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Enamel Microabrasion: A Comprehensive Review with Illustrative Case Reports

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KEYWORDS

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ABSTRACT:

Tooth discolouration remains a prominent aesthetic challenge in clinical dentistry. Enamel microabrasion (EM) has gained recognition as a minimally invasive, cost-effective technique for treating superficial enamel stains and surface irregularities. This review aims to elucidate EM's role in enhancing enamel smoothness and brightness, both as a standalone procedure and in conjunction with adjunctive modalities such as tooth bleaching and resin infiltration. Emphasis is placed on the evolution of microabrasive agent-acid combinations, procedural nuances, diagnostic precision, and often-overlooked technical considerations. A narrative review was conducted through targeted searches in PubMed and Google Scholar using key terms related to enamel microabrasion, covering literature up to 2024. The technique was further contextualized through the presentation and analysis of three clinical cases, illustrating its practical implementation and aesthetic outcomes. Among 34 reviewed articles, EM was consistently reported as effective for managing mild to moderate presentations of dental fluorosis, enamel hypoplasia, white spot lesions, and dysmineralization. Owing to its conservative nature, EM is especially advantageous for pediatric and adolescent populations, allowing for aesthetic restoration without invasive intervention. Clinical scenarios demonstrated how modifications in application technique can significantly impact surface morphology and patient satisfaction. EM aligns seamlessly with the principles of contemporary conservative aesthetic dentistry: precision, preservation, and patient-focused care. Its documented efficacy, adaptability, and minimally invasive profile underscore its value as a key tool in the clinician's aesthetic armamentarium.

Introduction

The increasing demand for flawless smiles has led many to pursue aesthetic dental treatments. Tooth discoloration, a prevalent issue, can tarnish an otherwise attractive smile. This discoloration can be caused by intrinsic factors, such as congenital conditions, fluorosis, or dental trauma, or extrinsic factors, including habits like tobacco use or consumption of pigmented foods and drinks. Dental professionals face the challenge of improving patients' smiles with minimal procedures and interventions, while also considering patients' financial constraints and decision-making processes.[1]

Enamel microabrasion (EM) has emerged as a minimally invasive and cost-effective solution for addressing superficial stains or irregularities. Introduced in 1986, it has been widely studied and utilized with documented successes and evolving techniques.[2] EM is particularly effective for managing intrinsic discoloration caused by enamel-related conditions like enamel hypoplasia and mild to moderate fluorosis. The procedure removes brown or opaque stains while delivering a smoother and shinier enamel surface.[3]

EM involves exfoliating the porous enamel layer and eliminating trapped stains by applying a gel composed of acid and abrasive agents. The enamel stain or flaw is mechanically removed using a low-speed micromotor, which combines the erosive and abrasive effects of the mixture. As the procedure is safe, minimally invasive and less likely to negatively impact enamel or dentin surface characteristics, it can be used prior to or as an adjuvant in bleaching extensive stains.[3,4] A comprehensive understanding of the relevant clinical case, technique, its advantages, and the key factors influencing this procedure is essential for the success of EM, which is emphasised in the current article. Targeted searches in PubMed and Google Scholar employing enamel microabrasion–related keywords were conducted to compile literature for this narrative review, covering publications up to April 2025.

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Indications

Selecting the appropriate case is crucial for the success of EM. To achieve a more precise diagnosis, it is recommended to perform the examination in wet conditions, as the disparity in the refractive index is greater between air and enamel compared to water and enamel.[5] Moreover, determining the depth and thickness of intrinsic stains is essential and can be achieved through clinical techniques and transillumination. As described by Robles and Lawson, a stain that appears painted on the tooth's surface is generally more superficial than one located behind a layer of translucent enamel. The thickness of a stain can be assessed by transillumination using a light-cure unit. A darker lesion typically indicates greater depth within the enamel, whereas stains that allow light to pass through suggest a shallower location. EM is recommended for the following conditions.[6]

a. Dysmineralization

According to Croll, dysmineralization refers to a disruption in the development of the inorganic component of enamel. When this disruption occurs due to excessive fluoride intake during amelogenesis, it is identified as fluorosis.[6]

