



Kristha Jannette Parajón-Oliveros¹, Aline Leite de Farias¹, Diego Fernando Rojas-Gualdrón², Juan Diego Mejía¹, Diego Giroto Bussaneli³, Lourdes Santos-Pinto³, Manuel Restrepo¹

Two-Year Clinical and Patient Outcomes of Resin Infiltration in Anterior MIH Teeth

Dvogodišnji klinički ishodi i ishodi prema procjeni korisnika nakon infiltracije smolom na prednjim zubima zahvaćenima MIH-om

¹ Basic and Clinical Research Group in Dentistry, School of Dentistry, CES University, Medellín, Colombia. *Sveučilište CES, Stomatološki fakultet, Istraživačka skupina za temeljna i klinička istraživanja u dentalnoj medicini, Medellín, Kolumbija*
² School of Medicine, CES University, Medellín, Colombia. *Sveučilište CES, Medicinski fakultet, Medellín, Kolumbija*
³ Department of Morphology, Genetics, Orthodontics and Pediatric Dentistry, São Paulo State University (Unesp), Araraquara School of Dentistry, Araraquara, São Paulo, Brazil. *Sveučilište São Paulo (Unesp), Stomatološki fakultet u Araraquari, Zavod za morfologiju, genetiku, ortodonciju i dječju stomatologiju, Araraquara, São Paulo, Brazil*

Abstract

Objective: To evaluate a two-year clinical performance of resin infiltration in anterior teeth affected by Molar Incisor Hypomineralisation (MIH), focusing on esthetic outcomes, hypersensitivity control, and patient-reported satisfaction. **Materials and Methods:** This retrospective observational study included 106 MIH-affected permanent incisors from children aged 7–10 years, treated at a university-based pediatric dental clinic. The primary outcome was esthetic improvement (colour match, FDI criteria). Secondary outcomes included patient-reported hypersensitivity (VAS), additional esthetic and biological properties from the FDI index, and patient and guardian satisfaction. Esthetic and biological properties, hypersensitivity, and satisfaction were recorded at 1, 12, and 24 months following resin infiltration of demarcated opacities. Data were analysed using descriptive and comparative statistics. **Results:** A two-year clinical success rate of resin infiltration was 96.2% based on colour match. Hypersensitivity scores (VAS 0–10) decreased from 8 at baseline to 0 at 24 months. Success rates for esthetic and biological properties, as assessed with the FDI index, all exceeded 90%. Patient and guardian satisfaction was high at 1 and 12 months but declined at 24 months, particularly in cases with yellow-brown demarcated opacities. **Conclusion:** Resin infiltration showed high effectiveness for improving esthetic integration and colour match in anterior teeth affected by MIH, with high initial satisfaction reported by patients and guardians.

Received: October 4, 2025

Accepted: January 20, 2026

Address for correspondence

Manuel Restrepo
Facultad de Odontología. Universidad CES
Calle 10A #22-04
Medellín, Colombia
mrrestrepo@ces.edu.co

MeSH Terms: Molar Hypomineralization; Dentin Sensitivity; Tooth Discoloration; Resin Cements; Composite Resins; Dental Esthetics; Child

Author Keywords: Conservative treatment; dental care; dental esthetics; developmental defects of enamel; resin infiltration.

Kristha Jannette Parajón-Oliveros <https://orcid.org/0009-0008-4647-0602>
Aline Leite de Farias <https://orcid.org/0000-0001-5950-5634>
Diego Fernando Rojas-Gualdrón <https://orcid.org/0000-0002-2293-0431>
Juan Diego Mejía <https://orcid.org/0000-0002-8911-3305>

Diego Giroto Bussaneli <https://orcid.org/0000-0001-9078-7385>
Lourdes Santos-Pinto <https://orcid.org/0000-0003-2386-842X>
Manuel Restrepo <https://orcid.org/0000-0003-2621-2231>

Introduction

Molar-Incisor Hypomineralisation (MIH) is a qualitative developmental defect of enamel of multifactorial origin that affects at least one first permanent molar and frequently the permanent incisors, in an asymmetrical pattern (1-3). MIH is characterised by the presence of demarcated opacities in white-cream and yellow-brown colours, which may be associated with post-eruptive enamel breakdown, atypical carious lesions, atypical restorations, hypersensitivity, and esthetic compromise (1,2). While posterior teeth often pres-

Uvod

Molarno-incizivna hipomineralizacija (MIH) kvalitativni je razvojni defekt cakline multifaktorijalne etiologije koji zahvaća najmanje jedan prvi trajni kutnjak, a često i trajne sjekutiće, u asimetričnom uzorku (1 – 3). MIH obilježavaju demarkirani opaciteti kremasto bijele i žutosmeđe boje koji mogu biti povezani s posteruptivnim raspadanjem cakline, netipičnim karijesnim lezijama, netipičnim restauracijama, preosjetljivošću i narušavanjem estetike (1, 2). Dok se na stražnjim zubima često uočavaju strukturna krhkost, poste-

ent with structural fragility, posteruptive fractures, and the need for extensive restorative management, anterior teeth are mainly affected by changes in opacity, colour, and hypersensitivity, leading primarily to esthetic concerns rather than functional impairment.

The management of anterior teeth affected by MIH should take into account a patient's age, the extension and severity of the defect, the colour of the opacity, symptomatology, and the expectations of the child and their guardians (2,4). A range of treatment modalities have been proposed, including microabrasion, external bleaching, composite resin restorations, the etch-bleach-seal approach, and resin infiltration (4,5). Each of these techniques presents specific advantages and limitations (4,5). For example, microabrasion and bleaching can improve superficial colour discrepancies but may be insufficient for deeper lesions (4,5); restorative approaches are effective but invasive and may compromise long-term preservation of dental structure (6). Resin infiltration, in contrast, is a minimally invasive procedure that masks enamel opacities by reducing light scattering within hypomineralised enamel and may relieve hypersensitivity (4,5,7). It is therefore considered a promising microinvasive option for managing anterior MIH lesions, particularly in children where invasive restorations would otherwise be indicated at an early age.

The technique consists of three steps: hydrochloric acid etching to remove the superficial enamel layer, ethanol to promote drying and resin penetration, and a low-viscosity TEGDMA-based infiltrant that penetrates subsurface porosities by capillary action. The similarity in refractive index between resin (≈ 1.52) and enamel (≈ 1.62) enhances optical integration and produces an esthetic masking effect (7,8). Clinical trials and systematic reviews have confirmed its short-term efficacy in improving esthetic outcomes and controlling hypersensitivity in anterior MIH lesions (9,10), although outcomes are less predictable in yellow-brown opacities (11).

Nevertheless, most available studies are limited by small sample sizes, heterogeneous protocols, or short follow-up periods, and robust evidence regarding long-term clinical performance remains scarce. In addition, few studies have systematically integrated both clinician-based and patient-reported outcomes, despite the clear impact of anterior MIH lesions on oral health-related quality of life, self-esteem, and psychosocial well-being of children and adolescents (11).

Variability in MIH knowledge and clinical decision-making among dental practitioners and students has been reported, reinforcing the need for clear, evidence-based approaches for common clinical scenarios (12).

Therefore, there is a need for studies providing real-world, longitudinal evidence on the outcomes of resin infiltration in anterior teeth affected by MIH, with emphasis on both clinical performance and patient-centred perspectives. The present retrospective study was designed to address this gap by evaluating a two-year clinical and patient-reported outcomes of resin infiltration in anterior teeth affected by MIH, with primary emphasis on esthetic performance and colour stability, and assessment of patient-reported hypersensitivity and satisfaction.

ruptivne frakture i potreba za opsežnim restaurativnim zbrinjavanjem, prednji su zubi ponajprije zahvaćeni promjenama u opacitetu, boji i preosjetljivosti, što primarno rezultira lošim estetskim izgledom, a rjeđe funkcijskim oštećenjem.

Pri liječenju prednjih zuba zahvaćenih MIH-om treba uzeti u obzir dob pacijenta, opseg i težinu defekta, boju opaciteta, simptomatologiju te očekivanja djeteta i njegovih skrbnika (2, 4). Predložen je niz terapija, uključujući mikroabraziju, vanjsko izbjeljivanje, restauracije kompozitnim smolama, pristup jetkanje-izbjeljivanje-pečaćenje (engl. *etch-bleach-seal*) te infiltracija smolom (4, 5). Svaka od tih tehnika ima specifične prednosti i ograničenja (4 – 5). Primjerice, mikroabrazija i izbjeljivanje mogu poboljšati površinske diskoloracije, ali mogu biti nedostatne za dublje lezije (4 – 5). Restaurativni pristupi su učinkoviti, ali i invazivni pa mogu kompromitirati dugoročno očuvanje zubne strukture (6). Infiltracija smolom, nasuprot tomu, minimalno je invazivni postupak koji maskira opacitete cakline tako što smanjuje raspršivanje svjetlosti unutar hipomineralizirane cakline te može ublažiti preosjetljivost (4, 5, 7). Zato se smatra obećavajućom mikroinvazivnom opcijom za zbrinjavanje lezija MIH-a na prednjim zubima, posebno kada je riječ o djeci kod koje bi se inače invazivne restauracije indicirale u ranoj dobi.

Tehnika se sastoji od tri koraka: jetkanja klorovodičnom kiselinom radi uklanjanja površinskog sloja cakline, primjene etanola da bi se potaknulo sušenje i olakšala penetracije smole te infiltrata niske viskoznosti na bazi TEGDMA-e koji kapilarnim djelovanjem prodire u potpovršinske porozitete. Sličnost indeksa loma između smole ($\approx 1,52$) i cakline ($\approx 1,62$) poboljšava optičku integraciju i stvara estetski učinak maskiranja (6, 7). Klinička ispitivanja i sustavni pregledi potvrdili su kratkoročnu učinkovitost te metode u poboljšanju estetskih ishoda i kontroli preosjetljivosti kod lezija MIH-a na prednjim zubima (9, 10), premda su ishodi manje predvidljivi u žutosmeđim opacitetima (11).

Unatoč tomu, većina dostupnih istraživanja ograničena je zbog malih uzoraka, heterogenih protokola ili kratkog razdoblja praćenja, a čvrsti dokazi o dugoročnoj kliničkoj uspješnosti i dalje su oskudni. Nadalje, u malo su studija sustavno integrirani i ishodi na temelju procjene kliničara i oni prema riječima pacijenta, unatoč jasnom utjecaju lezija MIH-a na prednjim zubima na oralno-zdravstvenu kvalitetu života, samopoštovanje te psihosocijalno blagostanje djece i adolescenata (11).

Prijavljena je varijabilnost u znanju o MIH-u i u kliničkom donošenju odluka među stomatolozima i studentima, što pojačava potrebu za jasnim, na dokazima utemeljenim pristupima za uobičajene kliničke scenarije (12).

Zato su potrebna istraživanja koja pružaju longitudinalne dokaze iz stvarne kliničke prakse o ishodima infiltracije smolom na prednjim zubima zahvaćenima MIH-om, uz naglasak i na kliničku uspješnost i na perspektive kad je riječ o pacijentu. Ovo retrospektivno istraživanje osmišljeno je da bi se odgovorilo na taj nedostatak procjenom dvogodišnjih kliničkih ishoda i onih prema riječima pacijenta nakon infiltracije smolom na prednjim zubima zahvaćenima MIH-om, s primarnim naglaskom na estetsku uspješnost i stabilnost boje, te procjenu preosjetljivosti i zadovoljstva prema riječima pacijenta.

Materials and Methods

This study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline for cohort studies (13) and the reporting checklist for studies evaluating direct and indirect restorations (14).

The research protocol was approved by the CES University Institutional Ethics Review Board (project code: 557; act: 231/23), and conducted in accordance with the Declaration of Helsinki and the guidelines on the use of medical records for research purposes issued by the Council for International Organizations of Medical Sciences. All medical records included signed informed consent from the legal guardian authorising dental treatment and the use of information for research purposes.

Study Design

This retrospective observational study used real-world data (15) from standardized clinical records of pediatric patients treated at a university-based paediatric dentistry clinic. The study included children and adolescents who received resin infiltration therapy for anterior teeth affected by MIH between January 2017 and August 2021. Follow-up assessments were carried out at 1, 12, and 24 months post-treatment to evaluate clinical and patient-centred outcomes. Data were collected between January 2022 and December 2023.

Setting

This study was conducted at the Paediatric Dentistry Graduate Clinic of the Faculty of Dentistry at CES University (Medellin, Colombia), a private dental clinic operating in a teaching-service model that provides care to patients of all ages and socioeconomic backgrounds in Medellin. The clinic uses a proprietary electronic medical record system (Quirón, Medellin, Colombia), which stores medical and dental information and serves as a research tool.

