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**Review Article**

# Injectable Composite Resin in Orthodontics: A Novel Approach for Optimized Smile Aesthetics

**Qinghuang Tang[1], Alanna Mears[1], Kany Bonnaire[1]***

[1]Department of Orthodontics, School of Dental Medicine, University of Pennsylvania, Philadelphia, PA 19104, USA.

***E-mail** ✉ Kanybannaire@outlook.com

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## ABSTRACT

The injection moulding technique (IMT) offers a minimally invasive approach for restorative dentistry by allowing thin, flowable composite material to be applied into a stable, transparent silicone index that serves as a customized mould. The composite's fluidity ensures complete adaptation to the mould and intimate integration with the tooth surface, often avoiding the need for any enamel preparation and maintaining tooth integrity. The technique employs a conventional etch-and-rinse protocol and is reproducible across cases. IMT is particularly advantageous following orthodontic treatment, where small adjustments in tooth shape or alignment are necessary to achieve optimal aesthetics and function. Combining restorative procedures with orthodontic care is essential for predictable, long-lasting results, especially in interdisciplinary cases. This retrospective study reports on two pediatric patients (12.6 and 12.3 years old) who received conservative restorations of maxillary lateral incisors using IMT, both before and after orthodontic treatment. The procedure served as a temporary solution until the patients could receive definitive all-ceramic veneers.

The IMT was effective for correcting minor diastemas, small interdental gaps, and slightly retruded teeth. In cases with irregular tooth sizes or morphologies, this additive approach allowed precise adaptation without invasive tooth preparation. The technique provided a practical solution for improving tooth form and alignment in a minimally invasive manner. IMT is a valuable tool for pediatric orthodontic patients at both the initiation and completion of treatment. It assists clinicians in addressing tooth size discrepancies and shape anomalies while integrating seamlessly with orthodontic finishing. The combination of IMT with a digital workflow enables same-appointment delivery of thermo-printed retainers, reducing treatment time and improving clinical efficiency. Overall, this method enhances both functional and aesthetic outcomes in integrated orthodontic–restorative treatment.

**Keywords:** Injection moulding technique, Injectable composite, High-filled composite, Silicone index, Digital workflow, Conservative restoration

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## Introduction

In contemporary dental practice, aesthetics is increasingly recognized as a fundamental component of patient care [1]. Modern restorative approaches aim not only to restore occlusal function but also to enhance overall well-being, self-confidence, and quality of life [2]. Various strategies exist for smile rehabilitation, depending on patient-specific factors such as age and clinical presentation. Ceramic veneers are widely favored for their excellent aesthetic outcomes, durability, and biomechanical performance across a range of scenarios [3–5]. Composite restorations are also extensively employed in operative, prosthetic, and aesthetic dentistry [6], offering benefits in reduced chair time and cost compared to conventional prosthetic options [7–11].

Traditional freehand composite bonding allows clinicians to layer materials with different opacities to achieve highly aesthetic results. While effective, this

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technique demands advanced clinical expertise, considerable skill, and prolonged chair-side time [12, 13].

The advent of computer-aided design and manufacturing (CAD/CAM) technologies has introduced new tools for planning and executing complex clinical treatments [14]. Digital technologies such as intraoral scanning, cone-beam computed tomography (CBCT), digital smile design (DSD), and orthodontic digital setups enable comprehensive 3D planning, particularly in interdisciplinary cases [15]. Early digital pre-visualization, especially using DSD, facilitates precise treatment planning by defining optimal tooth aesthetics and function [16]. Open-source software solutions (e.g., Digital Smile Design via Keynote) further enhance efficiency and cost-effectiveness during the design phase [17, 18].

The injection moulding technique (IMT) provides a minimally invasive alternative to freehand bonding. This method involves placing a flowable composite into a stable, transparent silicone index that acts as a mould [7–10]. The composite's fluidity ensures accurate adaptation within the index and intimate integration with the tooth surface, often eliminating the need for enamel preparation and preserving tooth integrity. The etch-and-rinse protocol underpins the method, offering high reproducibility and clinical consistency [10].

Following orthodontic treatment, IMT can be used for minor adjustments to tooth form, addressing aesthetic and functional concerns in a conservative manner. Integrating orthodontic and restorative procedures is essential for maintaining predictable long-term outcomes, particularly in interdisciplinary cases. Conservative interventions are especially useful for correcting conditions such as tooth wear, incisal margin abrasion, irregular tooth shape or size, and Bolton index discrepancies [7].