The severity of fluorosis can range from opaque white areas to yellow or dark brown discolorations with porosities on the enamel surface. Changes in enamel can be presented as thin, white, opaque lines or entirely chalky white surfaces, with diffuse and horizontal striations observed on all teeth mineralizing concurrently.[7,8] The stain's intensity depends on pigment penetration into the demineralized surface. EM is an effective first-line treatment for mild to moderate fluorosis (Thylstrup Fejerskov Index 1-7) and can significantly enhance the aesthetic appearance of the teeth. The severity of enamel stains determines the number of microabrasion applications needed, ranging from five for mild cases to ten for moderate to severe fluorosis.[9,10]

b. Superficial surface irregularities of enamel

Developmental defects may arise during mineralization such as hypocalcification or breach in enamel formation. EM is an effective technique to smooth out such developmental or acquired surface irregularities.[5]

c. Enamel hypoplasia

EM is used to treat localized or idiopathic enamel hypoplasia, a condition caused by defects in enamel matrix formation due to trauma or infection of deciduous teeth, affecting only the outer enamel layer.[9] It is highly effective in improving aesthetics and can reduce the need for more extensive restorative measures. It is particularly beneficial for younger patients who may need to avoid invasive treatments. Added treatment options might be required to establish the desired outcome if satisfactory results are not obtained from the procedure of EM alone. [5]

d. White spot lesions

Enamel opacities, also known as white spot lesions (WSL), which result from enamel demineralization caused by cariogenic activity, fluorosis, enamel hypoplasia or hypo-mineralisation, can also be treated with EM.[11]

Contraindications [12,13]

1. Uncooperative patients, especially in children

2. Patients with a history of sensitivity to cold and hot substances

3. Patients with deficient lip sealing, due to a lack of moisture can reduce effectiveness

4. Failure to achieve proper isolation causing soft tissue irritation

5. Enamel hypoplastic changes such as amelogenesis imperfecta

6. Deep dentinal stains like tetracycline staining

Table 1 describes the evolution of micro abrasive agents and its application.[5, 14-18] The optimal microabrasion technique should ensure minimal enamel loss, preserve the pulp and periodontal tissues, deliver lasting results in a short clinical timeframe, and provide a comfortable experience for the patient. The procedure begins by taking preoperative photographs for documentation, medico-legal consideration and patient/parent education. A high speed, diamond bur/disc (tapered diamond bur No. 3195 FF) can be used under copious irrigation to remove 0.1-0.3 mm of the superficial stained enamel layer to speed up the treatment results (macroabrasion). Afterward, a layer of petroleum jelly is applied to the gingival tissues to protect them from

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the microabrasion compound. In EM procedure, rubber dam is placed to isolate the teeth. It is essential for the patient, assistants, and operator to wear eye protection during the procedure. For removing the remaining stains, a mild acid and an abrasive is used. A specially designed rubber cup in a slow-speed handpiece is used to apply the abrasive compound with firm pressure. The abrasive compound is applied in four to six applications of 10-15 seconds each, with irrigation between each application, until the discoloration is considerably reduced or eliminated. The rubber dam is removed and after completion, the teeth should be treated with fluoride gel for remineralization. 2% neutral-pH sodium fluoride gel is applied for four minutes, and the patient is advised not to ingest solids or liquids for at least 30 minutes.[12,19] Table 2 enlists the advantages and disadvantages of enamel microabrasion. Figures 1, 2, and 3 illustrate the EM procedure performed using various microabrasive agents, each contributing to remarkable aesthetic results and a high level of patient satisfaction.

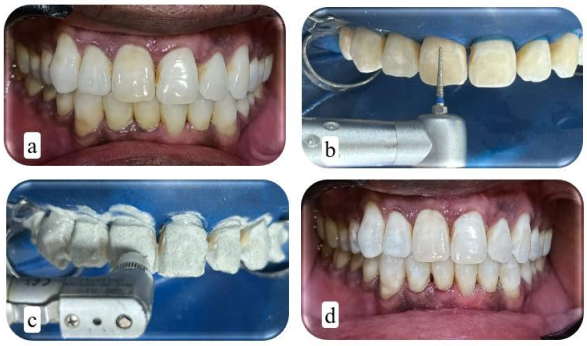

Fig 1 Macroabrasion followed by microabrasion with 6% HCl and silicon carbide abrasive particles in a patient with generalised moderate fluorosis. (a) Pre-operative clinical photograph (b) Macroabrasion with high-speed tapered fine diamond bur (c) 6% HCl and silicon carbide powder abrasive compound applied in three applications of one minute each (d) Post-operative clinical photograph

Fig 2 Microabrasion with 37% phosphoric acid and silicon carbide abrasive particles in patient with generalized mild fluorosis. (a) Pre-operative clinical photograph (b) Three applications for one minute each of 37% phosphoric acid and silicon carbide (c) 2% Sodium fluoride application for four minutes (d), Post-operative clinical photograph.

