through almost the whole of the lesion if the latter is deep.

Key Learnings

- Traumatic hypomineralization of a permanent tooth is a consequence of periodontal trauma affecting the deciduous teeth.
- The diagnosis of traumatic hypomineralization remains essentially diagnosis by exclusion (with Fluorosis, White spots and MIH).
- A last light curing is necessary under glycerin to avoid the inhibited layer because of oxygen.

The third times Icon-Ory application (after 3 cycles). For our patient 3 deep cycles have been necessary: the optical change now concerns all lesions in totality and infiltration is possible. In Fig. 7: infiltration is performed with Icon-Infiltrant during 1 minutes [4]. Use of dental floss before light curing is recommended. A second infiltration is necessary for 1 minute and light curing too. In Fig. 8: All the lesions are translucent. If the hollow left by milling or sandblasting is significant, the slight loss of hard tissue can be made up with composite. After light-curing of the infiltrate, the resin will be used as an adhesive support. For this reason, glycerin should not be used before composite application. Several studies have shown that bonding between the resin infiltrate and composite is of very good quality [5]. So the application of a thin composite build-up to this tooth is performed with one single shade of enamel composite resin. No stratification is required: only a work of surface texture with different brushes. A last light curing is necessary under glycerin to avoid the inhibited layer because of oxygen.

References

MIH is a condition related to demarcated hypomineralised lesions affecting at least one permanent first molar and often the permanent incisors. Other teeth can be affected by demarcated hypomineralised lesions (such as the second primary molar), however, these are not included in the MIH definition, but should be able to be treated in a similar manner.

MIH affects approximately 14% of the population [1], with approximately one third being severely affected. Diagnosis is from detection of a demarcated opaque lesion of the enamel located in the occlusal 2/3 of the crown (the gingival third is not affected) [2]. The colour varies from opaque white to yellow/brown, and severity of mineral loss normally increases with darker colour.

With more severe lesions, there may be post-eruptive breakdown (PEB) or loss of enamel, and this may be associated with a carious lesion.

MIH-type demarcated lesions differ from other developmental defects such as hypoplasia and fluorosis. Hypoplasia is a quantitative defect – that is, there is developmentally thin enamel, often in a horizontal linear pattern or pitting. Fluorosis is a diffuse hypomineralised lesion, corresponding to the developmental lines of the tooth development, with indistinct definition between sound and fluorosed enamel.

Until now, MIH is not indicated for the infiltration treatment with Icon. Nevertheless, infiltration of MIH lesions often leads to significant improvements of aesthetics and has a positive impact of patient’s quality of life. In this chapter various MIH cases with different approaches and successes are shown.

Prof. Dr. David J. Manton

Molar Incisor Hypomineralisation (MIH).
Dental history and visual diagnosis.

Patient history or etiology. Unknown, non specific.

Affected tooth/teeth. One to four affected permanent molars and the associated incisors.

Localization. Affected first permanent incisors with MIH are asymmetrical. Usually limited to the incisal or cuspal third of the crown, rarely involving the cervical third.

Border. Well-demarcated, a qualitative defect affecting enamel translucency. No changes to the enamel thickness.

Color. Whitish-cream or yellow-brown.
The intact enamel surface is hard, smooth and often hypomineralised following posteruptive maturation, the subsurface enamel is soft and porous [3,4].

References:
A new concept for treating enamel opacities.

Introducing resin infiltration technique has completely redefined the way we treat enamel hypomineralization. However, this procedure remains a depth-dependent technique [1]. Regarding the fact that the success of the infiltration technique totally depends on the lesion’s topography, a new classification of enamel hypomineralization, based entirely on the lesion’s depth was set forth. The optical properties of the enamel served as the basis for this classification. The latter includes a precise, but simple, description of the lesion in daylight conditions as well as under transillumination, to eventually match the clinical data collected to the corresponding lesion topography. This classification regroups three major types of enamel opacities: Superficial, mixed and deep lesions. Each category has specific clinical features in relation with the topography of the lesion and the proper treatment approach will be then adopted accordingly. While keeping in mind that superficial lesions represent the easiest category to achieve a favorable treatment outcome, the idea behind the treatment concept proposed implies that the transformation of mixed and deep lesions into superficial ones using abrasive procedures before proceeding with their infiltration [2]. This clinical case report describes a suggested treatment of a deep lesion affecting a lateral incisor related to MIH based on transillumination, focalization and lesion transformation to achieve a good aesthetic result.

References
Deep infiltration of MIH lesions: the use of transillumination as a diagnostic tool.