At the CES University dental clinic, demarcated opacities associated with MIH are treated using a cycle of Icon Vestibular (DMG, Hamburg, Germany) as follows: prophylaxis of the buccal surface was performed using a glycine-based prophylactic powder (Clinpro™ Glycine Prophy Powder, 3M ESPE, New York, USA). Considering the need for absolute isolation and the hypersensitivity associated with MIH, a 20% benzocaine anesthetic gel (Farpag, Bogotá D.C., Colombia) was applied to the gingival sulcus, followed by an infiltrative injection of 2% lidocaine with epinephrine 1:50,000 (Lidocaine 2% with Epinephrine E-50; New Stetic, Guarne, Colombia). Under rubber dam isolation, ICON-Etch (15% HCl) was applied for 2 minutes, rinsed with water, and air-dried for 30 seconds. Icon-Dry (99% ethanol) was then applied for 30 seconds, and Icon-Infiltrant was actively applied for 3 minutes. Excess material was removed using a three-in-one syringe, and the infiltrant was light-cured for 40 seconds, according to the manufacturer's instructions, using an LED curing light (3M Elipar™ DeepCure-L LED, 3M ESPE, New York, USA). Finally, the surface was pol-

Materijali i metode

O ovom se istraživanju izvještava u skladu sa smjernicama *Strengthening the Reporting of Observational Studies in Epidemiology* (STROBE) za kohortne studije (13) te kontrolnom listom za izvještavanje o studijama u kojima se procjenjuju izravne i neizravne restauracije (14).

Istraživački protokol odobrilo je Institucionalno etičko povjerenstvo Sveučilišta CES (šifra projekta: 557; akt: 231/23) te je proveden u skladu s Helsinškom deklaracijom i smjernicama o uporabi medicinske dokumentacije u istraživačke svrhe koje je dao *Council for International Organizations of Medical Sciences*. Sva uključena medicinska dokumentacija sadržavala je potpisani informirani pristanak zakonskoga skrbnika kojim se odobrava stomatološko liječenje i uporaba podataka u istraživačke svrhe.

Dizajn istraživanja

Ovo retrospektivno opservacijsko istraživanje temeljilo se na podacima iz stvarne kliničke prakse (15) dobivenima iz standardiziranih kliničkih zapisa pedijatrijskih pacijenata liječenih u Sveučilišnoj klinici za dječju stomatologiju. U istraživanje su uključena djeca i adolescenti koji su između siječnja 2017. i kolovoza 2021. godine bili na terapiji infiltracijom smolom na prednjim zubima zahvaćenima MIH-om. Kontrolni pregledi bili su 1, 12 i 24 mjeseca poslije zahvata radi procjene kliničkih ishoda i ishoda postignutih kod pacijenata. Podatci su prikupljeni između siječnja 2022. i prosinca 2023. godine.

Okruženje

Istraživanje je provedeno u poslijediplomskoj Klinici za dječju stomatologiju Stomatološkog fakulteta Sveučilišta CES u Medellinu (Kolumbija), privatnoj stomatološkoj ordinaciji koja radi prema modelu podučavanje-usluga te pruža skrb pacijentima svih dobnih skupina i socioekonomskoga stanja. Klinika se koristi vlastitim sustavom elektroničkoga medicinskog kartona (Quiron, Medellin, Kolumbija) u koji se pohranjuju medicinski i stomatološki podatci te služi kao istraživački alat.

U Stomatološkoj klinici Sveučilišta CES demarkirani opaciteti povezani s MIH-om liječeni su ciklusom Icon Vestibular (DMG, Hamburg, Njemačka) kako slijedi: profilaksa bukalne plohe obavljena je glicinskim profilaktičnim prahom (Clinpro™ Glycine Prophy Powder, 3M ESPE, New York, SAD). Uzimajući u obzir potrebu za apsolutnom izolacijom i preosjetljivost povezanu s MIH-om, na gingivni sulkus nanesen je anestetički gel s 20 % benzokaina (Farpag, Bogotá D.C., Kolumbija), nakon čega je primijenjena infiltracijska injekcija od 2-postotnoga glidokaina s epinefrinom 1 : 50 000 (Lidocaine 2% with Epinephrine E-50; New Stetic, Guarne, Kolumbija). Pod izolacijskim gumenim štitičkom ICON-Etch (15 % HCl) nanesen je tijekom 2 minute, ispran vodom te sušen zrakom 30 sekunda. Zatim je Icon-Dry (99-postotni etanol) nanesen 30 sekunda, a Icon-Infiltrant aktivno je apliciran 3 minute. Višak materijala uklonjen je trostrukom štrcaljkom, a infiltrat je polimeriziran svjetlom 40 sekunda prema uputama proizvođača s pomoću LED polimerizacijske svjetiljke (3M Elipar™ DeepCure-L

ished using pre-polishing and final polishing discs and spirals (Sof-Lex™, 3M ESPE, New York, USA).

At the end of the procedure and during follow-up visits scheduled every six months, participants received verbal and written recommendations on diet and oral hygiene. They were advised to avoid consuming intensely coloured beverages, fruits, vegetables, and pigmented foods such as tea, sodas, artificial juices, blackberries, blueberries, and sweets. They were also prescribed toothpaste containing sodium monofluorophosphate (Colgate Cavity Protection, Colgate-Palmolive, Mexico). These details were verified with the child's guardian and recorded in the electronic medical record at each dental visit.

Participants

The medical records of systemically healthy patients aged 7 to 10 years were included if they had received treatment on maxillary or mandibular permanent incisors affected by demarcated opacities associated with MIH, and if the main reason for consultation involved both esthetic concerns about the opacities and hypersensitivity related to MIH. Demarcated opacities of white-cream or yellow-brown colour were included. This symptom was used as an inclusion criterion to standardize the clinical indication for treatment and assess the effectiveness of resin infiltration in relieving discomfort. Only one tooth per patient was selected for analysis. In cases where more than one incisor had been treated in the same patient, the most severely affected tooth, based on the extent and colour of the demarcated opacity (16), and the tooth with the longest follow-up period were selected.

Patients were excluded if their records showed incomplete documentation, a follow-up period of less than 24 months, or a history of orthodontic treatment prior to resin infiltration. Additional exclusion criteria included evidence of carious lesions on incisors, enamel defects unrelated to MIH, fractures or carious lesions associated with the demarcated opacity, previous restorative treatment on the selected incisor, or opacities limited to the incisal edge. These conditions were confirmed with the child's guardian and consistently recorded in electronic medical records during dental visits.

Variables

In this study, the primary outcome was clinical success of resin infiltration, defined by esthetic improvement measured by colour match according to the FDI World Dental Federation criteria (Domain A3) (14). Secondary outcomes included patient-reported hypersensitivity, assessed using a Visual Analogue Scale (VAS) after a standardized air stimulus, additional esthetic and biological parameters from the FDI index (A1, A2, and B1), and patient and guardian satisfaction with the treatment outcome.

Esthetic parameters included surface lustre and texture (A1) and marginal staining (A2). Biological parameters included the occurrence of carious lesions (B1), which was defined as margins of demarcated opacities rather than restoration margins. Given that resin infiltration does not create a restorative interface, the FDI B1 category was operation-

LED, 3M ESPE, New York, SAD). Na kraju je površina polirana diskovima i spiralama za pretpoliranje i završno poliranje (Sof-Lex™, 3M ESPE, New York, SAD).

Na kraju postupka i tijekom kontrolnih posjeta svakih šest mjeseci, sudionici su dobili usmene i napisane preporuke o prehrani i oralnoj higijeni. Savjetovano im je da izbjegavaju intenzivno obojene napitke, voće, povrće i pigmentiranu hranu kao što su čaj, gazirana pića, umjetni sokovi, kupine, borovnice i slastice. Također im je propisana zubna pasta koja sadržava natrijev monofluorofosfat (Colgate Cavity Protection, Colgate-Palmolive, Meksiko). Navedeni podatci provjereni su sa skrbnikom djeteta i zabilježeni u elektroničkom medicinskom kartonu tijekom svakoga stomatološkog posjeta.

Sudionici

Uključeni su medicinski zapisi sistemski zdrave djece u dobi od 7 do 10 godina ako su im bili liječeni trajni sjekutići gornje ili donje čeljusti zahvaćeni demarkiranim opacitetima povezanima s MIH-om te ako je glavni razlog dolaska uključivao i estetske nekorektnosti povezane s opacitetima i preosjetljivost povezanu s MIH-om. Uključeni su demarkirani opaciteti kremaste bijele ili žutosmeđe boje. Preosjetljivost je korištena kao kriterij za uključivanje radi standardizacije kliničke indikacije za liječenje i procjene učinkovitosti infiltracije smolom u ublažavanju nelagode. Za analizu je od svakoga pacijenta odabran samo jedan zub. U slučaju ako je istom pacijentu bilo liječeno više sjekutića, odabran je zub s najizraženijim zahvaćanjem na temelju opsega i boje demarkiranoga opaciteta, te zub s najduljim razdobljem praćenja (16).

Pacijenti su isključeni ako je dokumentacija bila nepotpuna, ako je razdoblje praćenja bilo kraće od 24 mjeseca ili ako je postojala anamneza ortodontskog liječenja prije infiltracije smolom. Dodatni kriteriji za isključivanje obuhvaćali su karijesne lezije na sjekutićima, defekte cakline koji nisu povezani s MIH-om, frakture ili karijesne lezije povezane s demarkiranim opacitetom, već obavljeno restaurativno liječenje na odabranom sjekutiću, ili opacitete ograničene na incizalni rub. Ta su stanja potvrđena sa skrbnikom djeteta i zabilježena u elektroničkim medicinskim kartonima.

Varijable

U ovom istraživanju primarni ishod bila je klinička uspješnost infiltracije smolom, definirana estetskim poboljšanjem mjerenim podudarnošću boje prema kriterijima organizacije *World Dental Federation* – FDI (domena A3) (14). Sekundarni ishodi uključivali su preosjetljivost prema riječima pacijenta, a procjenjivala se vizualno-analognom ljestvicom (VAS) nakon standardiziranoga zračnog podražaja, dodatnih estetskih i bioloških parametara iz FDI indeksa (A1, A2 i B1) te zadovoljstva pacijenta i skrbnika ishodom liječenja.

Estetski parametri obuhvaćali su površinski sjaj i teksturu (A1) te rubno obojenje (A2). Biološki parametri uključivali su pojavu karijesnih lezija (B1) koja je u ovom kontekstu definirana na rubovima demarkiranih opaciteta, a ne na rubovima restauracije. Budući da infiltracija smolom ne stva-

ally adapted to the transition line between the demarcated opacity and adjacent sound enamel ("opacity margin"). This adaptation is consistent with modular nature of the revised FDI criteria (14), which allows the selection and operational definition of individual categories across different clinical contexts (14). The adapted B1 operational definition was incorporated into the annual calibration sessions using written criteria and clinical photographs and was therefore included in the reported inter-examiner agreement (see below; kappa = 0.87).

In addition, overall patient and guardian satisfaction with the treatment outcome was recorded at each follow-up. In addition, the following covariates were recorded and included in the statistical analysis: patient age, gender, dental caries experience, and plaque index. These variables were included to explore potential associations with both clinical and subjective treatment outcomes.

Measurements and Control of Bias

Clinical procedures and the recording of primary and secondary outcomes in the electronic medical records were carried out by eight pediatric dentistry residents and validated by two pediatric dentistry specialists with over 15 years of clinical and research experience (inter-examiner kappa = 0.87). As part of the "Basic Operative Dentistry Techniques" course in the Pediatric Dentistry postgraduate programme at CES University, residents receive 48 hours of theoretical and practical training during their first semester. This training includes practical exercises on classifying enamel developmental defects and dental carious lesions, as well as using FDI criteria to evaluate direct and indirect restorations (14). This process forms part of a broader academic and clinical-research initiative within the Faculty of Dentistry focused on real-world evidence (15). For this reason, pediatric dentistry specialists undergo formal annual calibration in the classification of MIH and the application of FDI criteria. Information related to diagnosis, treatment planning, clinical procedures, and follow-up is collected in a standardized manner (15). Data from electronic medical records were extracted and organized by a researcher using Microsoft Excel, version 16.81 (Microsoft Corporation, Washington, USA).

