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Underlying Resin Infiltration and Direct Composite Veneers for the Treatment of Severe White Color Alterations of the Enamel: Case Report and 13-Month Follow-Up

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Clinical Relevance

The combination of underlying resin infiltration and direct composite veneers presents a minimally invasive alternative for the correction of tooth color and shape in cases of developmental enamel defects, such as severe dental fluorosis in adolescent patients.

SUMMARY

Pronounced white color alterations due to structural anomalies of the enamel are often insufficiently masked by bleaching techniques or resin infiltration procedures alone. This frequently leads to the choice of more invasive prosthetic restorations in order to correct tooth color and form. This article describes a minimally invasive treatment option for esthetic and functional rehabilitation in the case of a 13-year-old female patient with suspected severe fluorosis and misalignment of the anterior teeth. The restorations were performed using underlying resin infiltration to homogenize the tooth shade. In a second step, direct composite veneers were applied on top to attain a natural tooth color and adjust tooth alignment and form. By joining the two minimally and noninvasive techniques, this treatment option combines the directive for preservation of hard tooth structure while treating adolescents with the benefits of easy adaptation and repair when the occlusion is still in adjustment.

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INTRODUCTION

Developmental anomalies of the enamel can have an important effect on dental esthetic appearances. Often, these manifest as white color defects with high opacity, presenting a significant challenge for the clinician attempting to mask these alterations. The most frequent developmental whitish enamel defects include traumatic hypomineralization, mo-

lar-incisor hypomineralization, and fluorosis.[1] Whereas the first two affect only single teeth or groups of teeth, severe cases of dental fluorosis can affect the whole dentition, with discolorations ranging up to an overall parchment-like affect of the tooth surface. Although the underlying mechanisms of dental fluorosis are not yet completely understood, it is recognized that influences on ameloblastic metabolism affect the pre-eruptive mineralization of the enamel, leading to an increase in porosity.[2] The result is a difference in refraction indices, causing a deviation of incoming light rays and thus appearing as white lesions to the observer.[4,5] Posteruptively, further discoloration can take place by the penetration of extrinsic pigments.[6] In severe cases, the extent of the hypomineralized zone leaves only a very thin layer of intact surface enamel, prone to pitting by means of posteruptive trauma. Due to the growing establishment of preventive care in modern dentistry, including the widespread use of fluoride-containing oral hygiene products, an increase in these dental fluorosis manifestations may be expected. There are great variations in the reported prevalence, depending on the time and place of observation. For instance, a European multicenter survey among eight-year-old children ranged the prevalence of smaller diffuse lesions between 28% and 61%, depending on the study site. However, only 0% to 4% of examined children showed severe manifestations.[7]

Consequently, dentists are typically confronted with mild cases of fluorosis, usually manifesting in the form of white spots, lines, or diffuse opacities. Several treatment options have been proposed to mask these discolorations. One approach is bleaching of the affected teeth, aimed at removing any incorporated extrinsic stains from the porosities and adapting the tooth color to minimize the differences and therefore the visibility of the opacities.[8,9] However, bleaching therapy cannot reach full color masking, as the lesions themselves are not altered. Microabrasion, a technique described since 1984,[10,11] using a combination of acidic and abrasive agents to remove the altered enamel, is a slightly more invasive alternative. Yet again, this technique is limited by the depth of the lesion[12] and can result in a substantial reduction of enamel thickness, depending on the number of applications and the materials used.[13,14]

In recent years, resin infiltration of early-stage carious lesions[15-17] has gained popularity as a new microinvasive therapeutic option. The uppermost intact enamel layer must equally be removed by means of hydrochloric acid to gain access to the porosities. However, the altered enamel remains and is infiltrated by a low-viscosity resin, adjusting the refractive index. Furthermore, it has been used in cases of developmentally hypomineralized enamel, improving appearances of tooth color, but not managing to mask extensive lesions.[18,19]

Thus, in cases with more pronounced white color defects, when confronted with an insufficient esthetic outcome after application of the previously mentioned techniques, many practitioners fall back on more invasive treatments. These include veneering or crowning of affected teeth.[8,20-23]

This article proposes a minimally invasive alternative for the esthetic management of severe white color alterations in young patients using a combination of resin infiltration and direct composite veneers.

