Microabrasion in the management of enamel discolorations in paediatric dentistry: a systematic review

Isabelle Blanchet1,2,3,* Isabelle Blanchet1,2,3, Ariane Camoin1,2,3, Corinne Tardieu1,2,3, Bruno Jacquot1,2,4

1 Dental school, Medical and Paramedical Sciences Faculty, AixMarseille University, 13005 Marseille, France
2 APHM Timone Hospital, 13005 Marseille, France
3 ADES CNRS EFS UMR 7268, AixMarseille University, 13344 Marseille, France
4 EA4203, Laboratory BioHealth and Nanosciences, Dental school, Montpellier University, 34193 Montpellier, France
*Correspondence isabelle.blanchet@univ-amu.fr (Isabelle Blanchet)

Abstract

Structural abnormalities of the anterior teeth could be aesthetically compromising in young patients. The dentist must provide solutions while preserving dental tissue. Microabrasion approach can be a solution. We conducted a systematic literature review to evaluate whether microabrasion treatment in paediatric dentistry can improve aesthetic in cases of pre- or post-eruptive discolorations on tooth enamel. 741 articles published up to September 2021 were selected from 3 databases using the key word “microabrasion”. 11 prospective studies including 6 randomized were relevant to the inclusion criteria. Microabrasion appears to be an effective and reliable technique for the management of pre and post enamel discoloration in paediatric dentistry, especially in fluorosis. More high-powered, well-conducted randomized studies with complete evaluation criteria are needed for other types of spots. Standardization of criteria for assessing treatment success and of the protocol required should be explored.

Keywords
Dental enamel; Microabrasion; Aesthetic; Paediatric dentistry; Minimally invasive dentistry

1. Introduction

Enamel discoloration lesions are defined as surface and sub-surface demineralization of enamel without cavitation, altering its chemical composition and, consequently, its optical characteristics [1]. They can occur on a permanent tooth as a consequence of pre-eruptive damage as in fluorosis, traumatic hypocalcification, amelogenesis imperfecta, and molar incisor hypomineralization (MIH) caused by disrupted enamel development or post-eruptive damage [2] following orthodontic treatment. When these discolorations occur in anterior teeth, aesthetic appearance can be compromised with potentially significant consequences for psychosocial development [3]. In accordance with the tissue-sparing approach and the principle of prevention, and to preserve the existing dental tissue of young patients, the least invasive treatment will be more readily selected, to allow further interventions on the tooth if required. Topical application of remineralizing agents (fluoride or Casein Phosphopeptide-Amorphous Calcium Phosphate (CPP-ACP)), microabrasion, bleaching and resin infiltration [1, 4] represent treatments for improving tooth appearance without being invasive. These different techniques can be used alone or in combination. In cases of mild surface hypomineralization, crystal reprecipitation may be sufficient to restore a normal enamel substrate with fluoride or phosphopeptide casein treatment. When the staining is deeper, reprecipitation is not sufficient, the inner part of the lesion remains, with its microporosities. Other techniques should be considered. The microabrasion procedure uses a combination of acidic substances and abrasive agents manufactured commercially or by dental practitioners themselves and reduces the whitish appearance of a lesion through the removal of the outer dysplastic layer of enamel [5, 6]. The success of this aesthetic treatment is based on an objective evaluation of the attenuation or disappearance of the discoloration, as well as on the subjective opinion of the patient and their satisfaction with the result obtained [7].

This systematic review aimed to evaluate the scientific literature available on microabrasion treatment for the purpose of aesthetic improvement in cases of pre- or post-eruptive enamel discolorations in clinical paediatric dentistry.

2. Materials and Methods

2.1 Protocol and registration

A study protocol based on the Preffered Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) was elaborated. In addition, the reporting of the study was based on the PRISMA checklist and registered in PROSPERO under reference CRD42021282023.
2.2 Eligibility criteria

The PICO process was used to develop search strategies. The population (P) component included children and adolescents (World Health Organization (WHO) definition: up to the age of 19) with enamel discoloration of the anterior teeth and good oral hygiene. The intervention (I) component was characterized by clinical utilization of microabrasion for treatment of pre and post eruptive enamel discoloration. The outcome (O) of interest was the improvement produced in the discoloured enamel before and after treatment. The comparison (C) was performed independently to eliminate studies that were obviously irrelevant.