For MIH classification, the MIH Index proposed and validated by Ghanim (17-19) was employed, following the recommendations of the training manual for clinical field surveys and practice (Module III: Examination Protocol and Standardisation) (17). This index records the presence of demarcated opacities, post-eruptive enamel breakdown, atypical restorations, atypical carious lesions, and teeth missing due to MIH, while distinguishing this condition from diffuse opacities, hypoplasia, amelogenesis imperfecta, and other enamel defects not associated with MIH (17,18). Moreover, the MIH Index enables classification of the defect's extent according to the thirds of the affected surface area (17,18).

Hypersensitivity was evaluated at baseline, 1, 12, and 24 months and defined as the level of pain intensity in response to an air stimulus. A one-second air jet was applied perpendicularly at a distance of 3 mm from the buccal surface of the tooth. Participants rated their pain using a Visual Ana-

ra restaurativno sučelje, kategorija FDI B1 operativno je prilagođena prijelaznoj liniji između demarkiranoga opaciteta i susjedne zdrave cakline (*rub opaciteta*). Ta je prilagodba u skladu s modularnom prirodom revidiranih FDI kriterija (14) koja omogućuje odabir i operativnu definiciju pojedinih kategorija u različitim kliničkim kontekstima (14). Prilagođena operativna definicija kategorije B1 uključena je u godišnje kalibracijske sesije uz pisane kriterije i kliničke fotografije te je zato obuhvaćena prikazanim međuispitivačkim slaganjima (vidi u nastavku; kappa = 0,87).

Dodatno, ukupno zadovoljstvo pacijenta i skrbnika ishodom liječenja bilježilo se tijekom svakoga kontrolnog pregleda. Nadalje, zabilježene su i sljedeće suvarijante te uključene u statističku analizu: dob pacijenta, spol, karijesno iskustvo i indeks plaka. Te su varijable uključene radi ispitivanja potencijalnih povezanosti i s kliničkim i sa subjektivnim ishodom liječenja.

Mjerenja i kontrola pristranosti (*bias*)

Kliničke postupke te primarne i sekundarne ishode bilježilo je u elektroničkim medicinskim kartonima osam specijalizirana dječje stomatologije, a validirala su ih dva specijalista dječje stomatologije s više od 15 godina kliničkoga i istraživačkoga iskustva (međuispitivačka kappa = 0,87). U sklopu kolegija *Basic Operative Dentistry Techniques* prema poslijediplomskom kurikululu za dječju stomatologiju na Sveučilištu CES, specijalizanti tijekom prvog semestra imaju 48 sati teorijske i praktične nastave. Ta edukacija obuhvaća praktične vježbe za klasifikaciju razvojnih defekata cakline i karijesnih lezija, te primjenu FDI kriterija za procjenu izravnih i neizravnih restauracija (14). Taj je postupak dio šire akademske i kliničko-istraživačke inicijative unutar Stomatološkog fakulteta usmjerene na dokaze iz stvarne kliničke prakse (15). Zbog toga specijalisti dječje stomatologije imaju formalnu godišnju kalibraciju u klasifikaciji MIH-a i primjeni FDI kriterija. Podatci povezani s dijagnozom, planiranjem liječenja, kliničkim postupcima i praćenjem prikupljaju se standardizirano (15). Podatci iz elektroničkih medicinskih kartona izdvojeni su i organiziraju ih istraživači s pomoću programa Microsoft Excel, verzija 16.81 (Microsoft Corporation, Washington, SAD).

Za klasifikaciju MIH-a primijenjen je indeks MIH-a koji je predložio i validirao Ghanim (17 – 19) u skladu s preporukama iz priručnika za edukaciju za klinička terenska istraživanja i praksu (Modul III: Protokol pregleda i standardizacija) (17). Tim se indeksom bilježe demarkirani opaciteti, posteruptivno raspadanje cakline, netipične restauracije, netipične karijesne lezije i zubi izgubljeni zbog MIH-a, uz razlikovanje ovog stanja od difuznih opaciteta, hipoplazije, *amelogenesis imperfecta* i drugih defekata cakline koji nisu povezani s MIH-om (17, 18). Nadalje, indeks MIH-a omogućuje klasifikaciju opsega defekta prema trećinama zahvaćene površine (17, 18).

Preosjetljivost je procjenjivana na početku te poslije 1, 12 i 24 mjeseca i definirana je kao razina intenziteta boli kao odgovor na zračni podražaj. Mlaz zraka u trajanju od jedne sekunde apliciran je okomito s udaljenosti od 3 mm od bukalne plohe zuba. Sudionici su procijenili bol vizualno-analognom

logue Scale (VAS), which consists of a 10 cm horizontal line marked at both ends: “no pain” and “worst pain.” The final score was determined by measuring, in centimetres, the distance from the “no pain” point to the patient’s mark (6). To minimize patient-level bias, only the most severely affected tooth with the longest follow-up period was included per participant. The hypersensitivity assessment was performed exclusively on the selected tooth, which had been previously identified and confirmed during clinical documentation. Additionally, non-treated teeth were covered with polytetrafluoroethylene tape to prevent hypersensitivity from adjacent teeth during evaluation of the selected (infiltrated) tooth, ensuring that the recorded VAS response reflected only the sensitivity of the treated surface. No additional sensitivity indices (e.g., Schiff cold air sensitivity test) were used; therefore, hypersensitivity findings should be interpreted as patient-reported responses to a standardized air stimulus.

The FDI World Dental Federation criteria were used at 1, 12, and 24 months to assess esthetic and biological parameters (14). This system comprises four domains and eleven categories, and, according to its authors, each domain or category can be selected independently, thereby creating a modular diagnostic system with considerable flexibility for evaluating direct restorations (14). In the present study, the domains assessed were: esthetic properties (Domain A), including surface lustre and texture (A1), marginal staining (A2), and colour match (A3); and biological properties (Domain B), specifically the occurrence of carious lesions (B1). As no restoration margins exist in resin-infiltrated lesions, B1 was adapted to refer to the margins of demarcated opacities rather than restoration margins. For the purposes of this study, the “margins of demarcated opacities” were defined as a visible boundary where the hypomineralized enamel (demarcated opacity) meets clinically sound enamel on the buccal surface. At each follow-up, this boundary was examined under standard clinical lighting after gentle air-drying. The adapted B1 category was scored as success (FDI score 1 or 2) when no caries lesion or post-eruptive enamel breakdown was present at, or immediately adjacent to, the opacity margin (no cavitation, no surface discontinuity, and no caries-related opacity/softening on visual-tactile inspection). Any caries lesion or breakdown affecting the opacity margin was scored as failure for B1 (adapted).

All parameters were scored one month after the resin infiltration procedure, and again at 12 and 24 months. No baseline stratification by the patient’s perception of esthetic acceptability was performed; however, all included cases presented esthetic concerns and a desire for improvement, as well as hypersensitivity associated with MIH, as part of the chief complaint.

Dental caries experience was evaluated and recorded using the Decayed, Missing, and Filled Teeth (DMFT) index, as proposed by the World Health Organization (WHO) (20). The plaque index was recorded according to O’Leary’s Visible Plaque Index (21). Patient and guardian satisfaction with the colour (esthetics) achieved through resin infiltration was rated on a Likert scale as very satisfied, satisfied, dissatisfied, or very dissatisfied (6).

ljestvicom (VAS) koja se sastoji od vodoravne linije duge 10 cm označene na oba kraja: *bez boli* i *najsnažnija bol*. Konačni rezultat određen je mjerenjem u centimetrima udaljenosti od točke *bez boli* do oznake koju je postavio pacijent (6). Radi smanjenja pristranosti na razini pacijenta, svakom je sudioniku u analizu uključen samo najteže zahvaćeni zub s najduljim razdobljem praćenja. Procjena preosjetljivosti provedena je isključivo na odabranom zubu koji je prije toga bio identificiran i potvrđen tijekom kliničkog dokumentiranja. Dodatno, neliječeni zubi bili su prekriveni politetrafluoretilenskom (PTFE) trakom da bi se spriječio doprinos preosjetljivosti susjednih zuba tijekom procjene odabranoga (infiltriranoga) zuba, čime se osiguralo da zabilježeni VAS odgovor pokazuje isključivo osjetljivost tretirane površine. Nisu korišteni dodatni indeksi osjetljivosti (npr., Schiffov test osjetljivosti na hladni zrak) pa zato nalaze o preosjetljivosti treba tumačiti kao odgovore pacijenta na standardizirani zračni podražaj.

FDI kriteriji prema *World Dental Federationu*, korišteni su poslije 1, 12 i 24 mjeseca za procjenu estetskih i bioloških parametara (14). Taj sustav obuhvaća četiri domene i jedanaest kategorija te, prema stajalištu autora, omogućuje neovisni odabir svake domene ili kategorije, čime se stvara modularni dijagnostički sustav znatne fleksibilnosti za procjenu izravnih restauracija (14). U ovoj su studiji procjenjivane domene: estetska svojstva (domena A), uključujući površinski sjaj i teksturu (A1); rubno obojenje (A2) i podudarnost boje (A3) te biološka svojstva (domena B) i, konkretno, pojava karijesnih lezija (B1). Budući da kod lezija tretiranih infiltracijom smolom ne postoje rubovi restauracije, kategorija B1 prilagođena je tako da se odnosi na rubove demarkiranih opaciteta, a ne na rubove restauracije. Za potrebe ove studije *rubovi demarkiranih opaciteta* definirani su kao vidljiva granica na bukalnoj plohi gdje se hipomineralizirana caklina (demarkirani opacitet) dotiče s klinički zdravom caklinom. Pri svakom kontrolnom pregledu ta je granica pregledana pod standardnim kliničkim osvjetljenjem nakon nježnoga sušenja zrakom. Prilagođena kategorija B1 ocijenjena je kao uspješna (FDI-jeva ocjena 1 ili 2) kada na rubu opaciteta ili neposredno uz njega nije bilo ni karijesne lezije, ni posteruptivnoga raspadanja cakline (bez kavitacije, bez diskontinuiteta površine i bez karijesom povezanoga opaciteta/omekšanja pri vizualno-taktilnom pregledu). Svaka karijesna lezija ili raspadanje koje zahvaća rub opaciteta ocijenjeno je kao neuspjeh za prilagođenu kategoriju B1.

Svi su parametri ocijenjeni mjesec dana poslije postupka infiltracije smolom te ponovno poslije 12 i 24 mjeseca. Nije provedena početna stratifikacija prema pacijentovoj percepciji estetske prihvatljivosti, no svi uključeni slučajevi imali su loš estetski izgled i želju za poboljšanjem te preosjetljivost povezanu s MIH-om, što je bio glavni razlog za dolazak u kliniku.

Karijesno iskustvo procijenjeno je i zabilježeno KEP indeksom, kako ga je predložila Svjetska zdravstvena organizacija (WHO) (20). Indeks plaka bilježen je prema O’Learyjevu indeksu vidljivoga plaka (21). Zadovoljstvo pacijenta i skrbnika bojom (estetikom) postignutom infiltracijom smolom ocijenjeno je Likertovom ljestvicom s četiri razine: vrlo zadovoljni, zadovoljni, nezadovoljni ili vrlo nezadovoljni (6).

To control for attrition bias, only medical records with a documented 24-month follow-up were included. However, participants who discontinued the follow-up were not analyzed, which may introduce a reporting bias if dissatisfaction contributed to dropout. Because this was a retrospective study, the follow-up attendance could not be controlled. Therefore, outcome-specific analyses used available data at each time point (complete-case per outcome), and no imputation was performed. The number of observations for each outcome at 24 months is reported in the tables and footnotes to account transparently for the small number of missing outcome data.

At baseline, data were collected on clinical characteristics, extent of MIH, hypersensitivity, dental caries experience, and plaque index. Esthetic and biological properties of the resin infiltration (assessed using the FDI World Dental Federation criteria), as well as hypersensitivity and treatment satisfaction reported by participants and their guardians, were documented at 1, 12, and 24 months following the resin infiltration of demarcated opacities associated with MIH.

Study Size

All consecutive cases that met the eligibility criteria and were treated during the study period were included, as this was a retrospective, real-world cohort with no a priori sample size set. To provide statistical justification, post hoc power calculations were performed for the main outcomes.

For the primary binary outcome (clinical success according to A3), with $n = 106$ and an alpha level of 0.05, the study had 80% power to show that the success rate exceeded 87.5% using a one-sample proportion test, based on clinical benchmarks reported in previous studies of resin infiltration in enamel defects (22,23).

For hypersensitivity assessed using the VAS (0–10), the observed baseline variability (IQR 7–9; SD approximated as $IQR/1.35 \approx 1.5$) and a conservative minimally clinically important difference of 2 VAS points were used to estimate power. A paired comparison with $n = 106$ yielded power > 0.99 at an alpha level of 0.05. Therefore, the sample was considered adequate to detect clinically meaningful changes in hypersensitivity over time at 1, 12, and 24 months.