PATIENT PRESENTATION AND TREATMENT PLAN

A 13-year-old female patient without general diseases presented at the Department of Conservative Dentistry, Heidelberg University Hospital, on referral by her orthodontist, where she was currently being treated for a class II malocclusion with removable braces (class II activator). She was seeking a diagnosis and esthetic rehabilitation due to generalized structural anomalies of the enamel. She also wished for esthetic and functional corrections of the slight deviations in tooth position of the maxillary and mandibular incisors, as her orthodontist did not want to bond fixed braces to the severely altered enamel. In her family history, there had been no similar case. Her medical history further revealed that she had simultaneously received dietary fluoride supplements, prescribed by her pediatrician, as well as fluoridated toothpaste (500 ppm) and fluoridated salt (250 ppm) during early childhood. Moreover, according to the anamnesis, her height and weight during these first years were significantly lower than the average in her age group. No other medication use with risks of altered tooth development could be determined.

Clinical examination showed generalized white and yellowish opacities, encompassing the complete permanent dentition, extending over the whole tooth surface. Pitting of the enamel surface was ubiquitously present but differed in degree. Her maxillary central incisors and first molars were particularly affected. The interplay of anamnesis, distribution, form, and coloration of the structural defects suggested the diagnosis of a TF5 fluorosis (Thylstr-

up-Fejerskov Index[24]). The irregular tooth surface also provided niches for plaque retention, leading to an accompanying generalized gingivitis. The previously mentioned orthodontic diagnoses may also be noted (Figure 1).

The following treatment goals were decided on:

1. Establishment of a harmonious tooth shade and color within the visible area
2. Esthetic correction of the tooth position and form of the anterior teeth
3. Prevention of further loss of hard tooth structures
4. Establishment of sufficient oral hygiene on highly plaque-affected sites

The treatment plan foresaw the following measures:

1. Underlying microinvasive resin infiltration of the facial surfaces of all anterior teeth and premolars in order to achieve a homogenization and removal of the white opaque color
2. Direct composite veneers for the correction of tooth form, position, and final establishment of a natural tooth color
3. Professional teeth cleaning and oral hygiene instructions with close follow-up intervals

TWO-STEP CLINICAL TREATMENT CONCEPT

The correction of form and color was planned as a two-step clinical treatment concept. Due to the extended defects of this patient, the treatment took place in five consecutive sessions. First, an underlying resin infiltration for homogenization of the tooth shade was performed, followed by direct composite veneers for the correction of tooth form, position, and color. Patient counseling included the creation of a diagnostic wax-up to visualize the potential outcome (for illustration, see Figures A.1 and A.2 in the Appendix). Because of the large extent of the measures envisaged, the anterior maxillary teeth were treated first, followed by the anterior mandibular teeth and, finally, all premolars. The two stages are described next.

First Step: Underlying Resin Infiltration

After cleaning of the buccal surfaces, relative isolation of the working field was achieved by use of a lip and cheek retractor (Optragate, Ivoclar Vivadent, Schaan, Liechtenstein), a resinous gingival barrier (OpalDam, Ultradent, Cologne, Germany), and cotton rolls. Afterward, the buccal surfaces were etched with hydrochloric acid for two minutes (Icon Etch, HCl 15%-20%, DMG, Hamburg,

