RESIN INFILTRATION FOR THE MANAGEMENT OF ENAMEL OPACITY - A CASE SERIES AND LITERATURE REVIEW

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Abstract

Resin infiltration (RI) technique was introduced as one of the minimally invasive dentistry techniques for the management of enamel opacity. Six young patients with post-orthodontic white spot lesions, molar incisor hypomineralization, fluorosis, and amelogenesis imperfecta were treated with resin infiltration (RI). RI was used alone or in conjunction with bleaching or microabrasion. The esthetic improvement of lesions is immediately noticeable following treatment, even though some enamel discoloration remained visible. No color changes of the treated teeth noted after 6-month review. The use of RI alone or in combination with the other interventions has been shown to be successfully masking enamel opacities in young patients. Therefore, RI technique can be an option in managing enamel opacity of anterior teeth due to demineralization or developmental defects of enamel.

Keywords: Enamel opacity, Esthetic, Microabrasion, Minimal invasive dentistry, Resin infiltration

Introduction

Developmental defects of enamel (DDE) are an esthetic, functional and frequently psychological concern, particularly in young patients (1). There are a number of genetic, systemic, environmental and local factors that may contribute to the etiology of DDE (1, 2). Clinical manifestations of DDE include white/cream enamel opacity (demarcated opacities, diffuse opacities, hypoplasia or their combination (3, 4). Enamel hypomineralization and enamel hypoplasia are the most common of developmental enamel defects seen in children (3). Enamel hypomineralization is a qualitative defect characterized by alterations in enamel translucency and opacity. The defective enamel has normal thickness, and opacities may be diffuse or demarcated and the colour ranges from white, yellow, to brown opacities (3). Enamel hypoplasia is a quantitative abnormality, whereas enamel hypomineralization is a variation in enamel translucency and opacity resulting from a qualitative defect in the enamel (4). A qualitative defect in the enamel causes variable refraction indices in the tooth and deviates incoming light beams to the observer, hence manifesting as enamel opacity (2).

The most prevalent enamel defects include amelogenesis imperfecta, molar incisor hypomineralization and fluorosis (2, 3). The presence of these enamel defects on anterior teeth may cause esthetic concern and has a negative effect on the quality of life of the patient (4). Various minimally invasive techniques can be used to attempt to reduce the appearance of anterior opacities while preserving the enamel. Predicting the probable success of any intervention is, however, one of the most difficult tasks (4). The options for managing enamel opacities include remineralization with Casein phosphopeptide-amorphous calcium phosphate (CCP-ACP) or fluoride-containing products, microabrasion, argon-laser irradiation, bleaching, resin infiltration (RI) and direct/indirect composite resin restorations (5, 6).

In 2009, RI with the brand name ICON® (DMG, Hamburg, Germany) became available as a minimally invasive therapeutic option (5, 6). Indications for RI include non-cavitated enamel caries and dentin caries that have not progressed beyond the first third of the dentin, lesions caused by molar incisor hypomineralization, hypoplasia discolorations following dental trauma, and fluorosis (5, 6). RI contains 15% hydrochloric acid (HCl) etchant, ethanol as a dehydrating agent, and triethylene glycol dimethacrylate (TEGDMA) resin infiltrant (7, 8, 9). RI involves etching the tooth lesion surface with 15% HCl for two minutes,

desiccating the tooth adequately, placement of low-viscosity resin and allows the material to penetrate the demineralized or hypomineralized enamel intercrystallite spaces and then light-curing the resin material (5, 9). RI could be used as a long-term therapeutic technique in between prevention and restoration (7). This approach has many benefits, including preservation and maintenance of sound hard tooth substance, suppression of caries progression, mechanical stabilization of tooth structure and aids in concealing the enamel lesion (5, 8). Table 1 displayed the RI utilization protocol based on manufacturer recommendations.