Statistical Analysis

Statistical analysis was performed using STATA version 16.1 for Microsoft Windows (StataCorp, College Station, TX, USA). Descriptive statistics were used to characterise the study population. Categorical variables are presented as absolute and relative frequencies, while quantitative variables are reported as means and standard deviations. Statistical significance of differences over time and between groups (white-cream vs yellow-brown demarcated opacities) was analyzed using the chi-square test (exact test) for categorical outcomes and quantile regression for quantitative variables. A significance level of $p < 0.05$ was considered statistically significant.

The primary outcome was clinical success at 1, 12, and 24 months, defined as esthetic improvement, as measured by

Radi kontrole pristranosti zbog gubitka praćenja (*attrition bias*), uključeni su samo medicinski zapisi s dokumentiranim 24-mjesečnim praćenjem. Međutim, sudionici koji su prekinuli praćenje nisu analizirani, što može uvesti pristranost u izvještavanje ako je odustajanje pridonijelo nezadovoljstvo. Budući da je riječ o retrospektivnoj studiji, dolasci na kontrole nisu se mogli kontrolirati. Zato su se za analize specifične za ishod koristili dostupni podatci u svakoj vremenskoj točki, a imputacija nije provedena. Broj opažanja za svaki ishod poslije 24 mjeseca naveden je u tablicama i podrubnicama radi transparentnog prikaza malog broja nedostajućih podataka o ishodima.

Na početku su prikupljeni podatci o kliničkim obilježjima, opsegu MIH-a, preosjetljivosti, karijesnom iskustvu i indeksu plaka. Estetska i biološka svojstva infiltracije smolom (procijenjena prema kriterijima FDI-ja (World Dental Federation), te preosjetljivost i zadovoljstvo liječenjem prema riječima sudionika i njihovih skrbnika, dokumentirani su 1, 12 i 24 mjeseca poslije infiltracije smolom demarkiranih opaciteta povezanih s MIH-om.

Veličina uzorka

Uključeni su svi uzastopni slučajevi koji su zadovoljavali kriterije prihvatljivosti i bili liječeni tijekom istraživanja zato što je riječ o retrospektivnoj kohorti iz stvarne kliničke prakse bez unaprijed definirane veličine uzorka. Zbog statističkog obrazloženja provedeni su *post hoc* izračuni snage za glavne ishode.

Za primarni binarni ishod (klinička uspješnost prema A3), uz $n = 106$ i razinu alfa od 0,05, studija je imala 80 % snage da pokaže kako stopa uspjeha premašuje 87,5 % primjenom testa udjela za jedan uzorak, na temelju kliničkih referentnih vrijednosti prijavljenih u prethodnim studijama i infiltraciji smolom kod defekata cakline (19, 20).

Za preosjetljivost procijenjenu VAS ljestvicom (0 – 10), opažena početna varijabilnost (IQR 7 – 9; SD aproksimiran kao $IQR/1,35 \approx 1,5$) i konzervativna klinički minimalno važna razlika od 2 VAS-ova boda korišteni su za procjenu snage. Uparena usporedba s $n = 106$ dala je snagu $> 0,99$ pri razini alfa od 0,05. Zato se uzorak smatrao dostatnim za detekciju klinički značajnih promjena u preosjetljivosti tijekom 1, 12 i 24 mjeseca.

Statistička analiza

Statistička analiza provedena je u programu STATA, verzija 16.1 za Windowse (StataCorp, College Station, TX, SAD). Deskriptivna statistika korištena je za prikaz obilježja ispitivane populacije. Kategorijske varijable prikazane su kao apsolutne i relativne frekvencije, a kvantitativne kao srednje vrijednosti i standardne devijacije. Statistička značajnost razlika tijekom vremena i između skupina (kremasta bijela prema žutosmeđim demarkiranim opacitetima) analizirana je hi-kvadrat testom (egzaktni test) za kategorijske ishode te kvantilnom regresijom za kvantitativne varijable. Razina značajnosti $p < 0,05$ smatrana je statistički značajnom.

Primarni ishod bila je klinička uspješnost poslije 1, 12 i 24 mjeseca, definirana estetskim poboljšanjem mjerenim ocjenama 1 ili 2 u domeni FDI A3 (podudarnost boje) (14).

FDI Domain A3 (colour match) scores of 1 or 2 (14).

Patient-reported hypersensitivity was analyzed as a secondary outcome using VAS scores and summarised over time (baseline, 1, 12, and 24 months); VAS scores of 0 were considered complete patient-reported resolution.

Secondary outcomes included success in specific FDI domains (A1, A2, and B1), which were also analyzed as proportions of teeth scoring 1 or 2 in each category (14). Hypersensitivity was additionally summarized using medians and interquartile ranges, given the ordinal nature of the scale.

Patient- and guardian-reported satisfaction with colour was assessed using a four-point Likert scale. Favourable responses ("very satisfied" or "satisfied") were summarised as percentages.

Only one index tooth per participant was included. Analyses were performed on complete cases with available data at 24 months of follow-up.

Results

Participants

Out of 178 potentially eligible medical records, 146 were evaluated. Of these, 21 were excluded due to incomplete documentation; 12 participants had initiated orthodontic treatment, and seven had received restorative treatment with composite resin. The final sample comprised 106 medical records, each corresponding to an anterior tooth affected by MIH and treated with resin infiltrant ($n = 106$). Follow-up data were available for all cases at 1 and 12 months, and for 105 cases at 24 months.

Descriptive Data

Table 1 presents the characteristics of participants according to the colour of the demarcated opacity. In this study, 67% of participants were male, with a mean age of 8.8 ± 1.4 years. The mean dental caries experience (DMFT) was 1.4 ± 1.2 . On average, participants had five teeth affected by MIH. Among the sample, 59.4% exhibited yellow-brown demarcated opacities, while 40.6% presented with white-cream demarcated opacities. Compared with those presenting white-cream demarcated opacities, the participants with yellow-brown opacities were predominantly male (77.8% vs 51.2%), younger (8.6 vs 9.2 years), and had more teeth affected by MIH (5.3 vs 4.2 teeth). Conversely, fewer participants with yellow-brown demarcated opacities had teeth classified as extension III of MIH (68.3% vs 83.7%). There were no statistically significant differences between groups in mean dental caries experience (1.4 vs 1.3 teeth), mean plaque index (10.7% vs 11.2%), or the number of teeth treated with resin infiltrant. Figure 1 shows the percentage distribution of MIH clinical characteristics and extent by tooth type.

Primary Outcomes Data (A3)

Although all medical records included in the study documented a 24-month follow-up, in a few cases, certain clinical parameters were not recorded at the final visit, resulting in minor variations in the number of observations per outcome. No clinically poor outcomes were reported in any of the treated participants.

Preosjetljivost prema riječima pacijenta analizirana je kao sekundarni ishod korištenjem VAS vrijednosti i sažeta tijekom vremena (početno, 1, 12 i 24 mjeseca); VAS vrijednosti 0 smatrane su potpunim subjektivnim povlačenjem preosjetljivosti.

Sekundarni ishodi uključivali su uspjeh u ostalim FDI-jevim kategorijama (A1, A2 i B1) koje su također analizirane kao udjeli zuba s ocjenom 1 ili 2 u svakoj kategoriji (14). Preosjetljivost je dodatno sažeta medijanima i interkvartilnim rasponima, s obzirom na ordinalnu prirodu ljestvice.

Zadovoljstvo bojom, prema riječima pacijenta i skrbnika, procijenjeno je Likertovom ljestvicom s četiri stupnja. Povoljni odgovori (*vrlo zadovoljni* ili *zadovoljni*) prikazani su kao postotci.

U analizu je uključen samo jedan indeksni zub po sudioniku. Analize su provedene na potpunim slučajevima s dostupnim podatcima poslije 24 mjeseca praćenja.

Rezultati

Sudionici

Od 178 potencijalno prihvatljivih medicinskih kartona, analizirano je 146. Od toga je 21 isključen zbog nepotpune dokumentacije, 12 sudionika počelo je s ortodontskim liječenjem, a sedam je restaurativno liječeno kompozitnom smolom. Konačni uzorak obuhvatio je 106 medicinskih kartona, pri čemu je svaki odgovarao jednom prednjem zubu zahvaćenom MIH-om i liječenom infiltratom smole ($n = 106$). Podatci praćenja bili su dostupni za sve slučajeve poslije 1 i 12 mjeseci te za 105 slučajeva poslije 24 mjeseca.

Deskriptivni podatci

U tablici 1. nalaze se obilježja sudionika prema boji demarkiranoga opaciteta. U ovom istraživanju 67 % sudionika bilo je muškog spola i prosječne dobi $8,8 \pm 1,4$ godine. Prosječno karijesno iskustvo (DMFT) iznosilo je $1,4 \pm 1,2$. U prosjeku je po sudioniku bilo pet zuba zahvaćenih MIH-om. U uzorku je 59,4 % imalo žutosmeđe demarkirane opacitete, a 40,6 % kremasto bijele. U usporedbi sa sudionicima s kremasto bijelim demarkiranim opacitetima, sudionici sa žutosmeđima bili su pretežito muškog spola (77,8 % prema 51,2 %), mlađi (8,6 prema 9,2 godine) te su imali više zuba zahvaćenih MIH-om (5,3 prema 4,2 zuba). Suprotno tomu, manji udio sudionika sa žutosmeđim demarkiranim opacitetima imao je zube klasificirane kao opseg III MIH-a (68,3 % prema 83,7 %). Nisu pronađene statistički značajne razlike između skupina u prosječnom karijesnom iskustvu (1,4 prema 1,3 zuba), prosječnom indeksu plaka (10,7 % prema 11,2 %) ni u broju zuba liječenih infiltratom smole. Na slici 1. postotna je raspodjela kliničkih obilježja i opsega MIH-a prema tipu zuba.

Podatci o primarnom ishodu (A3)

Iako su svi medicinski kartoni uključeni u studiju sadržavali 24-mjesečno praćenje, u nekoliko slučajeva pojedini klinički parametri nisu bili zabilježeni tijekom završnog posjeta, što je rezultiralo manjim varijacijama u broju opažanja po ishodu. Nisu zabilježeni loši klinički ishodi ni kod jednoga liječenog sudionika.

Table 1 Participant characteristics by demarcated opacity colour
Tablica 1. Obilježja sudionika prema boji demarkiranog opaciteta

Characteristic	Total		Demarcated opacity				p-value
	n	%	White-Cream		Yellow-Brown		
			n	%	n	%	
Sex							0.004
Male	71	67.0	22	51.2	49	77.8	
Female	35	33.0	21	48.8	14	22.2	
Age (Mean ± SD)	8.8	1.4	9.2	1.3	8.6	1.3	0.023
DMFT (Mean ± SD)	1.4	1.2	1.3	1.1	1.4	1.2	0.943
MIH (Mean ± SD)	4.9	1.8	4.2	1.3	5.3	2.0	<0.001
Affected Incisors (International nomenclature)							0.207
11	33	31.1	18	41.9	15	23.8	
12	15	14.2	2	4.7	13	20.6	
21	16	15.1	6	14.0	10	15.9	
22	20	18.9	10	23.3	10	15.9	
31	5	4.7	1	2.3	4	6.3	
32	8	7.5	3	7.0	5	7.9	
41	4	3.8	1	2.3	3	4.8	
42	5	4.7	2	4.7	3	4.8	
MIH Extension*							<0.001
I	5	4.7	5	11.6	0	0.0	
II	22	20.8	2	4.7	20	31.7	
III	79	74.5	36	83.7	43	68.3	
Plaque Index							
1 month	10.8	(7.1 - 16.1)	11.2	(7.1 - 16.1)	10.7	(7.1 - 16.1)	
12 months	10.7	(7 - 17.3)	12.8	(8.9 - 17.1)	10	(6.8 - 18)	
24 months	18.9	(11 - 25.7)	17.8	(12 - 27.5)	19	(10 - 24.8)	

*I: Less than a third of affected surface area; II: At least one third but less than two thirds of affected surface area; III: At least two thirds of affected surface area. • *I: manje od jedne trećine zahvaćene površine; II: najmanje jedna trećina, ali manje od dvije trećine zahvaćene površine; III: najmanje dvije trećine zahvaćene površine

Table 2 Domain-specific success rate by demarcated opacity colour
Tablica 2. Stopa uspjeha po domenama prema boji demarkiranog opaciteta

Property	White-Cream demarcated opacity (n= 43*)		Yellow-Brown demarcated opacity (n= 63)		Total (n= 106*)		p-value
	n	%	n	%	n	%	
Surface lustre and texture (A1)							0.960
1 month	43	100	63	100	106	100	
12 months	43	100	60	95.2	103	97.2	
24 months	39	92.9	59	93.7	98	93.3	
Marginal staining (A2)							0.997
1 month	43	100	63	100	106	100	
12 months	43	100	63	100	106	100	
24 months	41	97.6	59	93.7	100	95.2	
Colour match (A3)							0.995
1 month	43	100	63	100	106	100	
12 months	42	97.7	63	100	105	99.1	
24 months	41	97.6	60	95.2	101	96.2	
Caries lesion (B1)**							0.999
1 month	43	100	63	100	106	100	
12 months	42	97.7	62	98.4	104	98.1	
24 months	41	97.6	61	96.8	102	97.1	

*Note • Napomena: At the 24-month follow-up, one patient was lost, resulting in a final sample of 105 teeth. Additionally, domain-specific data were missing in a few cases due to incomplete clinical recording at the final visit. This accounts for variations in the number of observations across outcome measures. • Na kontroli poslije 24 mjeseca jedan je pacijent odustao od praćenja, što je rezultiralo konačnim uzorkom od 105 zuba. Dodatno, u nekoliko slučajeva podatci po pojedinim domenama nedostajali su zbog nepotpunoga kliničkog bilježenja tijekom završnog posjeta. To objašnjava varijacije u broju opažanja među ishodnim mjerama.