Fig 3 Microabrasion with 37% phosphoric acid followed by CPP-ACP in a patient with generalised moderate fluorosis. (a) Pre-operative clinical photograph (b) Application of 37% phosphoric acid for one minute, followed by application of 2% sodium fluoride for four minutes (c) CPP-ACP application for four minutes (d) Post-operative clinical photograph.

Table 1: Evolution of microabrasive agents

Authors	Agents used	Procedure
Walter Kane in 1916, as reported by Robert McCloskey in 1984[5]	36 % HCl (muriatic acid) with heat	A heated metallic instrument was utilized to enhance the acid's penetration into the altered enamel during its application.
Raper in 1947[5]	18% HCl	The mixture was spread and rubbed using a

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		wooden spatula wrapped in cotton for a maximum duration of ten minutes. Sodium bicarbonate was then used to neutralize the effects of the hydrochloric acid.
Murrin in 1982[14]	36% HCl with pumice	The slurry was applied using a rubber cup coupled to a micromotor for five minutes continuously.
Croll and Cavanaugh named the technique as microabrasion in 1986[2]	18% HCl and Pumice	The mixture was applied with a wooden stick and firm finger pressure for five seconds with total of 15 applications, washing and drying of enamel was done between each application.
Kamp in 1989[15]	35% phosphoric acid and pumice.	A wood spreader or a rubber bowl operating at low rotation to is used to apply a mixture of pumice stone and phosphoric acid.
PREMA Compound (Not in use anymore) (Premier Dental Company (Philadelphia, PA, United States)[16]	10% hydrochloric acid and Silicon carbide (SiC) abrasive particles of size 30-60 µm	The PREMA slurry is a specialized acid-abrasive formula designed to address superficial enamel defects such as white, brown, or multi-colored discolorations which was applied with a low-speed handpiece equipped with a 10:1 gear reduction angle.
Opalustre Compound (Ultradent Products, South Jordan, UT, United States)[17]	6.6% hydrochloric acid (<10%) and SiC abrasive particles (30%-50%) of size 20-160 µm, other ingredients: polyethylene glycol (<10%), dimethicone (<1%), trade secret (<1%)	Opalustre layer is applied over the teeth to be treated and spread using OpalCup bristle at approximately 500 rpm with intermittent medium to heavy pressure for approximately 60 seconds per application. The paste is removed with suction then rinsed, evaluated and repeated as necessary. The final polishing is completed using OpalCups, followed by fluoride application.
Whiteness RM (FGM, Joinville, SC, Brazil)[18]	Composed of 6% hydrochloric acid and SiC	After rubber dam isolation, a small quantity of the compound is applied on the area to be scorched using a spatula or rubber cup in low rotation for ten seconds for each teeth, washed and examined under moist condition. Multiple applications for 15 times is accepted in the same session. Finally neutral sodium fluoride is applied for one minute, followed by enamel polishing

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		with diamond felt disk using diamond excel polishing paste.

Table 2: Advantages and disadvantages of enamel microabrasion

Advantages	**Disadvantages**
1.EM is a highly effective and safe procedure. 2. It causes minimal enamel loss. 3.The treatment leaves the enamel surface smooth, radiant, reflective, and polished with a glass-like finish. 4. Changes in roughness or microhardness can be swiftly and effectively corrected through saliva exposure or polishing, ensuring optimal results. 5. The treatment effectively minimizes bacterial colonization on the enamel surface, enhancing oral health. 6. EM serves as a dependable auxiliary procedure post-orthodontic treatment, aiding in enamel polishing and removal of composite resin residues.	This technique utilizes highly concentrated acid, requiring careful application. Additionally, it may be ineffective in eliminating deeper stains and, in some instances, can lead to yellow discoloration of teeth post-treatment.

Technical considerations

To safeguard tooth integrity during EM, several critical factors must be taken into account. These include the choice of acid, its concentration, the abrasive material, the duration of the procedure, the manual or mechanical method of application, the amount of applied force, and the speed of rotations per minute.[7,9]

Choice of acid and its effects

Hydrochloric acid and phosphoric acid both exhibit erosive effects on enamel micromorphology, exposing interprismatic spaces despite differences in concentration.[5,20] Studies have shown that Opalustre and 37% phosphoric acid with pumice produce similar surface roughness, likely due to Opalustre's lower concentration of a stronger acid, which results in an erosive pattern with fewer porosities similar to a higher concentration of mild phosphoric acid.[21]