Table 1: The procedure for using resin infiltration based on manufacturer instruction

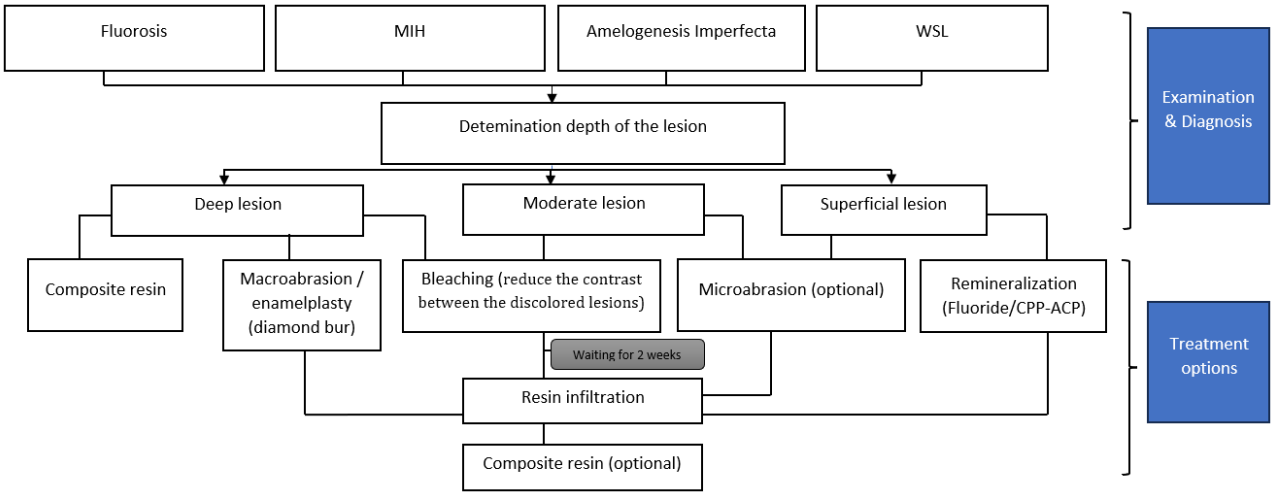
How to utilize ICON®? (9)
1. Take a pre-op photo.
2. Proper isolation with a rubber dam is essential to safeguard soft tissues and guarantee complete dryness.
3. The dental surface is thoroughly cleaned. Water is sprayed to eradicate residue.
4. Using a specialized brush applicator, 15% HCl (ICON® Etch) is applied directly to the lesion for 120 s while stirring gently.
5. The tooth is then cleansed for 30 seconds and allowed to air dry.
6. ICON® Dry is administered directly to the white lesion for 30 s using a syringe. Air dry.

(Procedures 4-6 can be repeated up to three times until the patient is satisfied with the appearance of the tooth).

7. The ICON® infiltrant is simply applied and left for 180 s.
8. Distribute using air and floss. The tooth is illuminated for 40 s. Apply an additional ICON® Infiltrant.
9. Left in place for one minute, excess removed, floss and light curative for 40 s.
10. Using soflex disc and floss for polishing and finishing.
11. Take a post-op photograph.

In terms of the management of enamel opacity, the literature indicates that the depth of a lesion is predictive of its severity, including its width; lesions with distinct borders are more severe than those with less distinct and opalescent borders (10, 11). The tooth should be evaluated using light transillumination with a light cure to determine the extent and depth of the lesion, with superficial lesions appearing more translucent and lesions closer to the dentoenamel junction appearing more opaque (12). The diagnosis and severity of the opacity aid the clinician in determining the best treatment option to manage the lesion (10, 11, 13). Remineralization, RI and microabrasion are indicated for mild to moderate enamel opacities, whereas bleaching or a combination of treatments can be used to treat enamel opacities that are deeply embedded within the tooth (11, 13). When these techniques fail to produce the desired outcome, camouflaging the opacity with composite resin may be effective (11, 13). Apart from that, the color of the lesion is a crucial determinant of the appropriate management strategy. Brown opacity contains more protein than yellow or chalky enamel (13). Microabrasion can be used to eliminate brown opacities, whereas an etch bleach and seal technique is more effective for removing yellow stains (13). Vital bleaching can help conceal the white opacity by increasing the overall brightness of the natural tooth and reducing the contrast between stains and normal enamel (12, 13). For white opacities, RI techniques have demonstrated some promising outcome (13). Figure 1 show the flow chart for the management of enamel opacity.