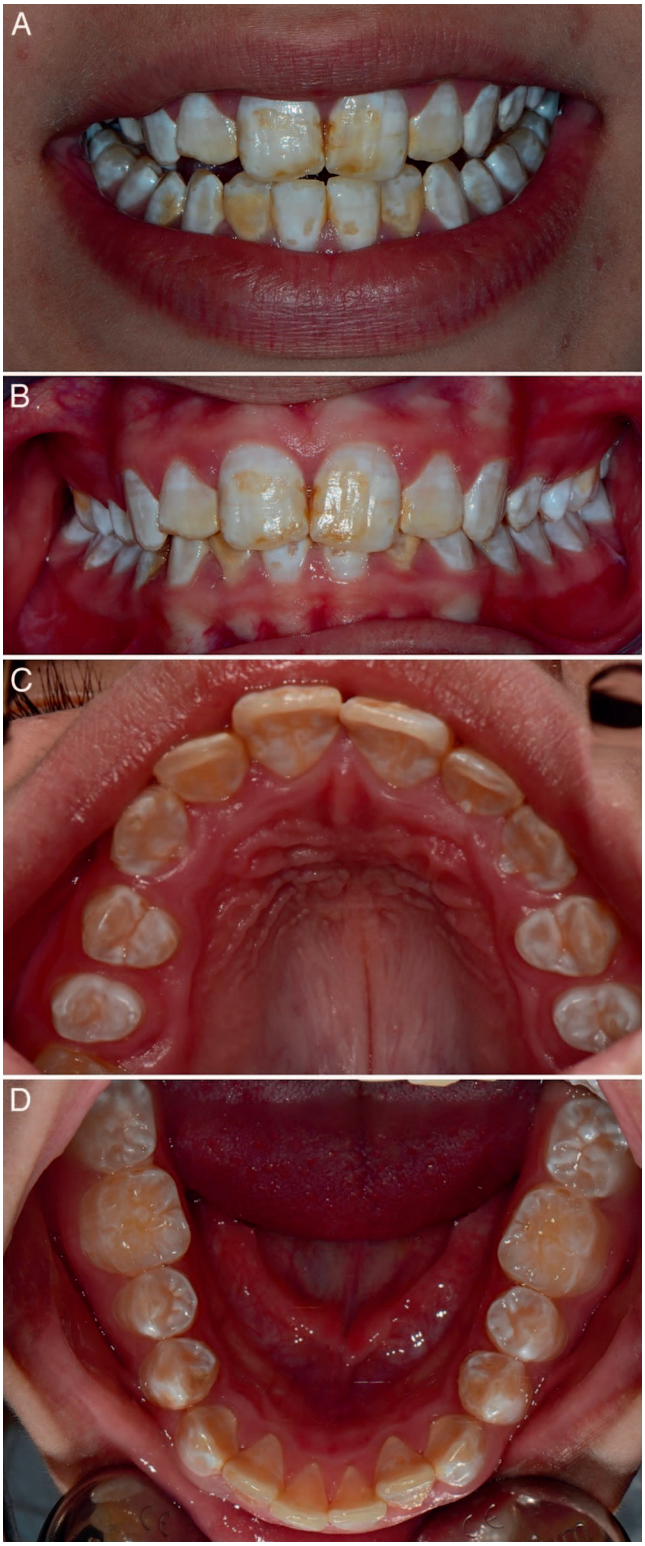

Figure 1. *Preoperative view of the 13-year-old female with a suspected TF5 fluorosis. The dual occlusion due to the current class II malocclusion treatment as well as the anterior misalignment of teeth may also be noted. (A): Facial view during smiling. (B): Facial view in occlusion. (C): Occlusal view of upper jaw. (D): Occlusal view of lower jaw.*

Germany). Rewetting was performed to assess the possible outcome. If the white discoloration did not vanish within a few seconds, etching was repeated until it did. On average, the etching procedure was repeated three or four times. Teeth were then dried with ethanol (Icon Dry, C2H6O<100%, DMG). Thereafter, the resin infiltrant (Icon Infiltrant, DMG) was gently applied for approximately six minutes and excess dispersed with air and then light cured (800 to 1000 mW/cm^2). Another infiltration for approximately one minute followed with subsequent light curing. Finally, surfaces and proximal areas were cleaned. The process is shown for the anterior teeth in Figure 2. In the first step of the treatment concept, a satisfactory homogenization of the tooth shade could be achieved, and the prominent white opaque lesions were removed. Figure 3 illustrates this change in tooth shade for the anterior teeth after full rehydration.