Table 1 describes the complete search strategy used in each database.

### Table 1. search strategy in different databases.

<table>
<thead>
<tr>
<th>Database</th>
<th>Search string</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>PubMed</td>
<td>“microabrasion” (All Fields) OR “microabrasive” (All Fields) Translations microabrasion: “microabrasion” (All Fields) OR “microabrasive” (All Fields)</td>
<td>393</td>
</tr>
<tr>
<td>Cochrane Library</td>
<td>ID Search Hits #1 (Microabrasion): ti,ab,kw (Word variations have been searched) Topic: (Microabrasion)</td>
<td>47</td>
</tr>
<tr>
<td>Web of science</td>
<td>Timespan: All years. Indexes: SCI-EXPANDED, SSCI, A&amp;HCI, CPCI-S, CPCI-SSH, ESCI, CCR-EXPANDED, IC.</td>
<td>301</td>
</tr>
</tbody>
</table>

2.4 Study selection

Articles were selected in three phases. Firstly, the two reviewers examined the titles and abstracts of all references independently to eliminate studies that were obviously irrelevant. Secondly, the full texts of the selected studies were reviewed independently by the same reviewers and screened accordingly to check that they matched the PICO search. Finally, the bibliographical references of the selected studies were analysed to check for possible inclusion in our research. The results were then compared in a discussion meeting between the two authors.

2.5 Assessment of risk of bias

Two authors (IB, AC) independently assessed the risk of bias of the included studies via the Cochrane Collaboration’s tool for assessing risk of bias [8] with the following parameters: random sequence generation; allocation concealment; blinding participants and personnel; blinding of outcome assessment; the amount, nature, and handling of incomplete outcome data; selective outcome reporting, and other types of bias not covered in the other domains in the tool. Review authors’ judgments were categorized as “low risk”, “high risk” or “unclear risk of bias”. Discrepancies were resolved by discussion with a third author (BJ). The criterion for a high risk of bias was the finding of high risk in one or more key domains, the criterion for a low risk of bias was a finding of low risk in all key domains, while an unclear risk indicated either lack of information or uncertainty regarding the potential for bias.

3. Results

The search identified 741 articles in three electronic databases. We eliminated 699 studies because of duplication, or because of titles or abstracts that did not answer the research question; 42 studies were selected for abstract analysis 31 of which were eliminated because the abstract did not match the PICO search. Thus, a total of 11 studies met all the inclusion criteria. Research was completed by a manual analysis of the bibliography of the selected studies, which did not result in the inclusion of additional articles. 11 articles were included in this study. A summary flowchart of the selection process according to the PRISMA checklist is shown in Fig. 1.

3.1 Characteristics of the studies included in our review

Details of the characteristics of the 11 included studies are listed in Table 2. The studies were five prospective studies [9–13], and six randomized prospective studies [14–19]. The years of publication ranged from 2005 to 2020. Pa-
tient ages ranged from 7 to 19 years. All studies analysed the improvement in smile aesthetics produced by microabra-
sion with the disappearance of discolorations. The origins of the discolorations were different, appearing pre- and post-
development. There were two studies which dealt with post
eruptive discoloration: post-orthodontic white spots. Pre-
eruptive discoloration, specially dental fluorosis was the most
common cause evoked (7 studies). The other characteristics
studied were the presence of sensitivity (3 studies), surface
condition: smoothness (2 studies) or enamel loss (1 study),
patient satisfaction (4 studies) and maintenance of results over
time (8 studies).