** Carious lesions (B1, adapted to demarcated opacity margins). • Karijesne lezije (B1, prilagođeno rubovima demarkiranog opaciteta)

1.

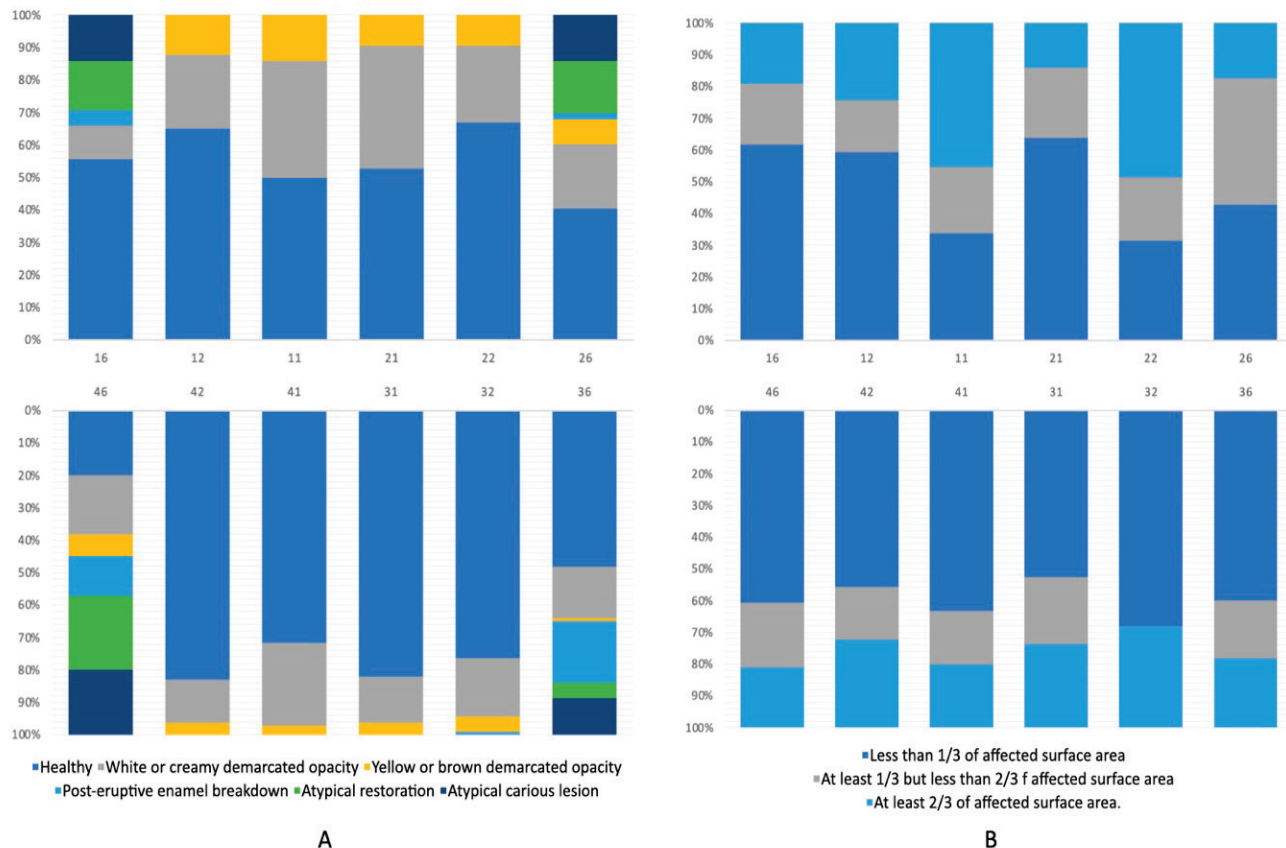


Figure 1 Percentage distribution of clinical characteristics (A) and lesion extension (B) of MIH, by index tooth ($n = 106$ participants), assessed according to the MIH Index (17-19).

Slika 1. Postotna raspodjela kliničkih obilježja (A) i opsega lezije (B) MIH-a prema indeksnom zubi ($n = 106$ sudionika) procijenjena prema indeksu MIH-a (14 – 16)

Table 2 presents the clinical success rates of resin infiltration at 1, 12, and 24 months, according to the colour of the demarcated opacity. At 24 months, the overall success rate of resin infiltration—based on colour match (A3)—was 96.2%.

Secondary Outcomes Data (hypersensitivity, A1, A2, B1, and satisfaction)

Hypersensitivity was assessed in all 106 participants at baseline and at the 1-, 12-, and 24-month follow-ups. At baseline, the median VAS pain score was 8 (IQR 7–9) for both white-cream and yellow-brown opacities. After one month, the median pain decreased to 2 (IQR 1–3) for white-cream opacities and 3 (IQR 0–4) for yellow-brown opacities. At the 12- and 24-month follow-ups, the median pain score was 0 (IQR 0–0) across all groups, indicating no reported pain (Table 3).

For white-cream opacities, surface lustre and texture (A1) achieved a 100% success rate at 12 months, decreasing to 92.9% at 24 months due to seven cases rated clinically unsatisfactory. Outcomes were more stable for yellow-brown opacities, with a 24-month success rate of 93.7%. Marginal staining (A2) showed a 100% success rate at 12 months but declined to 93.7% for yellow-brown opacities at the 24-month follow-up. Carious lesions (B1), adapted to demarcated opacity margins, demonstrated a 24-month success

U tablici 2. prikazane su stope kliničke uspješnosti infiltracije smolom nakon 1, 12 i 24 mjeseca, prema boji demarkiranog opaciteta. Poslije 24 mjeseca ukupna stopa uspjeha infiltracije smolom, na temelju podudarnosti boje (A3), iznosi 96,2 %.

Podatci o sekundarnim ishodima (preosjetljivost, A1, A2, B1 i zadovoljstvo)

Preosjetljivost je procijenjena kod svih 106 sudionika na početku te na kontrolama poslije 1, 12 i 24 mjeseca. Na početku je medijan VAS rezultata boli iznosio 8 (IQR 7 – 9) i za kremasto bijele i za žutosmeđe opacitete. Poslije jednog mjeseca medijan boli smanjio se na 2 (IQR 1 – 3) za kremasto bijele opacitete i na 3 (IQR 0 – 4) za žutosmeđe. Na kontrolama poslije 12 i 24 mjeseca medijan boli iznosio je 0 (IQR 0 – 0) u svim skupinama, što upućuje na izostanak prijavljene boli (tablica 3.).

Za kremasto bijele opacitete, površinski sjaj i tekstura (A1) postigli su stopu uspjeha od 100 % poslije 12 mjeseci, ali smanjila na 92,9 % poslije 24 mjeseca zbog sedam slučajeva ocijenjenih klinički nezadovoljavajućima. Ishodi su bili stabilniji za žutosmeđe opacitete, uz stopu uspjeha od 93,7 % poslije 24 mjeseca. Rubno obojenje (A2) pokazalo je stopu uspjeha od 100 % poslije 12 mjeseci, ali se na kontroli poslije 24 mjeseca smanjilo na 93,7 % za žutosmeđe opacitete. Karijezne lezije (B1), prilagođene rubovima demarkiranih opaci-

Table 3 Hypersensitivity, participant and guardian satisfaction with the colour (aesthetics) achieved through resin infiltration according to the colour of demarcated opacity
Tablica 3. Preosjetljivost te zadovoljstvo sudionika i skrbnika bojom (estetikom) postignutom infiltracijom smolom prema boji demarkiranoga opaciteta

	White-Cream demarcated opacity		Yellow-Brown demarcated opacity		Total		p-value
Hypersensitivity (VAS), median (IQR)							<0.001
Baseline	8	(6 - 8)	8	(7 - 9)	8	(7 - 9)	
1 month	2	(1 - 3)	3	(0 - 4)	2	(0 - 4)	
12 months	0	(0 - 0)	0	(0 - 0)	0	(0 - 0)	
24 months	0	(0 - 0)	0	(0 - 0)	0	(0 - 0)	
Patient satisfaction*, n (%)							0.683
1 month	39	90.7 %	49	77.8 %	88	83.0 %	
12 months	38	88.4 %	56	88.9 %	94	88.7 %	
24 months	38	90.5 %	43	68.3 %	81	76.4 %	
Guardian satisfaction*, n (%)							0.492
1 month	37	86.0 %	47	74.6 %	84	79.2 %	
12 months	37	86.0 %	49	77.8 %	86	81.1 %	
24 months	27	64.3 %	24	38.1 %	51	48.1 %	

Only "very satisfied" and "satisfied" responses are shown. Dissatisfied and very dissatisfied responses were recorded but are not included in the table. At the 24-month follow-up, one patient was lost, resulting in a final sample of 105 teeth.

Prikazani su samo odgovori vrlo zadovoljni i zadovoljni. Odgovori nezadovoljni i vrlo nezadovoljni zabilježeni su, ali nisu uključeni u tablicu. Na kontroli poslije 24 mjeseca jedan je pacijent odustao od praćenja, što je rezultiralo konačnim uzorkom od 105 zuba.

rate of 97.1%, which is consistent with the rate observed at the 12-month follow-up.

All participants and their guardians who completed the 24-month follow-up also completed the satisfaction questionnaire using a four-point Likert scale. Table 3 reports only the number and percentage of respondents who selected "very satisfied" or "satisfied". At the one-month follow-up, patient satisfaction was high, with a median of 90.7% for white-cream opacities and 77.8% for yellow-brown opacities. This overall satisfaction rate rose to 88.7% at 12 months but declined to 76.4% at 24 months. Guardian satisfaction began at 79.2% at one month, remained relatively stable at 81.1% at 12 months, but dropped markedly to 48.1% at 24 months, particularly among cases with yellow-brown opacities (Table 3).

Discussion

This study evaluated the clinical success of resin infiltration in anterior teeth affected by MIH, along with patient-centred outcomes. The findings demonstrated a high overall success rate at 24 months (96.2%). Furthermore, resin infiltration proved effective in controlling hypersensitivity and was well accepted by both participants and their guardians.

The use of the FDI criteria in this study was driven by the need for a standardized and validated tool to assess clinical quality (14), even in minimally invasive interventions such as resin infiltration. Although originally developed to evaluate direct and indirect restorations (14), the FDI criteria can be suitably adapted to assess emerging approaches such as microinvasive treatments, particularly when clinical objectives include improvements in esthetic integration, surface quality, and dental caries prevention. Methods such as spectrophotometry, quantitative light-induced fluorescence, and digital imaging analysis have been used in previous studies to

teta, pokazale su stopu uspjeha poslije 24 mjeseca od 97,1 %, u skladu s onom zabilježenom poslije 12 mjeseci.