Second Step: Direct Composite Veneers

In the second step, the tooth color, form, and position were corrected by direct composite veneers. The desired tooth shade was chosen in consultation with the patient. For the benefit of minimal invasiveness, no preparation of the teeth was performed. A dry work environment was achieved by usage of the lip and cheek retractor, cotton rolls and intrasulcular retraction cords (Ultrapak, Ultradent). The teeth to be treated were etched, air-dried, and bonded according to standard protocol of total etch technique (Email Preparator, Ivoclar Vivadent; OptiBond FL, Kerr, Biberach, Germany). The composite veneers were created by direct modeling in a multilayer technique. A nanohybrid composite in the colors dentin A2 and enamel A2 (Tetric Evo Ceram, Ivoclar Vivadent) was used. No translucent effect colors were applied in the incisal edge, as a thin basal layer of opaque dentin color was needed to cover the slight remaining inhomogeneities and the color of the resin infiltrant.

The proximal contacts were created using the individual matrix technique according to Hugo[25] and Klaiber.[26] In this technique, a transparent matrix is inserted into the proximal sulcus vertically. A light-curing provisional composite is then injected between the matrix and the adjacent tooth. The matrix is curved toward the adjacent tooth according to the desired proximal contour with a small spatula, simultaneously shaping the provisional composite in the interdental space. Next, the provisional composite is light cured while firmly pressing the matrix against the adjacent tooth in the desired