Further supporting this, Silva et al. demonstrated that 6.6% and 6% hydrochloric acid, as well as 37% phosphoric acid, selectively etch enamel by dissolving interprismatic regions or prism centers. This process leads to comparable surface irregularities and increased roughness, reinforcing the notion that both acids are effective in enamel modification.[22]

While Opalustre has a particle size range of 20-160 µm and Prema compound ranges from 30-60 µm, this difference does not raise clinical concerns.[5] Rodriguez et al. examined the effects of abrasive agents on enamel wear, finding that larger, irregular particles such as silicon carbide (SiC), when applied with rubber cups at a constant pressure of 217g for 120 seconds, resulted in a 10% reduction in enamel thickness compared to smaller, rounded pumice particles.[21] Despite this, repeated application of microabrasive agents not only reduces surface roughness but also enhances enamel density and mineralization, making it more resistant to bacterial colonization particularly by Streptococcus mutans, a key contributor to dental decay. This

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advantage strengthens its role in modern dentistry, promoting better oral health.[23]

Additionally, the incorporation of 6.6% hydrochloric acid and silica facilitates the inclusion of chloride ions and silica into enamel. Chloride ions, which contribute to over 60% of saliva's ionic strength, assist in enamel rehardening, while silica aids in forming a new apatite layer on acid-etched enamel, further reinforcing its structural integrity and durability. The combination of these elements enhances enamel resilience, positioning this approach as a valuable advancement in contemporary dental treatments.[5]

Enamel loss

Reports by Sundfeld et al. have demonstrated that one-minute application of Opalusture microabrasive system, one to ten times, resulted in the loss of 25 to 200 µm of enamel which is considered clinically acceptable.[13] Silva et al. showed the quantitative enamel weight loss (in grams) was highest with 6.6%HCl+SiC (Opalusture, 0.054g), followed by 10% HCl+pumice (0.052g), 6% HCl+SiC (Whiteness RM, 0.045g) and least with 37% phosphoric acid+pumice (0.037g) when applied for ten seconds, washed and repeated for 15 times (150 seconds).[22] The simultaneous wear and tear caused by abrasion and acid erosion can lead to the compaction of mineralized tissue within the organic area of enamel prisms. This process can replace the outer layer of prism-rich enamel with a densely compacted, prism-free region. As a result, the enamel surface becomes lustrous, shiny, and glass-like, which can cause light to reflect and refract differently which is known as the "abrosion effect", a term coined by Donly, which leads to the resultant ‘enamel glaze’. This can effectively hide any remaining subsurface enamel stains. The hydration of teeth through saliva further enhances these favourable optical properties.[9,23]

Pressure applied

The pressure applied during the microabrasion procedure is a key factor in achieving complete enamel removal. Dalzell et al. observed that enamel loss increases with higher pressure or when multiple factors, such as time, number of applications, and pressure, are simultaneously increased. In their study, minimal enamel loss (127 µm) was recorded when 18% HCl combined with pumice was applied for ten five-second intervals with a manual force of ten grams.[24] However most of the commercially available EM agents recommend use of rotary cups with moderate pressure at low speed of 500 rpm speed. [6, 19] (Table 1)

Manual vs Mechanical application

Zuanon and colleagues conducted a study to examine the effects of 37% H_3PO_4 combined with pumice on exfoliated primary maxillary molar teeth. Two methods were tested: manual application using a plastic spatula and mechanical application with a low-speed handpiece and rubber cup. The procedure involved ten 20-second applications, alternated with rinsing, and applied with a force of 20 g. The results indicated that the mechanical method caused 66% total enamel loss (274.16 µm), whereas the manual method led to 39% total enamel loss (152.59 µm). Based on their findings, the researchers suggested that to remove superficial stains, which typically involve about 100 µm of enamel, the abrasive agents could be applied four times using the mechanical method or seven times using the manual method.[25]

Macroabrasion

In 1995, Heymann et al. described macroabrasion as the procedure for removing localized superficial white spots through the use of handpiece instruments.[26] Compared to EM, macroabrasion is recommended for defects that penetrate more than 0.3mm into the enamel but do not exceed a quarter of its thickness. A 12-fluted carbide bur or a tapered fine diamond bur is moved over the enamel surface for five to ten seconds to remove the stains.[27] Bodden and Haywood's study indicated that the optimal results for performing macroabrasion were achieved by using a combination of long-bladed carbide burs and a sequence of flexible disks. The long burs efficiently eliminated the frosty-white enamel affected by fluorosis and were easy to maneuver to blend adjusted areas, preserving natural line angles and tooth contours. Additionally, a smooth enamel surface was achieved by the "shaving" action of the carbide blades.[28]