Svi sudionici i njihovi skrbnici koji su završili praćenje od 24 mjeseca također su ispunili upitnik o zadovoljstvu primjenom Likertove ljestvice s četiri stupnja. U tablici 3. nalazi se samo broj i postotak ispitanika koji su odabrali odgovore *vrlo zadovoljni* ili *zadovoljni*. Na kontroli poslije jednog mjeseca zadovoljstvo pacijenata bilo je visoko, s medijanom od 90,7 % za kremasto bijele opacitete i 77,8% za žutosmeđe. Ukupna stopa zadovoljstva porasla je na 88,7 % poslije 12 mjeseci, ali smanjila se na 76,4 % poslije 24 mjeseca. Zadovoljstvo skrbnika iznosilo je 79,2 % poslije jednog mjeseca, ostalo je razmjerno stabilno na 81,1 % poslije 12 mjeseci, no zatim se znatno smanjilo na 48,1 % poslije 24 mjeseca, osobito u slučajevima sa žutosmeđim opacitetima (tablica 3.).

Rasprava

U ovom istraživanju procijenjena je klinička uspješnost infiltracije smolom na prednjim zubima zahvaćenima MIH-om, zajedno s ishodima postignutima kod pacijenata. Nalazi su pokazali visoku ukupnu stopu uspjeha poslije 24 mjeseca (96,2 %). Nadalje, infiltracija smolom pokazala se učinkovitom u kontroli preosjetljivosti te je bila dobro prihvaćena i među sudionicima i među njihovim skrbnicima.

Primjena FDI kriterija u ovom istraživanju bila je potaknuta potrebom za standardiziranim i validiranim alatom za procjenu kliničke kvalitete (14) čak i u minimalno invazivnim intervencijama poput infiltracije smolom. Iako su FDI kriteriji izvorno nastali radi procjene izravnih i neizravnih restauracija (14), mogu se odgovarajuće prilagoditi i za procjenu novih pristupa kao što su mikroinvazivni tretmani, osobito kada su klinički ciljevi poboljšanje estetske integracije, kvaliteta površine i prevencija karijesa. U dosadašnjim istraživanjima korištene su metode poput spektrofotometri-

objectively quantify enamel colour changes; however, these techniques may not fully capture the esthetic perception or clinical significance of outcomes. The FDI criteria, though based on calibrated visual assessment, offer a reproducible and clinically meaningful framework that reflects real-world decision-making in paediatric dentistry. To ensure consistency, evaluators were calibrated, and clinical records were reviewed according to operational definitions tailored to resin infiltration cases. Nonetheless, the inherent subjectivity of visual assessment is acknowledged, and future investigations are encouraged to combine objective instrumental methods with validated clinical indices to enhance accuracy, comparability, and relevance to both clinicians and participants.

In vitro studies have explored various characteristics of resin infiltration, including colour stability (24), penetration into sound and caries-affected enamel (25,26), and surface microhardness (27). These properties may be influenced by the enamel substrate or opacity type, as well as by the application protocol. In the present study, demarcated opacities were treated using resin infiltration strictly in accordance with the manufacturer's recommended protocol. However, several clinical modifications have been proposed to optimize the masking effect of the infiltrant. These include the use of bleaching agents or microabrasion prior to infiltration, prolonged etching and/or infiltration times, selective surface removal, and the use of transillumination to guide both lesion reduction and resin application (28). A recent systematic review and meta-analysis evaluated the esthetic effectiveness of such modifications in the management of MIH-related opacities (25). Their findings indicate that supplementing the standard protocol with additional interventions may significantly improve lesion masking, particularly in yellow-brown opacities, which are typically more challenging to manage (28). Nonetheless, the review emphasized the limited methodological robustness of many included studies and highlighted potential biological risks, especially when more invasive or extended protocols are adopted. Consequently, high-quality clinical trials are still needed to establish definitive recommendations (28).

Some authors have proposed applying sodium hypochlorite (NaOCl) for up to 2 minutes prior to hydrochloric acid (HCl) etching to remove excess proteins in hypomineralized enamel and enhance resin-infiltrant penetration (29). However, the clinical benefit and superiority of this additional step remain unclear, raising concerns that NaOCl may diffuse through enamel and dentine, reach pulpal tissues at toxic concentrations, and disrupt pulpal homeostasis (6). A pilot study by Alghawe and Raslan demonstrated that multiple HCl etching cycles resulted in improved coverage and colour match with sound enamel when infiltrating white-cream and yellow-brown demarcated opacities, respectively (10). Despite limited clinical data, *in vitro* studies have indicated that HCl may diffuse through enamel and influence odontoblast differentiation, thereby compromising the defensive capacity of the dentine-pulp complex, including matrix formation and mineralization in response to potentially aggressive stimuli (30).

Colour is one of the most clinically relevant esthetic properties. The findings of the present study demonstrated

je, kvantitativne fluorescencije inducirane svjetlom i analize digitalnih snimki radi objektivnog kvantificiranja promjena boje cakline; no te tehnike možda ne obuhvaćaju potpuno estetsku percepciju ili kliničku važnost ishoda. FDI kriteriji, iako se temelje na kalibriranoj vizualnoj procjeni, nude obnovljiv i klinički smislen okvir koji odražava donošenje odluka u stvarnoj kliničkoj praksi dječje stomatologije. Radi osiguravanja dosljednosti, procjenjivači su kalibrirani, a klinički zapisi pregledani prema operativnim definicijama prilagođenima slučajevima infiltracije smolom. Unatoč tomu, prepoznaje se inherentna subjektivnost vizualne procjene te se u budućim istraživanjima preporučuje kombinirati objektivne instrumentalne metode s validiranim kliničkim indeksima radi povećanja točnosti, usporedivosti i relevantnosti i za kliničare i za sudionike.

U istraživanjima *in vitro* ispitane su različite značajke infiltracije smolom, uključujući stabilnost boje (24), penetraciju u zdravu caklinu i caklinu zahvaćenu karijesom (25,26) te površinsku mikrotvrdoću (27). Ta svojstva mogu biti pod utjecajem supstrata cakline ili tipa opaciteta te protokola primjene. U ovoj su studiji demarkirani opaciteti liječeni infiltracijom smolom strogo u skladu s protokolom koji preporučuje proizvođač. Međutim, predložene su različite kliničke modifikacije radi optimizacije učinka maskiranja infiltrata. One uključuju primjenu sredstava za izbjeljivanje ili mikroabrasije prije infiltracije, produljeno vrijeme jetkanja i/ili infiltracije, selektivno uklanjanje površine te primjenu transiluminacije za usmjeravanje redukcije lezije i aplikacije smole (28). U nedavnome sustavnom pregledu i metaanalizi procijenjena je estetska učinkovitost takvih modifikacija u zbrinjavanju opaciteta povezanih s MIH-om (28). Ti nalazi pokazuju da nadopuna standardnoga protokola dodatnim intervencijama može značajno poboljšati maskiranje lezija, osobito kod žutosmeđih opaciteta koje je obično zahtjevnije zbrinjavati (28). Ipak, u pregledu je istaknuta ograničena metodološka robusnost mnogih uključenih studija te potencijalni biološki rizici, osobito kada se primjenjuju invazivniji ili produljeni protokoli. Slijedom toga, i dalje su potrebna visokokvalitetna klinička ispitivanja kako bi se postavile konačne preporuke (25).

Neki autori predložili su primjenu natrijeva hipoklorita (NaOCl) do 2 minute prije jetkanja klorovodičnom kiselinom (HCl) radi uklanjanja viška proteina u hipomineraliziranoj caklini i poboljšanja penetracije infiltrata (29). No klinička korist i superiornost toga dodatnog postupka ostaju nejasne, uz zabrinutost da NaOCl može difuzijom proći kroz caklinu i dentin, dosegnuti pulpna tkiva u toksičnim koncentracijama te narušiti pulpnu homeostazu (6). U pilot-studiji Alghawe i Raslana pokazali su da su višestruki ciklusi jetkanja HCl-om rezultirali poboljšanim pokrivanjem i boljom podudarnošću boje sa zdravom caklinom pri infiltraciji kremasto bijelih, odnosno žutosmeđih demarkiranih opaciteta (10). Unatoč ograničenim kliničkim podacima, u studijama *in vitro* ističe se da HCl može difuzijom proći kroz caklinu i utjecati na diferencijaciju odontoblasta, čime se, kao odgovor na potencijalno agresivne podražaje, kompromitira obrambena sposobnost dentinsko-pulpnoga kompleksa, uključujući stvaranje matriksa i mineralizaciju (30).

a high degree of colour match between the resin infiltrant and adjacent enamel, particularly in white-cream demarcated opacities, which is consistent with the results reported by Alghawe and Raslan (10). The initial colour of the demarcated opacity appears to significantly influence the final esthetic outcome (10). Yellow-brown opacities are characterized by lower mineral content and higher organic content than white-cream opacities (31). The elevated protein content can obstruct submicroscopic porosities within the enamel, thus limiting resin infiltrant penetration and adversely affecting colour match (32). In a clinical study by Mazur et al. the application of resin infiltrant led to a positive change in both colour and translucency of teeth with enamel developmental defects, with a mean colour difference of 2.21 (95% CI: 1.728–2.695) between pre- and post-treatment values (22). Similarly, in a study by Brescia, 66.67% of restorations were rated “clinically excellent” and only 4.2% “clinically insufficient” following resin infiltration (23). These findings suggest that resin infiltrant can achieve an adequate and stable colour match over time, even in enamel with unfavourable structural characteristics.

In the present study, the resin infiltrant demonstrated over 90% success in relation to esthetic properties (Domain A). The results indicated that the infiltrant achieved a surface lustre and texture comparable to the adjacent dental structure, irrespective of the colour of the demarcated opacity. These esthetic features are produced by light reflection from the treated enamel surface and are largely dependent on the material properties and surface finish achieved after polishing (33). Marginal staining is influenced by the adhesive behavior of the material and patient-related factors such as saliva composition, plaque accumulation, dietary habits, and oral hygiene. In the present study, these variables were managed through standardized instructions and clinical monitoring, which may explain the favorable outcomes observed in this domain.

Recent evidence, including a meta-analysis, indicates significant colour improvement and high success rates up to two years (9). Consistently, Mazur et al. reported a mean colour difference of 2.21 between pre- and post-treatment values (22). These findings reinforce the concept of resin infiltration as a viable microinvasive approach for improving enamel esthetics in MIH-affected teeth, despite challenges related to lesion depth and colour variability. This aligns with the present study, in which over 90% of cases achieved a satisfactory colour match at the 24-month follow-up.

Although hypersensitivity is more frequently reported in molars (34), the anterior teeth affected by MIH may also present with moderate-to-severe sensitivity. In the present study, all included teeth exhibited baseline hypersensitivity, as this constituted one of the inclusion criteria. Consequently, the sample does not reflect an epidemiological distribution of hypersensitivity in anterior MIH-affected teeth. Furthermore, as the study was conducted in a university-based pediatric dental clinic, a higher proportion of symptomatic cases may have been referred for specialist care. These factors may account for the elevated baseline VAS scores observed. The results suggest that application of a resin infiltrant is ef-

Boja je jedno od klinički najrelevantnijih estetskih svojstava. Nalazi u ovom istraživanju pokazali su visok stupanj podudarnosti boje između infiltrata i susjedne cakline, osobito kod kremasto bijelih demarkiranih opaciteta, što je u skladu s rezultatima o kojima su izvjestili Alghawe i Raslan (10). Čini se da početna boja demarkiranoga opaciteta značajno utječe na konačni estetski ishod (10). Žutosmeđi opaciteti imaju niži mineralni sadržaj i viši organski u usporedbi s onima kremasto bijelima (31). Povišeni udio proteina može opstruirati submikroskopske porozitete u caklini, ograničavajući penetraciju infiltrata i nepovoljno utječući na podudarnost boje (32). U kliničkoj studiji Mazura i suradnika primjena infiltrata rezultirala je pozitivnom promjenom i boje i translucencijom zuba s razvojnim defektima cakline, uz prosječnu razliku boje od 2,21 (95 % CI: 1,728 – 2,695) između vrijednosti prije i poslije liječenja (22). Slično tomu, u studiji Bresciae 66,67 % restauracija ocijenjeno je *klinički izvrsnima*, a samo 4,2 % *klinički nedostatnima* nakon infiltracije smolom (23). Ti nalazi upućuju na to da se infiltratom može postići odgovarajuća i stabilna podudarnost boje tijekom vremena, čak i u caklini s nepovoljnim strukturnim obilježjima.

U ovoj studiji infiltrat je pokazao uspjeh veći od 90 % u odnosu prema estetskim svojstvima (domena A). Rezultati su pokazali da je infiltrat postigao površinski sjaj i teksturu usporedivu sa susjednom zubnom strukturom, neovisno o boji demarkiranoga opaciteta. Ta se estetska obilježja stvaraju refleksijom svjetlosti s tretirane površine cakline te u velikoj mjeri ovise o svojstvima materijala i završnoj obradi poliranjem (30). Rubno obojenje ovisi o adhezivnom ponašanju materijala i čimbenicima povezanim s pacijentom, poput sastava sline, nakupljanja plaka, prehrambenih navika i oralne higijene. U ovoj su studiji te varijable bile kontrolirane standardiziranim uputama i kliničkim praćenjem, što može objasniti povoljne ishode zabilježene u toj domeni.