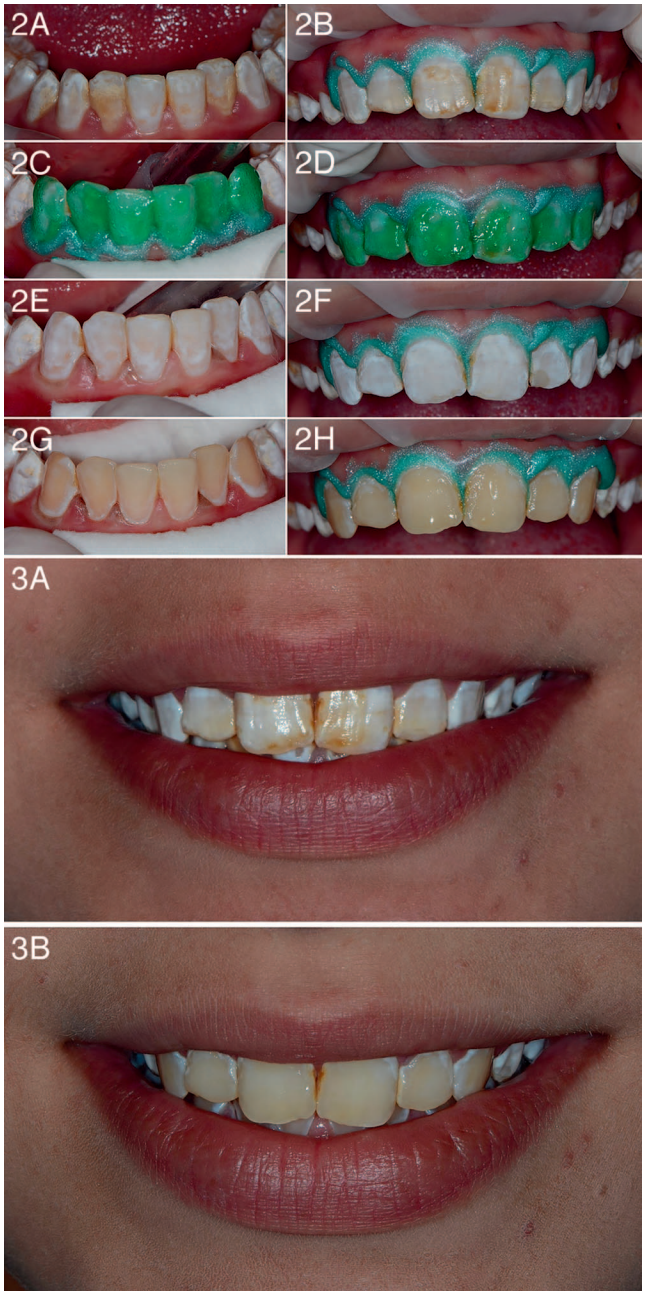

Figure 2. *Resin infiltration of the anterior teeth in the mandible (left side) and maxilla (right side). (A): Preoperative view. (B): Preoperative view after application of the liquid rubber dam. (C, D): Application of the hydrochloric acid. (E, F): Drying of the teeth with ethanol. (G, H): Application of the infiltrant. The liquid rubber dam could not fully withstand the repeated etching with hydrochloric acid. Small chemical burns could be observed at the marginal gingiva. However, these did not cause the patient any pain and healed within a few days. No postoperative sensibilities occurred.*

Figure 3. *Homogenization of tooth color after resin infiltration. (A): Preoperative view. (B): Four-day postoperative result after resin infiltration of the anterior teeth of mandible and maxilla.*

position. This holds the matrix in place, subsequently enabling easy proximal composite placement. For detailed step-by step illustrations, see Klaiber.[26] No proximal contacts were created in the posterior tooth region, as consultation with the attending orthodontist revealed that further extrusion of the teeth was planned as part of the class II malocclusion therapy. Finishing and polishing were performed using a flame-shaped finishing diamond, a sickle-shaped scalpel No. 12 (B. Braun, Melsungen, Germany), Sof-Lex disks (3M ESPE, Neuss, Germany), and flame-shaped polishing rubbers (AstroPol, Ivoclar Vivadent). The preliminary treatment outcome is shown in Figure 4.

During all phases of the treatment and follow-up, professional teeth-cleaning sessions and structured oral hygiene instructions took place repeatedly. Hereby, the regular use of accurately fitting interdental brushes was demonstrated to the patient. After the two-step treatment, a highly esthetic and remarkably less plaque-retentive situation was created, resulting in a considerable improvement in plaque levels and gingival condition (see Appendix Figure A.3). In view of the patient's deficient enamel, there may be an increased risk of excessive attrition. However, as the patient is still undergoing orthodontic treatment, the removable braces serve as protection so that no additional protective means, such as an occlusal splint, were implemented.

Follow-Up Examinations

Due to difficulties scheduling convenient appointments for the patient, the creation of a more pronounced macromorphological relief (ie, the three-dimensional shape of the tooth surface) as well as high-gloss polishing were realized in the course of the four-month follow-up. The shape of the labial surfaces was improved by accentuating the marginal ridges, thus giving the tooth a more natural appearance. The procedure and final result are presented in Figure 5. For further images on composite shaping and polishing, see Appendix Figure A.4.

At 13-month follow-up (Figure 6), all restorations presented intact, and no further abrasive changes to the enamel could be diagnosed. Transitions from tooth to restoration were smooth. The gingival situation presented without any inflammatory signs, and no bleeding on probing occurred. The patient was highly satisfied with the outcome and did not report any complaints. The class II malocclusion therapy is still in place, and further extrusion of the posterior teeth is anticipated. It should also be noted that due to improved oral hygiene and accompanying reduction of the gingival swelling, a small black triangle has appeared between the maxillary central incisors. However, the patient does not feel esthetically impaired by this occurrence.

DISCUSSION

The present case report demonstrated a novel two-step approach of minimally invasive procedures for the esthetic rehabilitation of a 13-year-old patient with suspected severe fluorosis. Here, the use of an underlying resin infiltration for the homogenization of tooth shade was performed before direct composite veneers were applied on top. To the best of our knowledge, such an elaborate procedure for severely affected teeth has not yet been described in literature. It is important to stress that high compliance is necessary when choosing a treatment option with all aspects performed directly on the patient. However, in our case, it showed that the apparent esthetic improvements during the treatment procedures can lead to high intrinsic motivation and equally high patient satisfaction.