This is a case series that describes the effectiveness of RI alone or combined with another intervention treatment for masking enamel opacity in young patients. The materials used in the treatment are listed in Table 2.



Abbreviation: MIH – Molar incisor hypomineralization; WSL – white spot lesions

Figure 1: Flow chart for the management of enamel opacity

Table 2: Materials used in the management of enamel opacities

	Resin Infiltration	Microabrasion	Bleaching
Brand	**ICON®**	**OPALUSTRE™**	**OPALESCENCE™**
Composition	• ICON®-dry: 99% ethanol • ICON®-etch: -15% Hydrochloric acid -Pyrogenic silicic acid • ICON®-Infiltrant: -Methacrylate based resin matrix - Initiator	• 6.6% hydrochloric acid • 20-160 µm silicon carbide microparticles	• 10% carbamide peroxide • Potassium nitrate and fluoride

Case Presentation

Six cases are presented based on the etiology of enamel opacity. The effectiveness of RI alone or in combination with another intervention treatment for masking enamel opacity in young patients is discussed in this case series. The same clinician treated all six cases. Table 3 show six cases of management of enamel opacity with resin infiltration alone or in combination with another intervention.

Table 3: Six cases of management of enamel opacity with resin infiltration alone or in combination with another intervention

Case	Age/ Gender/ Race	Complaint	Tooth	Diagnosis	Polishing cycle prior to etching or after RI	Number of etching cycles with 15% HCl	Number of resin infiltrant cycle	Changes in tooth shade?	Any combination with other treatments/ adjuncts?	Result (total/ partial resolution of enamel opacity)
1	14/F/ Chinese	Whitish discoloration on the upper front teeth and requested treatment.	11 & 21	Post-orthodontic white spot lesions	Yes	3	2	Yes	RI alone	Total resolution (Figure 2)
2	16/F/ Malay	I would like to get these white spots removed.	Generalized	Fluorosis (TSIF-score 3)	Yes	5	2	Yes. A3.5 to A2	First bleached with 10% carbamide peroxide in a night guard bleaching tray every night for 2 weeks, followed by suspension of treatment for 14 days to allow for color stabilization and bond strength restoration and followed by RI	Total resolution (Figure 3)
3	15/M/ India	Sought treatment for brownish lesion on upper front teeth	Generalized	Fluorosis (TSIF – score 3)	Yes	3	2	Yes	RI alone	Partially diminished (Figure 4)
4	9/F/ Malay	Unhappy with the appearance of the upper front teeth	11 & 21	Fluorosis (TSIF – score 3)	Yes	3	2	Yes	RI alone	Total resolution (Figure 5)
5	10/M/ Malay	Referred for the management of white opacity on the upper front teeth	11 & 21	Molar incisor hypomineralization	Yes	4	2	Yes	Microabrasion & RI	Partially diminished (Figure 6)
6	5/F/ Malay	Brownish color of teeth on the lower anterior incisor and canine	73 to 83	Amelogenesis imperfecta	Yes	5	2	Yes	RI alone	Total resolution (Figure 7)

Abbreviation: RI- resin infiltration; TSIF-Tooth Surface Index of Fluorosis

Case 1

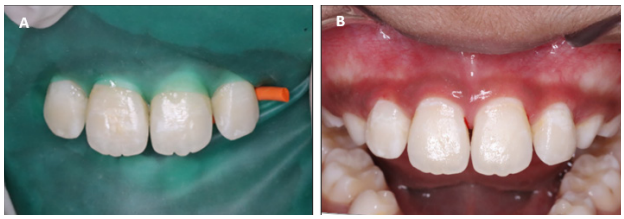


Figure 2: (A) Post orthodontic white spot lesion on teeth 11 and 21 prior to RI (B) Post orthodontic white spot lesion on teeth 11 and 21 after RI application