Noviji dokazi, uključujući metaanalizu, upućuju na znatno poboljšanje boje i visoku stopu uspjeha do dvije godine (9). U skladu s tim, Mazur i suradnici izvjestili su o prosječnoj razlici boje od 2,21 između vrijednosti prije i poslije liječenja (22). Ti nalazi podupiru koncepciju infiltracije smolom kao održiv mikroinvazivni pristup za poboljšanje estetike cakline na zubima zahvaćenima MIH-om, unatoč izazovima povezanim s dubinom lezije i varijabilnošću boje. To je u skladu s ovom studijom u kojoj se u više od 90 % slučajeva postigla zadovoljavajuća podudarnost boje na kontroli poslije 24 mjeseca.

Iako se preosjetljivost češće prijavljuje na kutnjacima (34), prednji zubi zahvaćeni MIH-om također mogu biti umjereni do znatno osjetljivi. U ovoj su studiji svi uključeni zubi bili početno preosjetljivi zato što je to bio jedan od kriterija za uključivanje. Slijedom toga, uzorak ne pokazuje epidemiološku raspodjelu preosjetljivosti na prednjim zubima zahvaćenima MIH-om. Nadalje, budući da je studija provedena u Sveučilišnoj klinici dječje stomatologije, veći udio simptomatskih slučajeva mogao je biti upućen na specijalističku skrb. Ti čimbenici mogu objasniti povišene početne VAS vrijednosti. Rezultati pokazuju da je primjena infiltrata učinkovita u kontroli preosjetljivosti povezane s MIH-om. Primjena

fective in controlling hypersensitivity associated with MIH. The application of a low-viscosity resin creates a physical barrier that prevents thermal, tactile, or chemical stimuli from reaching nociceptors at the dentine–pulp interface (35). A systematic review by Somani et al. demonstrated that various topical agents and low-power laser therapy can also reduce MIH-associated hypersensitivity (5).

The resin infiltrant's success in relation to biological properties (Domain B) exceeded 95%. Low incidence of carious lesions may be attributed to the polished surface and the anatomical location of the infiltrated, demarcated opacities, which are easily accessible for oral hygiene and are not typically prone to biofilm accumulation. Moreover, the oral hygiene instructions provided to participants at baseline and reinforced during follow-up appointments may have further contributed to this outcome.

In this study, patient- and family-centred factors were considered, which are essential when evaluating dental treatment success. Both participants and guardians reported high satisfaction with tooth colour (esthetics) one month after resin infiltrant application. This outcome may be attributed to the material's ability to mask demarcated opacities (7,9,10,28). However, satisfaction declined over the two-year period, particularly for yellow-brown demarcated opacities. This trend was more pronounced among guardians than among participants, suggesting that caregivers may develop higher esthetic expectations or more critical perspectives over time. These findings align with those of Alghawe and Raslan, who reported that the colour of the opacity influenced parental satisfaction (10). According to their study, average satisfaction scores were higher for white-cream demarcated opacities than for yellow-brown ones treated with resin infiltrant (10). This apparent discrepancy highlights a potential misalignment between traditional clinical success metrics and the subjective perceptions of treatment outcomes over time. Contributing factors may include the potential for infiltrant discolouration (23) and the evolution of esthetic expectations as children age. Additionally, although all satisfaction data were collected at the 24-month follow-up, inherent limitations of subjective measures, such as the Likert scale, and the study's retrospective nature may have influenced the results. These findings underscore the importance of integrating patient-centred outcomes alongside conventional clinical assessments when evaluating the long-term success of dental treatments.

Esthetic concerns associated with MIH, particularly when affecting anterior teeth, can significantly impact children's oral health-related quality of life (OHRQoL), including emotional well-being, self-esteem, and social interaction (2,36-38). As highlighted in recent literature, children with visible enamel opacities may avoid smiling or engaging socially, leading to psychological distress and negatively affecting both their own quality of life and that of their families (2,38). These impacts support the use of minimally invasive treatments that aim not only to improve the clinical appearance of affected teeth, but also to enhance psychosocial outcomes. Although OHRQoL was not directly measured, the satisfaction trends observed may indirectly reflect these psychosocial

smole niske viskoznosti stvara fizičku barijeru koja sprječava da termički, taktilni ili kemijski podražaji dosegnu nociceptore na dentinsko-pulpnom spoju (35). Sustavni pregled Somanija i suradnika pokazao je da različita topikalna sredstva i laserska terapija niske snage također mogu smanjiti preosjetljivost povezanu s MIH-om (5).

Uspjeh infiltrata u odnosu prema biološkim svojstvima (domena B) premašio je 95 %. Niska učestalost karijesnih lezija može se pripisati poliranoj površini i anatomske lokalizaciji infiltriranih demarkiranih opaciteta koji su bili lako dostupni za održavanje oralne higijene i obično nisu sklони nakupljanju biofilma. Nadalje, upute o oralnoj higijeni dane sudionicima na početku i njihovo ponavljanje tijekom kontrolnih pregleda mogle su dodatno pridonijeti tom ishodu.

U ovom su istraživanju uzeti u obzir čimbenici usmjereni na pacijenta i obitelj koji su ključni u procjeni uspješnosti stomatološkog liječenja. I sudionici i skrbnici izvijestili su o velikom zadovoljstvu bojom (estetikom) mjesec dana poslije primjene infiltrata. Taj se ishod može pripisati svojstvu materijala da maskira demarkirane opacitete (7, 9, 10, 28). Međutim, zadovoljstvo se tijekom dvogodišnjeg razdoblja smanjivalo, osobito kad je riječ o žutosmeđim demarkiranim opacitetima. Taj je trend bio izraženiji među skrbnicima nego među sudionicima, što upućuje da se kod skrbnika s vremenom mogu pojaviti veća estetska očekivanja ili kritičnije stajalište o ishodu. Ti se nalazi podudaraju s nalazima Alghawe i Raslana koji su izvijestili da boja opaciteta utječe na zadovoljstvo roditelja/skrbnika (10). Prema podacima iz njihove studije prosječne ocjene zadovoljstva bile su više za kremasto bijele demarkirane opacitete nego za žutosmeđe tretirane infiltratom (10). Ta razlika upućuje na moguću nesklad između tradicionalnih kliničkih mjera uspješnosti i subjektivnih percepcija ishoda liječenja tijekom vremena. Doprinosni čimbenici mogu uključivati mogućnost diskoloracije infiltrata (23) i promjenu estetskih očekivanja kako djeca odrastaju. Dodatno, iako su svi podatci o zadovoljstvu prikupljeni na kontroli poslije 24 mjeseca, inherentna ograničenja subjektivnih mjera, poput Likertove ljestvice te retrospektivna priroda studije, mogla su utjecati na rezultate. Ti nalazi ističu važnost integriranja ishoda postignutih kod pacijenta, uz konvencionalne kliničke procjene pri vrjednovanju dugoročne uspješnosti stomatoloških tretmana.

Estetske tegobe povezane s MIH-om, osobito kada zahvaćaju prednje zube, mogu značajno utjecati na oralno-zdravstvenu kvalitetu života (OHRQoL) djece, uključujući emocionalno blagostanje, samopoštovanje i socijalnu interakciju (2, 36 – 38). Kako je istaknuto u novijoj literaturi, djeca s vidljivim opacitetima cakline mogu izbjegavati smijanje ili socijalno uključivanje, što može završiti psihološkom patnjom i negativno utjecati na njihovu kvalitetu života i na kvalitetu života njihovih obitelji (2, 38). Ti učinci podupiru primjenu minimalno invazivnih tretmana koji ne teže samo poboljšanju kliničkoga izgleda zahvaćenih zuba, nego i poboljšanju psihosocijalnih ishoda. Iako OHRQoL nije izravno mjereno, opaženi trendovi zadovoljstva mogu neizravno odražavati te psihosocijalne dimenzije. U budućim istraživanjima trebalo bi se razmotriti uključivanje validiranih instrumenata OHRQoL-a da bi se bolje obuhvatili is-

dimensions. Future research should consider incorporating validated OHRQoL instruments to better capture patient-centred outcomes following the resin infiltration therapy.

The present study has certain limitations, and its findings should therefore be interpreted and generalized with caution. Although standardized scales and criteria were employed, a degree of subjectivity may have influenced the evaluation of esthetic properties and satisfaction outcomes reported by participants and their guardians. Future investigations may benefit from integrating quantitative approaches, such as artificial intelligence, to assess changes in the biological, functional, and aesthetic properties of restorations with greater precision. The depth of demarcated opacity was not accounted for in the present analysis, despite its potential relevance to the clinical performance of resin infiltration (39). Additionally, although all participants completed the 24-month follow-up, domain-specific clinical data were missing in some cases due to incomplete documentation during the final visit, which is an inherent limitation of retrospective data collection. Finally, the FDI index was originally designed to evaluate direct restorations. In this study, Domain B1 was adapted to the context of resin infiltration, with 'restoration margins' interpreted as margins of demarcated opacities. Although this adaptation enabled systematic recording of biological outcomes, it has not yet been formally validated and warrants further investigation (14).

Conclusion

Resin infiltration demonstrated high clinical success in anterior teeth affected by MIH over a two-year period, thus leading to improved aesthetics and colour match. Although initial satisfaction levels were high, satisfaction declined over time, particularly in teeth with yellow-brown opacities. These findings support the use of resin infiltration as a conservative treatment option in children and adolescents; however, its long-term effectiveness may vary with the structural and optical characteristics of the enamel demarcated opacity.

Conflict of interest: None declared

Author's contribution: K.J.P.O. - Conceptualisation, methodology, data collection, drafting of the initial manuscript; A. L.F. - Conceptualisation, methodology, drafting of the initial manuscript. D.F Rojas-Gualdrón: Methodology, data analysis, data management, drafting of the initial manuscript, and visualisation; J.D.M. - methodology, data collection; D.G.B. and L.S.P. - Contributed equally to the methodology; critically reviewed the manuscript and made important intellectual contributions to the final version; M. R. - Conceptualisation, project administration, methodology, data analysis, data management, drafting of the initial manuscript, and visualisation. All authors reviewed and approved the final version of the manuscript.

hodi postignuti kod pacijenata nakon terapije infiltracijom smolom.

Ovo istraživanje ima određena ograničenja te njegove nalaze treba tumačiti i generalizirati s oprezom. Iako su primijenjene standardizirane ljestvice i kriteriji, određeni stupanj subjektivnosti mogao je utjecati na procjenu estetskih svojstava i ishoda zadovoljstva prema riječima sudionika i njihovih skrbnika. Autori budućih istraživanja mogli bi imati korist od integriranja kvantitativnih pristupa, primjerice umjetne inteligencije, za precizniju procjenu promjena bioloških, funkcijskih i estetskih svojstava restauracija. U ovoj analizi nije uzeta u obzir dubina demarkiranoga opaciteta, unatoč njezinoj potencijalnoj važnosti za kliničku učinkovitost infiltracije smolom (39). Dodatno, iako su svi sudionici završili 24-mjesečno praćenje, u pojedinim slučajevima nedostajali su podatci za specifične domene zbog nepotpune dokumentacije na završnom posjetu, što je inherentno ograničenje retrospektivnog prikupljanja podataka. Konačno, FDI indeks izvorno je osmišljen za procjenu izravnih restauracija. U ovoj studiji domena B1 prilagođena je kontekstu infiltracije smolom, pri čemu su *rubovi restauracije* interpretirani kao rubovi demarkiranih opaciteta. Iako je ova prilagodba omogućila sustavno bilježenje bioloških ishoda još nije formalno validirana te zahtijeva daljnja istraživanja (13).

Zaključak

Infiltracija smolom pokazala je visoku kliničku uspješnost na prednjim zubima zahvaćenima MIH-om tijekom dvogodišnjeg razdoblja, uz poboljšanu estetiku i podudarnost boje. Iako su početne razine zadovoljstva bile visoke, zadovoljstvo se s vremenom smanjilo, osobito na zubima sa žutosmeđim opacitetima. Ovi nalazi podupiru infiltraciju smolom kao konzervativnu terapijsku opciju za djecu i adolescente, no njezina dugoročna učinkovitost može varirati ovisno o strukturnim i optičkim obilježjima demarkiranoga opaciteta cakline.

Sukob interesa: Nije prijavljen.