Until now, resin infiltration on developmental defects has always been evaluated depending on whether full masking of the structural anomaly was possible. At a certain extent of the enamel hypomineralization, however, full recovery of the dental esthetics cannot be expected. An incomplete disguise is often discussed as a limitation or disadvantage of the infiltration procedure.[1,19,27-29] This case aims to change this judgment by viewing the infiltration process as a pretreatment. Instead of aiming at instant full color masking, the ability of resin infiltration to homogenize the tooth shade can be used as a preparation for further restorations in a new two-step approach.

Every practitioner is aware that discolorations, especially white opacities, can shine through partially translucent restorations, such as ceramic veneers, ceramic crowns, or classical composite shades. The application of an opaque interlayer has been suggested;[30] however, the natural tooth color always comprises a certain translucency.[31] While opaque restorations can achieve a relatively natural outcome in elderly patients, the latter treatment option cannot be recommended for adolescent patients who possess a higher translucency in their tooth shade.[32]

Other proposed solutions usually encompass an augmented layer thickness of the restoration or removal of the discoloration, both resulting in a

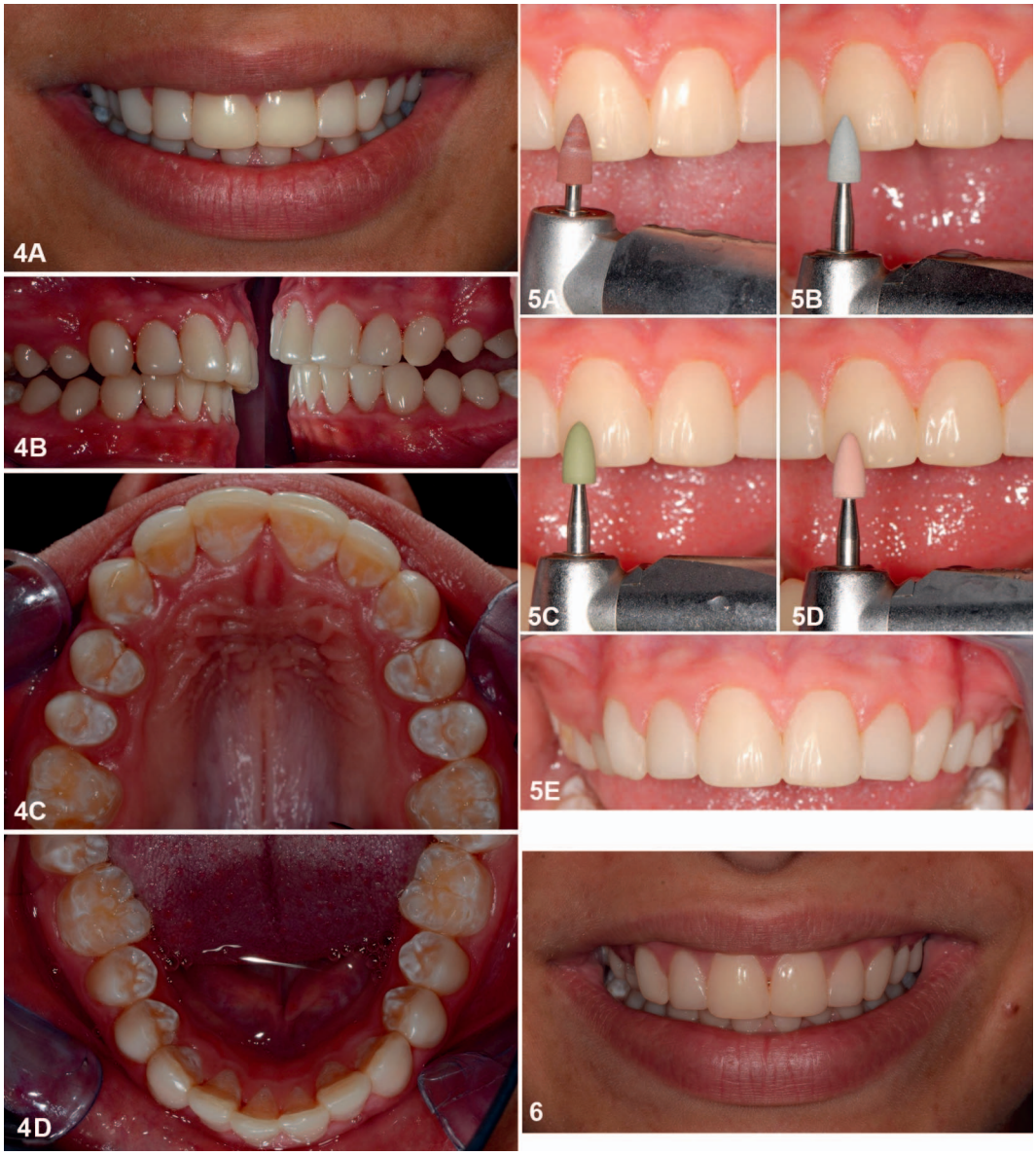

Figure 4. *Preliminary result of the two-step treatment concept with underlying resin infiltration and direct composite veneers at the top. (A): Facial view during smiling. (B): Right and left side. (C): Occlusal view of upper jaw. (D): Occlusal view of lower jaw. Macromorphological shaping of the relief has not yet been realized.*

Figure 5. *Realization of a more pronounced macromorphological relief with flame-shaped polishing rubbers. (A): Macromorphological impressions were first shaped with a brownie. (B-D): A special three-step polishing system (AstroPol, Ivoclar Vivadent) was used for high-gloss polishing. (E): Result after macromorphological shaping and polishing.*

Figure 6. *13-month follow-up.*

greater removal of hard tooth structures. This is particularly critical when treating young patients with extensive pulp chambers and a high risk of preparation trauma. It also leads to an early onset of the "vicious circle" of dental treatment, where the sacrifice of hard tooth structure always results in the necessity of an even more invasive following restoration.[33] Although some enamel is also removed during the (often multiple) etching before resin infiltration, it is nonetheless much less invasive than preparation or even microabrasion, as only the upmost layer above the porous enamel must be removed, whereas the lesion itself can remain.