Case 2

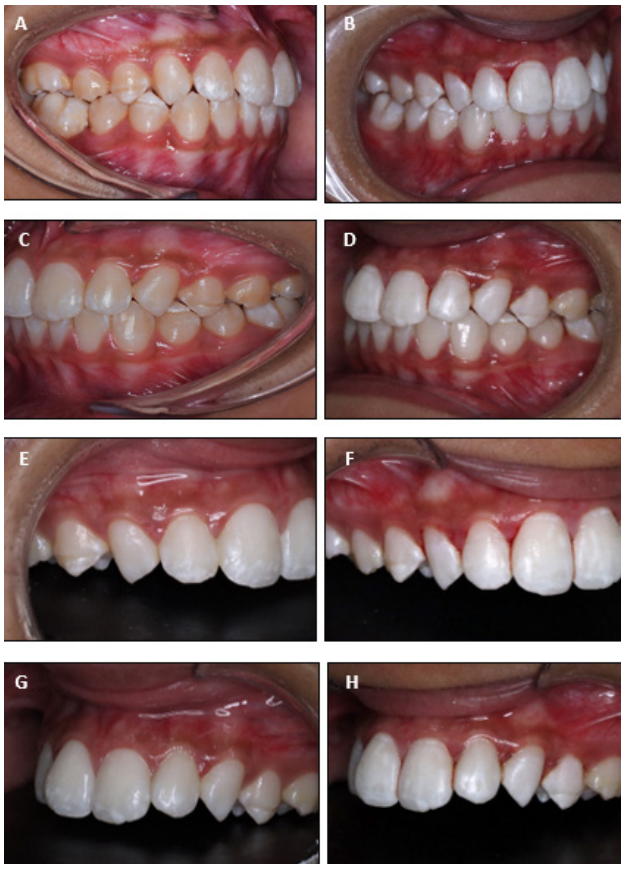


Figure 3: (A) Pre-operative right buccal view of fluorosis teeth prior to intervention (B) Post-operative right buccal view of fluorosis teeth after bleaching (C) Pre-operative left buccal view of fluorosis teeth prior to intervention (D) Post-operative left buccal view of fluorosis teeth after bleaching (E) Pre-operative view on teeth 14,13, 12 & 11 after bleaching (F) Post-operative view on teeth 14, 13, 12 & 11 after RI (G) Pre-operative view on teeth 21, 22, 23 & 24 after bleaching (H) Postoperative view on teeth 21, 22, 23 & 24 after RI.

Case 3

Figure 4: (A) Fluorosis on teeth 12, 11 and 21 prior to microabrasion and RI (B) Fluorosis on teeth 12, 11 and 21 after microabrasion and RI

Case 4

Figure 5: (A) Pre-operative fluorosis on teeth 11 and 21 prior to RI (B) Rubber dam placement on teeth 11 and 21 (C) Post-operative after RI.

Case 5

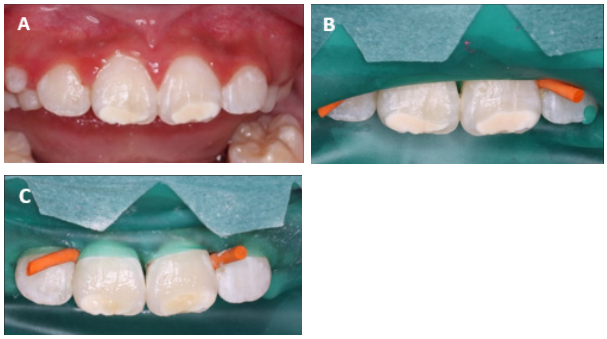


Figure 6: (A) Pre-operative Molar incisor hypomineralization teeth 11 and 21 prior to microabrasion and RI (B) Rubber dam placement on tooth 11 and 21 (C) Post-operative after microabrasion and RI.