Associate Prof. Carlos Rocha Gomes Torres, Associate Prof. Alessandra Bühler Borges

The esthetic treatment of white lesions in anterior teeth is a frequent challenge for the dentists in the clinical practice. Different etiologies may change the enamel mineral structure and interfere with its interaction with the environmental incident light. Due to pathological changes that affect the enamel refractive index, the light suffers deviation and reflection inside the lesion, creating an optical maze which is over-luminous and responsible for the whitish aspect on the affected area [1]. The enamel caries lesion is one of the most common problems, as a result of the hydroxyapatite demineralization by acids from bacterial biofilm, associated with the high consumption of fermentable carbohydrate. Even with the reduction of the caries disease activity, the arrested deep lesions can remain visible, impairing the esthetics of the smile. Since the 1970s, attempts to infiltrate initial enamel caries have been reported [2, 3], but only in the late 2000s the technique was improved and a commercial product (Icon, DMG) was developed.

At this time, the resinous infiltration technique was mainly directed to arrest the approximal lesions progression on posterior teeth, to reduce the caries disease activity, the arrested deep lesions and the caries progression on the posterior teeth [4, 5, 6]. The success of the infiltration protocol on the treatment of caries and fluorotic lesions, the resinous infiltration procedure also produced excellent clinical results on those cases [9]. However, the attempt to infiltrate the MIH lesions with the same technique applied for caries and fluorosis did not produce acceptable esthetic results. A white halo or edge effect was observed around the lesion after the infiltration, indicating an improper penetration of the infiltrant formulation has a refractive index close to the sound enamel, a color masking effect was observed, stimulating its use as an esthetic treatment on posterior teeth [7, 8]. Due to the histological structural similarities between carious white spot lesions and hypomineralized fluorotic white lesions, the resinous infiltration procedure also produced excellent clinical results on those cases [9]. In MIH, the lesions margins form an acute angle with the external surface in relation to the caries and fluorotic ones. The success of the infiltration protocol on the treatment of caries and fluorotic lesions stimulated the researchers to test this procedure in other kinds of developmental white lesions, such as traumatic lesions and Molar Incisor Hypomineralization (MIH). The MIH lesions are enamel defects that occur due to depressed activity of the enamel-forming ameloblasts. This condition has a multifactorial etiology, such as preterm born, low birth weight, respiratory diseases, poor general health or systemic conditions in the first 3 years of life [10, 11]. The clinical expression of the disease implies the presence of qualitative enamel defects in at least one of the four first permanent molars, associated or not with lesions on the permanent incisors. Sometimes, the cusps of the canines and the second molars are also involved [1].

In MIH, the lesions margins form an acute angle with the external surface, impairing the monomer penetration at this area, while for the caries and fluorosis lesions the borders form an obtuse angle with the surface, allowing an uniform resinous infiltration [1]. In addition, in deep MIH lesions, sometimes the defective enamel is covered by a layer of intact enamel, which cannot be removed by the erosive effect of the hydrochloric acid alone, completely preventing the interaction of the infiltrant with the lesion body [1].

In attempt to overcome this problem, Attal et al [12] proposed the deep infiltration protocol, in which the external lesion surface should be previously removed using mechanical abrasion with aluminum oxide sandblast or a rotary diamond bur. This procedure grants access to the lesion body, allowing penetration of the resinous monomers. In addition, the border area can be gently removed, preventing the halo effect after the infiltration. The area is then covered with a composite restoration. Even after a small superficial enamel tissue removal, the infiltration of the lesion body can increase the translucency of the subjacent affected enamel, providing a better background for the composite restoration. Without a previous infiltration, the opaque background hinders the proper masking of the whitish area by the composite layer applied, being necessary a deeper removal of the affected tissue in order to provide adequate results. Therefore, although the deep infiltration procedure demands some tissue removal, it could be considered a more conservative approach, since it eliminates the necessity of a deep cavity preparation in order to obtain acceptable esthetic outcome.

Fig. 1: Patient with main lesions in upper incisors, left canine and first upper molars, characterizing MIH. The lesions on mesial surface of molars were already restored with composite

Fig. 2 A-E: Transillumination of the main lesions in the upper. It can be observed that the main lesion in the left central incisor (Fig. 2 D) presented a black central area when transilluminated, indicating to be deeper than the lesions in the other incisors (Fig. 2 B, C and E). Based on that, the deep infiltration technique was applied only on the left central incisor. Besides the main lesions, small whitish areas were spread over the whole surfaces of the anterior teeth.
As a composite would be necessary to cover the deep infiltrated area, the shade selection was performed as the first step.

Fig. 3: A small preparation performed in the deep lesion in order to provide access to the lesion body and remove the external enamel on the borders. A round diamond bur was used to remove only a minimal amount of tissue.