3.2 Risk of bias
The results of the assessment of the methodological quality of
the 11 studies are shown in Table 3. The test results showed
that only half of the studies were randomized. The most
common risk of bias was a lack of follow up. There is difficulty
in knowing whether patients and personnel were familiar with
the procedure applied. It may still be considered that because
of the procedures implemented, it would have been difficult to
obtain blinding.
<table>
<thead>
<tr>
<th>Author Year</th>
<th>Study Design</th>
<th>Sample (n)</th>
<th>Subject Age (Years)</th>
<th>Type of Lesion</th>
<th>Treatment</th>
<th>Parameter Analyzed</th>
<th>Follow-Up (Months)</th>
<th>Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Akin [9], 2012</td>
<td>Prospective study 3 groups + control group</td>
<td>80</td>
<td>Mean ≃ 14.5</td>
<td>Orthodontic white spots (post-eruptive)</td>
<td>CCP-ACP vs. Fluorides vs. Microabrasion 18% HCl</td>
<td>Aesthetic</td>
<td>0</td>
<td>Microabrasion most effective</td>
</tr>
<tr>
<td>Bezerra [10], 2005</td>
<td>Prospective study 2 groups Split mouth</td>
<td>15</td>
<td>8 to 13</td>
<td>Mild to moderate fluorosis (pre-eruptive)</td>
<td>Microabrasion 18% HCl vs. Microabrasion H₃PO₄</td>
<td>Aesthetic Sensitivity</td>
<td>Patient satisfaction</td>
<td>1</td>
</tr>
<tr>
<td>Bhandari [14], 2019</td>
<td>Randomized prospective study 2 groups</td>
<td>43</td>
<td>7 to 16</td>
<td>Mild MIH (pre-eruptive)</td>
<td>Microabrasion 37% H₃PO₄ vs. Microabrasion 37% H₃PO₄ + Tooth Mousse Plus</td>
<td>Aesthetic</td>
<td>6</td>
<td>Aesthetic improvement for Microabrasion + Tooth Mousse Plus most effective</td>
</tr>
<tr>
<td>Bharath [15], 2014</td>
<td>Randomized prospective study 2 groups Split mouth</td>
<td>30</td>
<td>9 to 14</td>
<td>Mild to moderate fluorosis (pre-eruptive)</td>
<td>Microabrasion 18% HCl vs. McInnes solution for discoloration</td>
<td>Aesthetic Sensitivity</td>
<td>6</td>
<td>McInnes technique most effective No sensitivity</td>
</tr>
<tr>
<td>Gençer [11], 2019</td>
<td>Prospective study 2 lesion groups redistributed between 3 treatment groups</td>
<td>100</td>
<td>8 to 17</td>
<td>Fluorosis and hypomineralization (pre-eruptive)</td>
<td>Microabrasion Opalustre + Remineralization agent (varnish) vs. Microabrasion Opalustre + Tooth Mousse vs. Resin infiltration</td>
<td>Aesthetic</td>
<td>6</td>
<td>Resin infiltration most effective</td>
</tr>
<tr>
<td>Gu [16], 2019</td>
<td>Randomized prospective study 2 groups Split mouth</td>
<td>20</td>
<td>12 to 19</td>
<td>Orthodontic white spots (post-eruptive)</td>
<td>Microabrasion Opalustre vs. Resin infiltration</td>
<td>Aesthetic</td>
<td>12</td>
<td>Resin infiltration most effective</td>
</tr>
<tr>
<td>Author Year</td>
<td>Study Design</td>
<td>Sample (n)</td>
<td>Subject Age (Years)</td>
<td>Type of Lesion</td>
<td>Treatment</td>
<td>Parameter Analyzed</td>
<td>Follow-Up (Months)</td>
<td>Effectiveness</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------</td>
<td>------------</td>
<td>---------------------</td>
<td>----------------</td>
<td>-----------</td>
<td>--------------------</td>
<td>------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Gupta [17], 2017</td>
<td>Randomized prospective study. 3 groups</td>
<td>90</td>
<td>10 to 17</td>
<td>Moderate fluorosis (pre-eruptive)</td>
<td>Microabrasion PREMA + bleaching with carbamide peroxide vs. bleaching with hydrogen peroxide vs. bleaching with sodium hypochlorite</td>
<td>Aesthetic Sensitivity Patient satisfaction</td>
<td>3</td>
<td>Aesthetic improvement for all techniques No sensitivity Patient satisfied</td>
</tr>
<tr>
<td>Loguercio [18], 2007</td>
<td>Randomized prospective study. 2 groups Split mouth</td>
<td>36</td>
<td>10 to 12</td>
<td>Mild fluorosis (pre-eruptive)</td>
<td>Microabrasion Opalustre vs. Microabrasion PREMA</td>
<td>Aesthetic Smoothness Patient satisfaction</td>
<td>0</td>
<td>Aesthetic improvement faster with Opalustre Rougher after treatment (Opalustre &gt; PREMA) Patient satisfied</td>
</tr>
<tr>
<td>Nevárez-Rascón [12], 2020</td>
<td>Prospective study 3 groups (small, medium, large stains)</td>
<td>56</td>
<td>12 to 16</td>
<td>Moderate to severe fluorosis (pre-eruptive)</td>
<td>Microabrasion 16% HCl</td>
<td>Aesthetic Enamel loss</td>
<td>0</td>
<td>Aesthetic improvement Enamel loss dependent on procedure time</td>
</tr>
<tr>
<td>Sheoran [19], 2014</td>
<td>Randomized prospective study. 2 groups Split mouth</td>
<td>25</td>
<td>11 to 13</td>
<td>Developmental enamel opacity (pre-eruptive)</td>
<td>Microabrasion 18% HCl vs. Microabrasion H₃PO₄</td>
<td>Aesthetic Patient satisfaction</td>
<td>1</td>
<td>Aesthetic improvement for 2 materials Patient satisfied</td>
</tr>
<tr>
<td>Sinha [13], 2013</td>
<td>Prospective study 3 groups (mild, moderate, severe fluorosis) Split mouth</td>
<td>30</td>
<td>7 to 14</td>
<td>Mild to severe fluorosis (pre-eruptive)</td>
<td>Microabrasion 18% HCl vs. Microabrasion H₃PO₄</td>
<td>Aesthetic, Smoothness Sensitivity</td>
<td>1</td>
<td>Aesthetic improvement for 2 materials Smoother after treatment No sensitivity</td>
</tr>
</tbody>
</table>