Doprinos autora: K. J., P. O. – konceptualizacija, metodologija, prikupljanje podataka, pisanje teksta; A. L. F. – konceptualizacija, metodologija, pisanje teksta; D. F., R. G. – metodologija, analiza podataka, upravljanje podacima, pisanje teksta i vizualizacija; J. D. M. – metodologija, prikupljanje podataka; D. G. B., L. S. P. – doprinos metodologiji, kritički pregled teksta i doprinos konačnoj verziji teksta; M. R. – konceptualizacija, administracija projekta, metodologija, analiza podataka, upravljanje podacima, pisanje teksta i vizualizacija. Svi su autori pregledali tekst i odobrili konačnu verziju.

Sažetak

Cilj: Željela se procijeniti dvogodišnja klinička uspješnost infiltracije smolom na prednjim zubima zahvaćenima molarno-incizivnom hipomineralizacijom (MIH), s naglaskom na estetiku, kontrolu preosjetljivosti te zadovoljstvo pacijenata prema njihovim riječima. **Metodologija i metode:** Ovim retrospektivnim opservacijskim istraživanjem bilo je obuhvaćeno 106 trajnih sjekutića zahvaćenih MIH-om djece u dobi od 7 do 10 godina liječene u sveučilišnoj pedijatrijskoj stomatološkoj klinici. Primarni ishod bio je estetsko poboljšanje (podudarnost boje, FDI kriteriji). Sekundarni ishodi obuhvaćali su preosjetljivost prema riječima pacijenata (VAS), dodatna estetska i biološka svojstva prema FDI indeksu te zadovoljstvo pacijenta i skrbnika. Estetska i biološka svojstva, preosjetljivost i zadovoljstvo bilježeni su 1, 12 i 24 mjeseca poslije infiltracije smolom demarkiranih zamućenja. Podatci su analizirani deskriptivnom i komparativnom statistikom. **Rezultati:** Dvogodišnja klinička stopa uspjeha infiltracije smolom iznosila je 96,2 % na temelju podudarnosti boje. Rezultati preosjetljivosti (VAS 0–10) smanjili su se s 8 na početku na 0 poslije 24 mjeseca. Sve stope uspjeha za estetska i biološka svojstva, procijenjene FDI indeksom, premašile su 90 %. Zadovoljstvo pacijenata i skrbnika bilo je visoko poslije 1 i 12 mjeseci, ali se smanjilo poslije 24 mjeseca, osobito u kad je riječ o žutosmedim demarkiranim zamućenjima. **Zaključak:** Infiltracija smolom pokazala je visoku učinkovitost u poboljšanju estetske integracije i podudarnosti boje na prednjim zubima zahvaćenima MIH-om, uz visoko početno zadovoljstvo pacijenata i skrbnika.

Zaprimljen: 4. listopada 2025.**Prihvaćen:** 20. siječnja 2026.**Adresa za dopisivanje**

Manuel Restrepo
 Facultad de Odontología. Universidad CES
 Calle 10A #22-04
 Medellín, Kolumbija
 mrestrepo@ces.edu.co

MeSH pojmovi: hipomineralizacija kutnja; osjetljivost dentina; promjena boje zuba; cementne smole; kompozitne smole; dentalna estetika; dijete
Autorske ključne riječi: konzervativno liječenje; stomatološka skrb; razvojni nedostaci zubne cakline; prodirane smole

References

- Weerheijm KL, Jälevik B, Alaluusua S. Molar-incisor hypomineralisation. *Caries Res.* 2001 Sep;35(5):390-1.
- Bussaneli DG, Vieira AR, Santos-Pinto L, Restrepo M. Molar-incisor hypomineralisation: an updated view for aetiology 20 years later. *Eur Arch Paediatr Dent.* 2022 Feb;23(1):193-8.
- de Farias AL, Rojas-Gualdrón DF, Giroto Bussaneli D, Santos-Pinto L, Mejía JD, Restrepo M. Does molar-incisor hypomineralization (MIH) affect only permanent first molars and incisors? New observations on permanent second molars. *Int J Paediatr Dent.* 2022 Jan;32(1):1-10.
- Lygidakis NA, Garot E, Somani C, Taylor GD, Rouas P, Wong FSL. Best clinical practice guidance for clinicians dealing with children presenting with molar-incisor-hypomineralisation (MIH): an updated European Academy of Paediatric Dentistry policy document. *Eur Arch Paediatr Dent.* 2022 Feb;23(1):3-21.
- 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 Feb;23(1):39-64.
- de Farias AL, Rojas-Gualdrón DF, Mejía JD, Bussaneli DG, Santos-Pinto L, Restrepo M. Survival of stainless-steel crowns and composite resin restorations in molars affected by molar-incisor hypomineralization (MIH). *Int J Paediatr Dent.* 2022 Mar;32(2):240-50.
- Borges AB, Caneppele TM, Masterson D, Maia LC. Is resin infiltration an effective esthetic treatment for enamel development defects and white spot lesions? A systematic review. *J Dent.* 2017 Jan; 56:11-8.
- Paris S, Schwendicke F, Keltsch J, Dörfer C, Meyer-Lueckel H. Masking of white spot lesions by resin infiltration in vitro. *J Dent.* 2013 Sep;41 Suppl 5:e28-34.
- Hoan NQ, Huyen NP, Son DC, Thien DH, Sabet CJ, Ngoc VTN. Effectiveness of resin infiltration in the management of anterior teeth affected by molar incisor hypomineralisation (MIH): A systematic review and meta-analysis. *J Dent.* 2024 Oct; 149:105254.
- Alghawe S, Raslan N. Management of permanent incisors affected by Molar-Incisor-Hypomineralisation (MIH) using resin infiltration: a pilot study. *Eur Arch Paediatr Dent.* 2024 Feb;25(1):105-16.
- Athayde GDS, Reis PPGD, Jorge RC, Americano GCA, Fidalgo TKDS, Soviero VM. Impact of masking hypomineralization opacities in anterior teeth on the esthetic perception of children and parents: A randomized controlled clinical trial. *J Dent.* 2022 Aug; 123:104168.
- Lara JS, Restrepo M, Ureña-Cirett JL, Rodrigues J, Bim NA, Campoi BB, et al. Knowledge and Attitudes of Dental Professionals and Students on MIH: A Scoping Review. *Acta Stomatol Croat.* 2025 Sep;59(3):247-61.
- von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening of Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *J Clin Epidemiol.* 2008 Apr;61(4):344-9.
- Hickel R, Mesinger S, Opdam N, Loomans B, Frankenberger R, Cobić T. Revised FDI criteria for evaluating direct and indirect dental restorations-recommendations for its clinical use, interpretation, and reporting. *Clin Oral Investig.* 2023 Jun;27(6):2573-92.
- Santos-Pinto L, Fragelli CMB, Giroto Bussaneli D, Restrepo M, Jeremias F. Real-world evidence in the context of molar incisor hypomineralization: A new perspective. *Int J Paediatr Dent.* 2021 Jul;31(4):483-5.
- Arslanagić A, Marković N, Bajrić E, Burnazović Ristić L. Demarcated Opacities as Predictors of Progression of the Molar Incisor Hypomineralisation: a Pilot Study. *Acta Stomatol Croat.* 2020 Dec;54(4):420-30.
- Ghanim A, Silva MJ, Elfrink MEC, Lygidakis NA, Mariño RJ, Manton DJ. Molar incisor hypomineralisation (MIH) training manual for clinical field surveys and practice. *Eur Arch Paediatr Dent.* 2017 Aug;18(4):225-42.
- Ghanim A, Elfrink M, Weerheijm K, Mariño R, Manton D. A practical method for use in epidemiological studies on enamel hypomineralisation. *Eur Arch Paediatr Dent.* 2015 Jun;16(3):235-46.
- Ghanim A, Mariño R, Manton DJ. Validity and reproducibility testing of the Molar Incisor Hypomineralisation (MIH) Index. *Int J Paediatr Dent.* 2019 Jan;29(1):6-13.
- World Health Organization. *Oral Health Surveys: basic methods.* 5th ed. Geneva: WHO; 2013.
- O'Leary TJ, Drake RB, Naylor JE. The plaque control record. *J Periodontol.* 1972 Jan;43(1):38.
- Mazur M, Westland S, Guerra F, Corridore D, Vichi A, Maruotti A, et al. Objective and subjective esthetic performance of icon® treatment for enamel hypomineralization lesions in young adolescents: A retrospective single center study. *J Dent.* 2018 Jan; 68:104-8.
- Brescia AV, Montesani L, Fusaroli D, Docimo R, Di Gennaro G. Management of Enamel Defects with Resin Infiltration Techniques: Two Years Follow Up Retrospective Study. *Children (Basel).* 2022 Sep;9(9):1365.
- Hallgren K, Akyalcin S, English J, Tufekci E, Paravina RD. Color Properties of Demineralized Enamel Surfaces Treated with a Resin Infiltration System. *J Esthet Restor Dent.* 2016 Oct;28(5):339-46.
- Min JH, Inaba D, Kwon HK, Chung JH, Kim BI. Evaluation of penetration effect of resin infiltrant using optical coherence tomography. *J Dent.* 2015 Jun;43(6):720-5.
- Paris S, Meyer-Lueckel H, Cölfen H, Kielbassa AM. Resin infiltration of artificial enamel caries lesions with experimental light curing resins. *Dent Mater J.* 2007 Jul;26(4):582-8.
- Paris S, Schwendicke F, Seddig S, Müller WD, Dörfer C, Meyer-Lueckel H. Micro-hardness and mineral loss of enamel lesions after infiltration with various resins: influence of infiltrant composition and application frequency in vitro. *J Dent.* 2013 Jun;41(6):543-8.
- Prado NA, Jorge RC, Moreira RF, Effenberger S, Cebula M, Fidalgo TKDS, et al. Does the application protocol influence the masking effect of resin infiltration on MIH opacities? Systematic review and meta-analysis. *J Dent.* 2025 Apr; 155:105617.
- Crombie F, Manton D, Palamara J, Reynolds E. Resin infiltration of developmentally hypomineralised enamel. *Int J Paediatr Dent.* 2014 Jan;24(1):51-5.

30. Mendes Soares IP, Anovazzi G, Anselmi C, Paris S, Hebling J, de Souza Costa CA. Response of pulp cells to resin infiltration of enamel white spot-like lesions. *Dent Mater.* 2021 Jun;37(6): e329-40.
31. Elhennawy K, Manton DJ, Crombie F, Zaslansky P, Radlanski RJ, Jost-Brinkmann PG, et al. Structural, mechanical and chemical evaluation of molar-incisor hypomineralization-affected enamel: A systematic review. *Arch Oral Biol.* 2017 Nov; 83:272-81.
32. Shellis RP, Hallsworth AS, Kirkham J, Robinson C. Organic material and the optical properties of the dark zone in caries lesions of enamel. *Eur J Oral Sci.* 2002 Oct;110(5):392-5.
33. Kakaboura A, Fragouli M, Rahiotis C, Silikas N. Evaluation of surface characteristics of dental composites using profilometry, scanning electron, atomic force microscopy and gloss-meter. *J Mater Sci Mater Med.* 2007 Jan;18(1):155-63.
34. Raposo F, de Carvalho Rodrigues AC, Lia ÉN, Leal SC. Prevalence of Hypersensitivity in Teeth Affected by Molar-Incisor Hypomineralization (MIH). *Caries Res.* 2019 Jun;53(4):424-30.
35. Dionysopoulos D, Gerasimidou O, Beltes C. Dentin Hypersensitivity: Etiology, Diagnosis and Contemporary Therapeutic Approaches—A Review in Literature. *Appl Sci.* 2023 Nov; 13:11632.
36. Dantas-Neta NB, Moura LF, Cruz PF, Moura MS, Paiva SM, Martins CC, et al. Impact of molar-incisor hypomineralization on oral health-related quality of life in schoolchildren. *Braz Oral Res.* 2016 Oct;30(1): e117.
37. Fragelli C, Barbosa TS, Bussaneli DG, Restrepo M, Cordeiro RCL, Santos-Pinto L. Aesthetic perception in children with molar incisor hypomineralization. *Eur Arch Paediatr Dent.* 2021 Apr;22(2):227-34.
38. Lima MDM, Moura LFAD, Paiva SM, Lima CCB, Moura MS, Paschoal MAB. Impact of Molar Incisor Hypomineralisation on Quality of Life. *Monogr Oral Sci.* 2024 Jun; 32:79-87.
39. Marouane O, Chtioui F. Transillumination-aided infiltration: A diagnostic concept for treating enamel opacities. *J Esthet Restor Dent.* 2020 Jul;32(5):451-6.