Moreover, in this patient, indirect restorations in the posterior tooth region were contraindicated, as full tooth eruption had not yet taken place and

placement of indirect restorations would have resulted in their frequent replacement. In contrast, composite presents easy extension and repair possibilities.[34] In addition, direct veneers using adhesive resin composite technology demonstrate good clinical performance rates with a five-year survival rate of 84.6% to 89%.[35-38] Functional survival rates are even higher due to the previously mentioned reparability, as most failure events do not necessitate the restoration's removal but present as chipping fractures or color deterioration and can be restored by polishing or adhesive resin application. Survival rates of porcelain veneers may be even better,[39] but this must be balanced against the advantages of reduced cost and reduced destruction of hard tooth structure of direct composite veneers.

The influence of the infiltrant on adhesive composite restorations has been examined *in vitro* in several studies. The results indicate either no influence or even a beneficial effect on the bond strength.[40-42] Therefore, to our knowledge, there is currently no contraindication for an underlying resin infiltration before reshaping teeth by direct composite veneers or buildups. Successful case reports with less severe baseline conditions have already been published.[43,44] Nonetheless, it must be stressed that no reliable long-term prognosis can be made due to lacking evidence. Long-term studies are necessary to validate this treatment option. Prognosis is also dependent on the patient's oral hygiene and continuing compliance. However, the current restorations do not impede an indirect treatment at a later point in the patient's life if necessary and may then be accomplished with lower risk of iatrogenic pulp trauma and a more stable occlusion.

CONCLUSION

Based on this case report, pronounced white color alterations in adolescent patients can be successfully managed minimally invasively by means of a two-step treatment concept using underlying resin infiltration and direct composite restorations.

Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of the Clinic for Oral, Dental, and Maxillofacial Diseases, University Hospital Heidelberg.

Conflict of Interest

The authors of this article certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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