Case 6

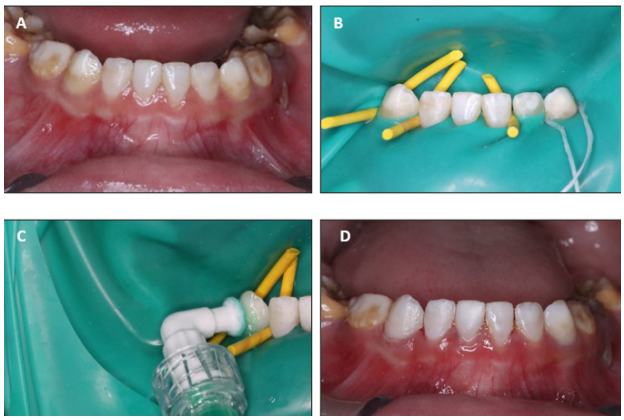


Figure 7: (A) Amelogenesis imperfecta on mandibular teeth (B) Isolation with rubber dam (C) Application of 15% Hydrochloric acid (ICON® Etch) (D) Appearance of amelogenesis imperfecta teeth after RI application on 73 to 83.

Discussion

Based on the type of pathological lesion, the severity of the lesion and the clinician's level of skill, this case series identifies different approaches for treating enamel opacity. The treatment options for mild to moderate opacities include remineralization, bleaching, RI and microabrasion, whereas more severe forms of these defects may require combinations of these treatments (13).

In cases with superficial enamel opacity where cavitations are not visible and only the optical qualities of the tooth are compromised, the use of RI as a new treatment option is widely recognized (8, 14). This treatment eliminates the appearance of opaque lesions by penetrating low-viscosity resin into hypomineralized or demineralized enamel tissue (5, 14). RI is a low-viscosity, light-curing compound that produces a low contact angle with enamel and due to its high surface tension, can infiltrate into the lesion body (8). To do this, 15% HCl gel is first applied to the lesion and then the resin infiltrant is drawn into the lesion by capillary forces (8). The rationale for masking enamel lesions with RI is based on changes in light scattering within the lesions (6, 7). The refractive index of healthy enamel is 1.62 (8, 12). The microporosities of enamel caries lesions are either filled with water (refractive index = 1.33) or air (refractive index = 1.0) (7, 8). When enamel lesions have their microporosities filled with resin, they lose their whitish appearance and resemble healthy enamel (5-7).

In accordance with the manufacturer's instructions, the etching cycle was repeated not more than three times (8). However, a high number of etching cycles up to five cycles were done in some cases without such negative effects (hypersensitivity or pain). This seems to indicate that deep lesions required more etching cycles to be resolved (14). The pores of a lesion do not have a uniform diameter at different depths, with the pores in the innermost areas being smaller. Thus, the probability of complete resin infiltrant penetration is reduced in deeper lesions, and the concealing effect of RI is unpredictable (13, 14).

The number of etching applications required seems to be accurately predicted by rewetting the lesions with ethanol (15). If there is still no noticeable improvement in enamel deterioration after using ICON® Etch and ICON® Dry, we repeated the etching cycles until a satisfactory result was achieved. In the current study, the enamel discoloration of four patients was completely and the enamel discoloration of the remaining patients was partially resolved in terms of esthetics, with varying results depending on the severity of the lesions and the treatment approach.

Apart from that, literature revealed that a dual application of the resin infiltrant reduces the polymerization contraction of the material after the first application (14). Following resin infiltrant penetration, light scattering intensity of demineralized lesions decreased, indicating that the number of micropores in demineralized enamel decreased, and thus enhance the esthetic appearance of the tooth (14).