CPP-ACP: Casein Phosphopeptides-Amorphous Calcium Phosphate; HCl: Hydrochloric Acid; H₃PO₄: Phosphoric Acid; MIH: Molar Incisiv Hypomineralisation.
3.3 Summary of outcomes

The main assessment used in the included studies was an improvement in smile aesthetics after microabrasion treatment. The initial description of the discoloration follows a clinical examination allowing comparison with different classifications (TF Index [10, 12], Dean Index [13, 15, 17, 18], TSIF [11], ICDAS [16], MDDEI [11], DDE index [19], MIH EAPD classification [14]) without precise depth assessment. There was considerable variability in the criteria used to assess the success of treatment: decreased numbers of opacities, decreased stain coloration, change in the size of the stain, evaluation according to non-specific visual scales or a complete specific scale [13], by photographic examination or by computerized analysis. There was no consensus on the maintenance of results over time. At the one-month time point, there appeared to be maintenance of this aesthetic result, but the authors did not draw the same conclusions with regard to long-term outcome. Gu et al. [16] considered that microabrasion treatment was sufficiently durable over a 12-month period while for Gupta et al. [17], there was a very slight reappearance of the defect at 3 months, and Bharath et al. [15] considered that, at 6 months, there was a real decrease in aesthetic quality. Gupta explains this reappearance because teeth were dehydrated immediately after bleaching causing an illusionary effect of whitening, which tended to disappear after rehydration.

Some studies detailed secondary assessments: patient satisfaction, hypersensitivity assessed by pulp tests and patient feeling, roughness, and enamel loss after treatment. Patients were satisfied with results in all studies that assessed this parameter, with a positive impact on well-being and social integration [18]. Hypersensitivity was not detected by any assessment method employed. Microabrasion changed the surface condition of the teeth treated and conclusions varied according to the authors who describe increases in roughness or conversely a smooth texture. There was a relationship between procedure time and enamel loss [12]. Loguercio et al. [18] considered that treatment with Opalustre further increased the feeling of roughness. This assessment was conducted by questioning the children prior to the polishing procedure. While Sinha et al. [13] judged that enamel surfaces acquired a glass-like lustre and an exceptionally smooth texture following complete treatment, this assessment was carried out by means of a scanning electron microscope analysis.

These multiple conclusions were dependent on a lack of standardization regarding the criteria used to define treatment success but also on substantial variability in the protocols and products used (Table 4).

In all studies materials were applied mechanically with a rotating cup at slow speed except for Nevárez-Rascón et al. [12] who chose manual application on cotton. The application time for H₃PO₄ ranged from 5 to 30 s, repeated until the stain disappeared for a maximum of 4 to 6 times. HCl application time ranged from 5 to 60 s, repeated until the stain disappeared up to a maximum of 15 times. The procedure was or was not repeated over time with a maximum of 5 sessions. Water rinse times were also very variable; sodium bicarbonate was sometimes used before possibly switching to a polishing procedure.