However, the correct diagnosis and clinical decision about when to indicate the regular superficial infiltration and when to use the deep infiltration technique remains a clinical challenge. In order to help the clinician to take this decision, the transillumination technique can be very useful. This procedure was originally developed for diagnosis of caries lesions mainly in the proximal surface of posterior and anterior teeth. It is performed placing a high output light source, such as a blue light-curing unit, on the lingual surface of the suspected tooth, allowing the light to pass through its structure and reach the labial surface, which can be evaluated by the dentist. On a sound tooth, due to the relatively homogeneous structure of enamel and dentin, the light is normally transmitted and a light blue aspect is noticed in the whole crown. However, in the presence of caries or a hypomineralized lesion, the area can appear dark blue or completely black, indicating the reduction or complete blockage of the light transmission through the tooth, depending on the lesion dimensions. Our personal experience on using the transillumination technique on MIH lesions has shown that, when a light blue aspect is noticed in the baseline analysis of the clinical case, the lesion is supposed to be shallow, and the regular superficial infiltration can be attempted first. However, when dark blue or black areas are observed in the center of the lesion, it is considered deep, and the deep infiltration technique should be performed since the beginning of the treatment.

Next, a clinical case of color masking of MIH lesions is presented, in which some lesions were infiltrated with the superficial technique, while others received the deep infiltration procedure associated with the composite restoration.

Fig. 4 A-B: After that, etching with hydrochloric acid gel was performed only over the main lesions, in order to remove the external surface of the shallow ones, and increase the permeability of the bur opened deep ones. The acid (Icon-Etch, DMG) was applied for 6 minutes over the main lesions, since shorter times are usually insufficient on those cases. Then, the whole surface was additionally etched for 2 minutes, in order to etch the small lesions spread over the teeth surfaces.

Fig. 5 A-B:

A   B

Fig. 6 A-D: The gel was washed and the surfaces dried with an air stream, followed by the ethanol application (Icon-Dry, DMG). Besides to dehydrate the enamel, the ethanol penetration can also provide a preview of the infiltrant masking effect [13]. Although the refractive index of ethanol is lower than that of the infiltrant, if some masking effect is observed after its application, a more favorable masking will be provided by the resinous infiltrant. However, if the aspect is not changed after the ethanol application, no change is supposed to be observed after using the infiltrant, indicating that an additional etching or wear with the bur must be performed. Comparison among after etching and drying (A,B) and after the ethanol application (C,D).
After that, the surface was dried with air and the resinous infiltrant (Icon-Infiltrant, DMG) was applied over the labial surface of all teeth, remaining undisturbed for 3 min. The excess was removed with an air stream and the light-curing was performed during 40 s on each teeth. Then the infiltrant was applied again and let over the surface for 1 minute. The excess was removed and the light-curing was performed.

The transillumination procedure was repeated after the infiltration, showing a significant increase in the light transmission. The dark areas of the deep lesion in the left central incisor became lighter (Fig. 8 C and 8 F), while the lesion in the right lateral incisor became even more translucent than at the baseline (Fig. 8 A and 8 D).

Post-treatment results.

Key Learning

In the deep infiltration protocol the external lesion surface should be previously removed using mechanical abrasion with aluminum oxide sandblast or a rotary diamond bur.

Transillumination technique can be very useful to identify the depth of the lesion. When a light uniform blue aspect is noticed in the baseline analysis of the clinical case, the lesion is supposed to be shallow, and the regular superficial infiltration can be attempted first. However, when dark blue or black areas are observed in the center of the lesion, it is considered deep, and the deep infiltration technique should be performed.

The esthetic treatments of MIH may combined with the superficial infiltration technique and the deep infiltration procedure followed with the composite restoration.

References

Micro-invasive esthetic treatment for MIH lesions.

Molar incisor hypomineralization (MIH) lesions represent a challenge for Pediatric Dentistry with increasing prevalence [1]. The lesions are characterized by enamel with deficiency in minerals, rich in albumin and with normal content of amelogenin [2, 3]. Its etiology is still unknown but it is believed that it is caused by disturbances during the enamel mineralization stage [4].

The clinical aspects of the lesion are changes in the enamel color and translucency, resulting in brown-yellow or white asymmetrical spots mainly in incisors and first molars [4]. Histologically, these lesions are characterized by disorganized crystals and larger interprismatic spaces, with lower mineral density [5-7].

Attempt to mineralize the molars and incisor spots with fluoride varnishes, similarly to what is indicated for treatment of white spot lesions (WSL) has been made without the success [8-10]. Recently, the infiltration of low viscosity resin (Icon, DMG, Hamburg, Germany) became a minimally invasive option for treatment of WSL [11-14]. This treatment aims to fill the porous interprismatic spaces inside the lesion [11, 13, 15] with the resin infiltration [14]. The infiltrant presents similar light refraction index as sound enamel [16], and therefore creates a masking effect [14, 17].