A pathological diagnosis of enamel opacity is required prior to initiating RI treatment. It is possible that the depth of enamel opacity is not limited to the enamel outermost layer, which explains why some lesions remains visible following treatment with RI. Although there was no complete resolution of the enamel opacity, the patient was pleased with the improvement in his/her smile and no postoperative sensitivity was noted either immediately or in the recall examination. When the lesion extends beyond the enamel layer, extra vigilance and more invasive strategies are suggested such as composite or veneer restoration (6, 13). Thus, dental practitioners should be cautious and case selection must be undertaken with discretion.

Enamel microabrasion was another technique intended to enhance the surface texture, eliminate the superficial enamel lesions and expose the appearance of the unaffected enamel underneath (16). It removes the enamel outermost layers, which serve to balance the tooth color and prepares the surface for RI (16). Comparing the effects of the RI technique and microabrasion, it was discovered that the RI technique erodes enamel by only 30 to 40 µm, whereas microabrasion removes around 360 µm of enamel when applied at 5s intervals and repeated 20 times (17). Only three applications of microabrasion, which comprises 6.6% hydrochloric acid and silicon carbide were used and were sufficient to eliminate the brownish spots in in this case series. RI was then applied 1 week later, penetrating the deep lesions and forming resin infiltrated parts of the lesion. Consequently, the masking effects and microhardness were obtained through this process, as shown in this study (5, 7).

A recent clinical report suggests masking enamel fluorosis stains with home bleaching using 10% carbamide peroxide in an overnight tray, followed by RI to mask the

remaining white areas (18). One of the goals of external vital bleaching is to minimize the chromatic difference between the white spots and the unaffected portions of the tooth, hence increasing the esthetics perception of color (19). Additionally, it reduces the contrast between the opaque, discoloured lesion and its underlying color (18). Bleaching alone is insufficient to conceal a deeper white spot, necessitating the adjunct treatment such as RI which is able to reduce the diffuse whitish discoloration (19). It is important to know that the histopathology of fluorosis lesions is operate differently from caries lesions in that the hypomineralized zone is considerably deeper and an additional etching cycle usually be conducted to reach this zone to assure success with RI (18). This is comparable to our study, where the etching technique was carried out five times to provide a more esthetically pleasing result.

Combining these minimally invasive techniques results in reduction of the color of enamel opacities while preserving the sound enamel structure (11, 19). Due of the diversity of opacity types and sizes, a combination of methods such as bleaching and microabrasion may be required. The practitioner should set a realistic goal with the patients before beginning treatment. Based on the described cases, most opacities could not be eliminated entirely, rather, the therapy would minimize or 'blend' the opacities with healthy enamel. Furthermore, before and after photographs should be taken by the clinician to improve the communication with the patients. These photographs provide convincing evidence of the treatment efficacy to the patients and parents.

Given the limitations of RI treatment, the case series presented here demonstrated that RI, either alone or in combination with other interventions appears to be a viable alternative to the standard restorative procedures used for enamel opacity, but caution should be applied in case selection.

Conclusion

This case series shows that RI alone or in combination with other interventions is an appropriate and justifiable therapeutic option for a developmental defect of enamel. The unsightly enamel opacity appearance was partially or totally masked, and the patient's esthetic expectations were accomplished using minimally invasive techniques. In such circumstances, the patient's esthetic and functional issues should be addressed, and the most conservative treatment option should be offered in order to restore psychosocial self-confidence. Clinical success relies on correct diagnosis, clinical presentation of the lesions and type of intervention selected.

Acknowledgment

Not applicable

Declaration Of Interest

All authors deny any conflict of interest in the management and reporting of this case.