### Table 3. Risk of bias in the selected studies.

<table>
<thead>
<tr>
<th>Study</th>
<th>Random sequence generation</th>
<th>Allocation concealment</th>
<th>Blinding of participants and personnel</th>
<th>Blinding of outcome assessment</th>
<th>Incomplete outcome data</th>
<th>Selective Outcome Reporting</th>
<th>Other bias: follow up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Akin (2012)</td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
</tr>
<tr>
<td>Bezerra (2005)</td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
</tr>
<tr>
<td>Bhandari (2019)</td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
</tr>
<tr>
<td>Bharath (2014)</td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
</tr>
<tr>
<td>Gençer (2019)</td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
</tr>
<tr>
<td>Gu (2019)</td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
</tr>
<tr>
<td>Gupta (2017)</td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
</tr>
<tr>
<td>Loguercio (2007)</td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
</tr>
<tr>
<td>Nevárez-Rascón (2020)</td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
</tr>
<tr>
<td>Sheoran (2014)</td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
</tr>
<tr>
<td>Sinha (2013)</td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Red" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
<td><img src="#" alt="Green" /></td>
</tr>
</tbody>
</table>

*high risk of bias: red colour; unclear risk of bias: orange colour; low risk of bias: green colour.*
followed by the possible use of a remineralizing agent (GC Tooth Mousse for 4 or 15 minutes, 1.1% or 1.23% fluoride gel for 4 minutes, topical Acidulated Phosphate Fluoride for 4 minutes and GC Tooth Mousse Plus 2–6 minutes at home for 6 months).

In the search for the best possible aesthetic results, microabrasion was combined with other techniques. Gupta et al. [17] investigated the combination of microabrasion and bleaching. Microabrasion followed by dental bleaching with 44% carbamide peroxide gel in the dental surgery was as effective as an in-surgery bleaching session with 35% hydrogen peroxide activated by light-emitting diode (LED) and more effective than dental bleaching with 5% sodium hypochlorite in the surgery. According to the author, although much controversy surrounds the success of light sources, the use of high-intensity light increased the temperature of hydrogen peroxide (HP) and accelerated the rate of chemical whitening of teeth. Microabrasion combined with varnish or GC Tooth Mousse remained less effective than erosion-infiltration [11]. Microabrasion combined with GC Tooth Mousse Plus with application to the patient at home for 6 months improve the esthetics [14].

The last point investigated was the effectiveness of microabrasion in the improvement of smile aesthetics compared to other noninvasive treatments. Microabrasion appeared more effective than fluoride or CPP-ACP [9] but less effective than McNamara’s teeth whitening (bleaching mixture of 36% HCl and 30% H₂O₂ applied over the area of discoloration) [15], and resin infiltration [11, 16].

### 4. Discussion

The 11 included studies highlight an aesthetic improvement of enamel pre and post eruptive discolorations on the permanent anterior teeth of children and adolescents following microabrasion treatment. These studies were prospective clinical trials, only half of which were randomized.

Patient ages ranged from 7 to 19 years. To our knowledge, no clinical studies exist for children under 7 years of age. So microabrasion appears to be usable for permanent teeth, in paediatric dentistry if the teeth are sufficiently erupted to allow placement of a dental dam.

After microabrasion, enamel presents a lustrous, shiny, and glass-like surface, which may reflect and refract light differently [20]. This is called the “abrosion effect” [21, 22]. These optical properties may be able to camouflage any remaining subsurface enamel stains. Enamel microabrasion was initially performed for the removal of fluorotic white discolorations [5] and today, this remains the most common indication [20, 23]. The included studies explored dental fluorosis and confirmed the effectiveness of microabrasion. Microabrasion also appears in the recommendations for treatment of Molar Incisor Hypomineralisation [24], post-orthodontic demineralization, localized hypoplasia due to infection or trauma and idiopathic hypoplasia where the discoloration is limited to the outer enamel layer [4]. The results of the included studies were positive for these other indications, but more studies that specifically assess each type of stain for this etiology of spots are required. For MIH, only creamy yellow or whitish cream defects that are less porous and of variable depth can sometimes respond to microabrasion followed by CPP-ACP. It is not suitable for opacities deeper than 100 to 200 µm of enamel [24]. For localized hypoplasia, an additional restorative composite resin or laminate veneer may be required but microabrasion should be considered the first treatment option. It can reduce the need for enamel wear for a restorative approach, which is mainly important in young patients [25]. For post-orthodontic demineralization, the alternative treatments are fluoride or caseine phosphopeptide treatment for lesions with an ICDAS score of 1–2 and the erosion-infiltration for the score 2 [1]. However, for these treatment options, there is also a lack of reliable evidence [26].