The efficacy of resin infiltration for superficial WSL has been shown previously [12, 13, 18-20]. Since favorable esthetic outcomes were obtained, the technique was also used in enamel developmental defects lesions, such as fluorosis, traumatic hypomineralization, and MIH [21, 22].

Different from caries and fluorosis lesions, which presents an external surface larger than the internal one, the MIH lesions have origin at the dentin-enamel junction and extend into the enamel, therefore, the erosive effect by HCl application on surface before infiltration does not allow reaching the »ceiling« of the lesion [21].

As the infiltration takes place on superficial healthy enamel and the anatomy of the MIH lesion presents an internal surface larger than the external one, it does not produce a favorable optical effect, explaining why treatments of MIH lesions by erosion/infiltration are not successful. Thus, in MIH lesions, the requirements for deep infiltration are preferable [21]. In deep infiltration, the superficial portion of enamel must be slightly removed, in order to reach the subsurface enamel portion where the MIH lesion is present.

**CASE 4.3**

**Fig. 1:** Initial aspect of the lesion.

**Fig. 2:** Hypomineralization in the maxillary molar associated with MIH.

**Fig. 3:** Closer view of the white-yellow lesion in the enamel.

**Fig. 4:** In the first step, prophylaxis was performed and the labial surface of the affected enamel was slightly prepared with a diamond bur to expose the top surface of the lesion and allow the access of the resin infiltrant inside the affected region.

**Fig. 5:** After partial removal of affected enamel, (note that the discolored inner enamel remains), resin infiltration technique was performed using Icon-infiltrant for smooth surfaces kit (DMG, Hamburg, Germany). The rubbed dam isolation was applied.

**Fig. 6:** The surface was eroded with 15 % HCl gel (Icon-Etch) for 2 minutes. After that, the acid was fully washed with air/water spray and dried.

**Fig. 7:** In order to completely remove water from microporosities, the lesion surface received the application of 99 % ethanol (Icon-Dry) for 30 s, and again air-dried. After Icon-Dry application, when the lesion becomes invisible or is reduced in intensity, that means the etched lesion is ready to be proper infiltrated. When no change happens, the preparation can be extended in depth, and/or a new etching step is performed, until some masking with Icon-Dry is observed. The total depth of enamel removal in this clinical case was about 0.5 mm, and the acid was applied for 6 minutes (3 applications of 2 minutes). This progressive preparation is made to allow the minimal invasive intervention as possible.
ambient light with an opaque screen.

Application was performed for 5 minutes, with surface protected from light curing for 40 s. The adhesive was applied a second time, for 1 minute, and again light cured for 40 s.

Finishing and polishing procedures were performed (Soflex discs, 3M ESPE, St Paul, MN, USA) in increments. No separated bonding agent application was used. Each increment was light cured for 40 s.

Immediate outcome of the teeth in closer look.

Then, composite resin was applied (Filtek XTE Supreme, 3M ESPE), and increments were light cured for 40 s. The pronounced discolored lesion at the front incisor seriously complicated patient’s aesthetic clinical feature (Fig 10).

The pronounced discolored lesion at the front incisor seriously complicated patient’s aesthetic clinical feature (Fig 10).

Case Report

A 11-year-old female patient presented a yellow-white lesion in the left maxillary central incisor (Fig 1). The patient reported that the tooth erupted with the spot, and that she had never undergone any kind of dental trauma. Also, the diagnosis of fluorosis was discarded due to the asymmetrical distribution of discolorations. Since the defects affected both molars and incisors, MIH was diagnosed.

The proposed treatment option was deep resin infiltration associated with composite restoration.

Summary

Molar incisor hypomineralization is a growing concern in Pediatric Dentistry. The unsatisfactory aesthetic promoted by the white spots lesion in anterior teeth is usually the main reason patients look for treatment. Minimal intervention is required for these cases, and deep resin infiltration might be a viable option.

Key Learnings

- The MIH lesions have origin at the dentin-enamel junction and extend into the enamel, therefore, the anatomy of the MIH lesion presents an internal surface larger than the external one.
- As the infiltration takes place on superficial enamel and the anatomy of the MIH lesion, it does not produce a favorable optical effect, explaining why treatments of MIH lesions by erosion/infiltration are not successful. Thus, in MIH lesions, deep infiltration is necessary to be performed.
- In deep infiltration, the superficial portion of enamel must be slightly removed, in order to reach the subsurface enamel portion where the MIH lesion is present.

References

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