Consent

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References

Journal article:

1. Popescu M, Ionescu M, Scrieciu M, Popescu SM, Mercuţ R, Amărăscu MO, *et al*. Etiology Study of Acquired Developmental Defects of Enamel and Their Association with Dental Caries in Children between 3 and 19 Years Old from Dolj County, Romania. Children (Basel). 2022; 9(9):1386.
2. Castro MJ, Mendes JJ, Vinga S, de Andrade DC. Differential diagnosis of developmental defects of enamel: a review. Ann Med. 2021; 53(sup1):S37–S37.
3. Almuallem Z, Busuttil-Naudi A. Molar incisor hypomineralisation (MIH) – an overview. Br Dent J. 2018; 225(7):601–9.
4. Hasmun N, Vettore M V., Lawson JA, Elcock C, Zaitoun H, Rodd HD. Determinants of children's oral health-related quality of life following aesthetic treatment of enamel opacities. J Dent. 2020; 98:103372.
5. Dziaruddin N, Zakaria ASI. Resin Infiltration of Non-Cavitated Enamel Lesions in Paediatric Dentistry: A Narrative Review. Children. 2022; 9(12):1–26.
6. Warner C, Hasmun NN, Elcock C, Lawson JA, Vettore MV, Rodd HD. Making white spots disappear! Do minimally invasive treatments improve incisor opacities in children with molar-incisor hypomineralisation?. Int J Paediatr Dent. 2022; 32(4):617-625.
7. Bourouni S, Dritsas K, Kloukos D, Wierichs RJ. Efficacy of resin infiltration to mask post-orthodontic or non-post-orthodontic white spot lesions or fluorosis - a systematic review and meta-analysis. Clin Oral Investig. 2021; 25(8):4711-4719.
8. Ibrahim DFA, Liew YM, Hasmun NN, Venkiteswaran A. Resin infiltration ICON®: A Guide For Clinical Use. MalJour of Paed Dent 2023; 2(1):27-35.
9. Knösel M, Eckstein A, Helms HJ. Long-term follow-up of camouflage effects following resin infiltration of post orthodontic white-spot lesions in vivo. Angle Orthod. 2019; 89(1):33–9
10. Wallace A, Deery C. Management of Opacities in Children and Adolescents. Dent Update. 2015; 42(10):951-958.

11. Rodd HD, Graham A, Tajmehr N, Timms L, Hasmun N. Molar Incisor Hypomineralisation: Current Knowledge and Practice. Int Dent J. 2021; 71(4):285-291.
12. Marouane O, Chtioui F. Transillumination-aided infiltration: A diagnostic concept for treating enamel opacities. J Esthet Restor Dent. 2020; 32(5):451-456.
13. Somani C, Taylor GD, Garot E, Rouas P, Lygidakis NA, Wong FSL. An update of treatment modalities in children and adolescents with teeth affected by molar incisor hypomineralisation (MIH): a systematic review. Eur Arch Paediatr Dent. 2022; 23(1):39-64.
14. Ibrahim DFA, Hasmun NN, Liew YM, Venkiteswaran A. Repeated Etching Cycles of Resin Infiltration up to Nine Cycles on Demineralized Enamel: Surface Roughness and Esthetic Outcomes—In Vitro Study. Children. 2023; 10(7):1148.
15. Kobbe C, Fritz U, Wierichs RJ, Meyer-Lueckel H. Evaluation of the value of re-wetting prior to resin infiltration of post-orthodontic caries lesions. J Dent. 2019; 91:103243.
16. Gu X, Yang L, Yang D, Gao Y, Duan X, Zhu X, *et al*. Esthetic improvements of postorthodontic white-spot lesions treated with resin infiltration and microabrasion: A split-mouth, randomized clinical trial. Angle Orthod. 2019; 89(3):372–7.
17. Gençer MDG, Kirzioğlu Z. A comparison of the effectiveness of resin infiltration and microabrasion treatments applied to developmental enamel defects in color masking. Dent Mater J. 2019; 38(2):295–302.
18. Pan Z, Que K, Liu J, Sun G, Chen Y, Wang L, *et al*. Effects of at-home bleaching and resin infiltration treatments on the aesthetic and psychological status of patients with dental fluorosis: A prospective study. J Dent. 2019; 91:103228.
19. Schoppmeier CM, Derman SHM, Noack MJ, Wicht MJ. Power bleaching enhances resin infiltration masking effect of dental fluorosis. A randomized clinical trial. J Dent. 2018; 79:77-84.