All of these studies evidence an absence of standardization of the criteria used to assess treatment success. A reproducible scale, usable by all evaluators, was necessary. This scale should assess the aesthetic result but also all of the parameters defined by Croll [5] for an ideal microabrasion procedure: insignificant enamel loss, no damage to pulp or periodontal tissues, patient satisfaction, and permanent results achieved in a short clinical period with no patient discomfort. No scale present in the literature meets all these criteria. Many authors used a scale that rates improvement in stain appearance (ranging from 1 to 7) [27]. A complete and accurate scale using photomicrograph analysis has been described [13], but to improve management by the dentist, an aesthetic score that is simple to use could be proposed to standardize the evaluation of the treatment of white discolorations on enamel. This score must consider the extent of the defect, stain appearance, the boundaries of the defect, discoloration opacity, and stain colour. This score should be reproduced over a period of sev-

<table>
<thead>
<tr>
<th>Erosive Agent</th>
<th>Abrasive Agent</th>
<th>Fine powder</th>
<th>Diamond Paste</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCl</td>
<td>H₃PO₄</td>
<td>Silicon Carbide</td>
<td>6.6%</td>
</tr>
<tr>
<td>Opalustre PREMA Medical Custom-made</td>
<td>Opalustre Prema</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 4. Microabrasion materials found in the studies.

<table>
<thead>
<tr>
<th>Erosive Agent</th>
<th>Abrasive Agent</th>
<th>Fine powder</th>
<th>Diamond Paste</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCl</td>
<td>H₃PO₄</td>
<td>Silicon Carbide</td>
<td>6.6%</td>
</tr>
<tr>
<td>Opalustre PREMA Medical Custom-made</td>
<td>Opalustre Prema</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**HCl**: Hydrochloric Acid; H₃PO₄: Phosphoric Acid.
eral months for a long-term evaluation. It should be combined with a systematic assessment of patient satisfaction and feeling about the procedure immediately after treatment and in the long-term. As aesthetic quality is subjective, self-assessment by the patient should remain the priority; even more so in this paediatric population where aesthetic defects can lead to a negative psychosocial impact, loss of self-esteem and social disability [28].

Microabrasion also requires protocol standardization. In the included studies each author adapted the protocol thus influencing the results. Indeed, many secondary assessments are protocol dependent. The microabrasion method can be used with a very low-speed rotary handpiece with application of pressure to minimize enamel loss [5]. The residual thickness following microabrasion treatment depends on different parameters: procedure time, pressure, number of cycles and stain location. The relationship between enamel loss and procedure time has been demonstrated for some time [29] and appears to be between 200 and 300 µm for a period of 4 minutes [12]. The pressure used during the microabrasion procedure is also crucial [30]: the higher the pressure, the greater the quantity of enamel that is removed. Manual application results in an enamel loss of 152 µm whereas mechanical application results in a loss of 274 µm [31]. The number of cycles also has an impact on enamel loss [32] with an average loss of 12 µm for the initial application and an average loss of 26 µm for subsequent applications. The enamel on the vestibular surface of the maxillary incisors has an average thickness of 1.00 mm on the incisal third, 0.90 mm on the middle third, and 0.3 mm on the cervical third [33]. The loss of enamel does not have an equivalent impact on the surface of the crown. However, Croll [5] considers that quantification of enamel loss is of little importance if tooth function or appearance is not impaired. It is possible to remove the enamel gradually with control over the aesthetic result at each stage and control of each of its parameters so as to remain vigilant with regard to tissue loss.

Microabrasion impacts enamel surface properties. An increase in microhardness has been demonstrated [34]. The chemical features of the procedure also lead to increased roughness [35]. This can be reversed by polishing or by exposure to saliva [25]. This parameter explains the differences in the results noted in our included studies between Loguercio et al. [18] and Sinha et al. [13]. The simultaneous abrasion and acidic erosion of enamel prisms may compact mineralized tissue within the organic area, replacing the outer layer of prism-rich enamel with a densely compacted, prism-free region [22]. The resulting surface enamel layer is denser than that present physiologically [36]. When the enamel is reorganized, external particles from abrasive products or polishing products are incorporated into the mineral matrix. The exposure of this transformed enamel to saliva causes a precipitation of minerals on its surface. Microabrasion creates a smoother, dense, mineralized enamel layer, less conducive to bacterial colonization, particularly by Streptococcus mutans [37].