The macroabrasion technique offers several advantages, such as being simple, time efficient, economically feasible, eliminating the need for isolation, requiring minimal equipment or armamentarium, and overcoming challenges associated with acid irritation to the patient's

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or dentist's eyes. It also effectively preserves the sound structure of adjacent teeth. However, the disadvantages associated are technique sensitivity, risk of over abrasion, increased risk of tooth sensitivity, cannot be used for deeper stains and if utmost caution is not taken, it may result in significant damage to the tooth structure.[26]

In a 1990 study by Croll, both Prema Compound and the 12-fluted bur were found to effectively enhance the aesthetics of incisors affected by mineralization defects, with no significant difference in outcomes between the two techniques. Croll theorized that Prema compound microabrasion could induce remineralization, resulting in an extremely smooth, glass-like enamel surface within six months. This could potentially offer an advantage over the bur in removing gingival mineralization defects by reducing postoperative plaque accumulation and recurrent caries.[29] Subsequent research by various authors have supported this theory.[4,30,31] Hence for treating superficial defects, it has been suggested to start with macroabrasion followed by microabrasion to achieve optimal results.

Post EM procedures

The chapter on EM by Donly and Croll highlighted a 27-year follow-up case by Croll, which showcased successful outcomes. Tooth color improvement was achieved in a case 25 years after EM through the use of night guard bleaching with carbamide peroxide. The study also demonstrated high aesthetic outcomes among patients treated with Prema and Opalusture compounds for addressing decalcification, dysmineralization, and amelogenesis imperfecta. Numerous studies have compared different microabrasive compounds (Table 1) and found that they are all successful in treating enamel opacities.[14,32,33] However, if desired effect is not achieved alone, the procedure can be clubbed with other minimally invasive techniques like bleaching and resin infiltration.

Bleaching with carbamide peroxide can result in a considerable improvement in aesthetics that becomes more apparent after the removal of enamel stains with EM. It should be performed only under professional supervision and preferably on patients who do not have exposed dentin, as this may cause dentin sensitivity. Over time, the sensitivity disappears without the need for intervention. The patient is instructed to use bleaching trays supplied with 10% carbamide peroxide to be used in a dentist-supervised home bleaching protocol following the manufacturer's instructions. The patient is advised to place a small amount of bleaching gel in each tooth indentation, insert the tray, and wear it overnight. The treatment might last for four to six weeks depending on the clinical condition.[34]

Another option to improve aesthetics after EM is the ICON infiltration technique. After ensuring proper isolation, the initial step involves etching the lesion area exclusively with 15% hydrochloric acid for two minutes (ICON-etch). This is followed by thoroughly washing the etched zone with abundant water for 30 seconds and drying it immediately. Next, a drying agent containing 99% ethanol (ICON-dry) will be applied to eliminate any water retained within the surface's microporosity, allowing it to rest for 30 seconds. The above two steps can be repeated thrice, followed by gently applying the low-viscosity resin (ICON-infiltrant), allowing it to penetrate and fill the microporosities for three minutes. This is then light-cured for 40 seconds and the roughened enamel surface is polished using a polishing paste and disc. The goal of resin infiltration is to fully seal the subsurface microporosities while creating a boundary within the body of the lesion, rather than merely on its surface. The infiltration technique uses resin with a refractive index similar to enamel, having low viscosity, high surface tension, and low contact angle. This obstructs the diffusion pathways for acids and dissolved minerals and can also be used for mineralized lesions.[11, 35]

Future scope should encompass long term stability of EM outcomes, analysis of patient satisfaction, risk of over-abrasion, enamel susceptibility to staining post procedure and long term studies comparing bleaching and resin infiltration.

Conclusion

Enamel microabrasion stands as a remarkably effective and minimally invasive technique for achieving aesthetic dental enhancements. With negligible enamel loss EM offers a long-lasting improvement in tooth appearance. As a safe, conservative, and atraumatic approach, EM has proven invaluable in the removal of superficial enamel stains and defects, restoring a natural and refined finish.

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Beyond its clinical advantages, EM embodies the principles of precision and preservation, making it a preferred choice in modern dentistry. Its ability to enhance enamel while maintaining structural integrity underscores its significance in cosmetic and restorative treatments. Given its well-documented success and benefits, EM remains an essential tool for achieving aesthetic excellence with confidence and reliability.

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Data Availability

The authors confirm that the data supporting the findings of this study are available within the article.

Declarations

Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Ethical Approval

Not applicable.

Consent for Publication

Not applicable.

Informed Consent

Not applicable.

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