The materials used for microabrasion should also be clearly defined and standardized. Only four of the included studies used commercially produced materials, the others used materials custom-made by dental practitioners. In his original description, Croll [38] indicates specific products: hydrochloric acid in an aqueous solution in the concentration range 8% to 16%, and abrasive particulate matter from the group consisting of quartz, silicon carbide and diamond. The use of 35% phosphoric acid instead of hydrochloric acid was proposed by Kamp [39], considered advantageous as it is commonly used in clinical practice for other procedures. The three included studies that compared these two acids did not show differences in effectiveness. Commercial products only should be used to ensure adequate monitoring and traceability. Three products are available commercially. Prema Compound (Premier Dental Company, Philadelphia, PA, United States), which contains 10% hydrochloric acid, was the first to be introduced to the market. Its acid concentration is estimated at 1.4%, pH 3.2/3.5. To date, it is no longer available in the dental market. Opalustre (Ultradent Products Inc., South Jordan, UT, United States) contains approximately 6.6% HCl, pH 0.2 [40] while Whiteness RM (FGM Dental Products, Joinville, SC, Brazil) contains 6% HCl, the pH is unknown. These products silicon carbide as an abrasive agent with granules of different sizes dispersed in a water-soluble gel for easy removal. Only Prema and Opalustre were evaluated but product superiority was not really established for either formulation [40]. Results were achieved more quickly with Opalustre [18]. This effect may be due to the larger size of the silica granules in Opalustre and its more acid pH [25], leading to excessive substance removal [40, 41]. To our knowledge no other studies have compared the effectiveness of Opalustre and Prema.

Management of enamel pre and post eruptive discoloration by so-called non-invasive treatments may use microabrasion, bleaching and resin infiltration. Two studies tended to show greater effectiveness for erosion infiltration and a concentration-dependent, greater or identical effectiveness for bleaching (2 studies). However, the paediatric dentistry population exhibits some specific features which affect the place of microabrasion in the therapeutic arsenal. Bleaching is prohibited in Europe under the age of 18 [42]. In USA, it is not prohibited but a proper treatment plan with objectives should be drawn up before implementing any bleaching protocol or full-arch cosmetic bleaching for patients in the mixed dentition [43]. Whitening in adolescents is determined on a case-by-case basis and includes an analysis of risk (tooth sensitivity and gingival irritation) versus benefit [12]. Microabrasion could therefore represent an initial solution prior to bleaching. In the same way, the erosion infiltration technique, which requires pre-conditioning of the surface with 15% hydrochloric acid and removes approximately 40 µm of surface enamel to ensure resin penetration, may be used in cases with deeper stains not resolved by microabrasion, the last option before the invasive restorative approach [25]. The precise characterization of a stain, in particular of its depth, is not easy. Clinical examination alone may be insufficient. Transilluminated images may represent a promising imaging method for mapping hypomineralized enamel lesions, especially in MIH cases [44]. Additionally, given its conservative and non-invasive nature, we can recommend microabrasion in all cases in which it could be effective before considering another non-invasive or invasive treatment.
5. Conclusion

Microabrasion appears to be an effective and reliable technique for the management of pre and post eruptive enamel discolorations of permanent teeth in paediatric dentistry, especially for dental fluorosis for which this review shows an efficiency on the mild to severe forms. More high-powered, well-conducted randomized studies with complete evaluation criteria are needed for other types of spots. Due to the heterogeneity of the data, it has not been possible to perform a meta-analysis to date. Standardization of the assessment of treatment success, and of the protocol, which should use only commercial products, is needed. As aesthetic quality is subjective, self-assessment by the patient and their feelings about the procedure should remain the priority.

AUTHOR CONTRIBUTIONS
IB and AC—designed the research study and performed the literature search and data analysis. IB—wrote the manuscripts. BJ and CT—help and advice on the write, drafted and/or critically revised the work. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE
Not applicable.

ACKNOWLEDGMENT
Not applicable.

FUNDING
This research received no external funding.

CONFLICT OF INTEREST
The authors declare no conflict of interest.

REFERENCES