This study demonstrates the application of IMT for conservative restoration of maxillary lateral incisors in pediatric patients undergoing orthodontic treatment. The technique serves as a temporary solution until the patient becomes a candidate for definitive all-ceramic veneers. By incorporating a digital workflow, clinicians can design the desired tooth morphology efficiently, with thermoformed retainers or aligners fabricated and delivered within the same appointment. Compared to 3D-printing approaches, IMT offers a faster, cost-effective, and straightforward alternative with comparable aesthetic and functional outcomes, making it particularly suitable for pediatric cases. Its seamless integration into conventional orthodontic workflows further enhances practicality and accessibility in routine clinical practice.

*Case presentation*

These reports were prepared in accordance with the 2013 CARE guidelines [19]. Written informed consent was obtained from all participants prior to their inclusion in the study. The protocol adhered to the principles of the Declaration of Helsinki and received approval from the University of L'Aquila Ethics Committee (Project ID: 12/2020; approval date: 11 May 2020, L'Aquila, Italy).

*Case 1*

*Patient overview*

A 12.6-year-old girl presented for an orthodontic evaluation due to dissatisfaction with her smile aesthetics. Clinical inspection revealed that her maxillary lateral incisors (teeth 12 and 22) were undersized and demonstrated atypical morphological features.

A thorough medical and dental history was collected, confirming no systemic health issues and a lifestyle conducive to oral health. A caries risk assessment, including an analysis of dietary patterns, indicated low risk with a balanced nutritional intake.



*Clinical examination*

Examination revealed a skeletal Class I relationship and an oval-shaped face with symmetrical proportions and a mildly convex profile. The molars and canines exhibited Class I occlusion, with well-aligned dental midlines. No evidence of caries was found in either the anterior or posterior dentition. Minor crowding was noted in the lower arch.

*Diagnostic evaluation*

Comprehensive records were obtained, including photographs, radiographs, and dental casts. These records were organized and analyzed using the Digital Smile Design (Keynote) software to support precise treatment planning **(Figure 1)**. The software enabled virtual assessment and adjustment of tooth dimensions and morphology, facilitating a conservative and highly individualized restorative approach.



a) b) c) d)

**Figure 1.** a) Frontal view showing the slightly open mouth to highlight the conical shape of teeth 12 and 22. b) Occlusal view of the patient's maxillary arch. c, d) Radiographic imaging for diagnostic evaluation.

*Considered treatment options*

The orthodontic team evaluated two potential strategies to address the patient's malocclusion and aesthetic concerns. The first option involved extraction of the crowded lower incisor (tooth 42) to relieve crowding, combined with closure of the upper arch spaces through direct or indirect restorations of teeth 12 and 22. This plan required placement of a fixed upper retainer and a lower fixed retainer spanning teeth 33 to 43.

The second strategy avoided extractions by creating space in the lower arch via interproximal enamel reduction. This approach incorporated the injection moulding technique (IMT) to restore teeth 12 and 22, followed by removable upper retainers and a fixed lower retainer from teeth 43 to 33. Considering the patient's preferences, the second option was selected as the definitive treatment plan.

*Implementation of restorative procedure*

Once the desired tooth morphology was finalized digitally, a provisional resin mock-up was placed intraorally to evaluate aesthetic and functional suitability. Adjustments were made to ensure both patient satisfaction and clinical acceptability.

After approval of the mock-up, a thermoformed plastic tray was fabricated to hold a silicone stent corresponding to the final wax-up. The digital workflow was also used to produce the thermo-printed retainer and the triple-layer silicone index **(Figure 2)**, enabling precise adaptation of the restorative composite during the IMT procedure.





a) b) c)

**Figure 2.** a) Wax-up model of teeth 12 and 22. b) Thermoformed retainer placed on the upper left study model; the top-right panel shows the final post-orthodontic result, while the lower panel depicts the model used to fabricate the triple-layer silicone index c) Side-by-side comparison of the thermoformed retainer (left) and the triple-layer silicone index (right), both produced from the same digital design workflow.

To replicate the diagnostic wax-up with high fidelity for direct composite application, a triple-layer clear silicone index was created. Each layer had a dedicated function: the first layer ensured posterior stability, the second layer reduced flexural distortion during placement, and the third layer allowed optimal light penetration to facilitate curing. Small openings were incorporated at the incisal edges to guide the composite syringe and control the material flow **(Figure 3)**. The combination of flexibility and rigidity in the silicone ensured accurate adaptation to the teeth while maintaining structural support. The index was fabricated using a combination of materials: EXACLEAR GC Transparent Silicone for the moulding template (durometer ~60 Shore-A), ERCO-DURE thermoformed plates (2–3 mm thick) to stabilize the retainer and mask, and LASCODE ERGASIL Double Paste A + B Silicone (70 Shore-A hardness) for precision detailing.

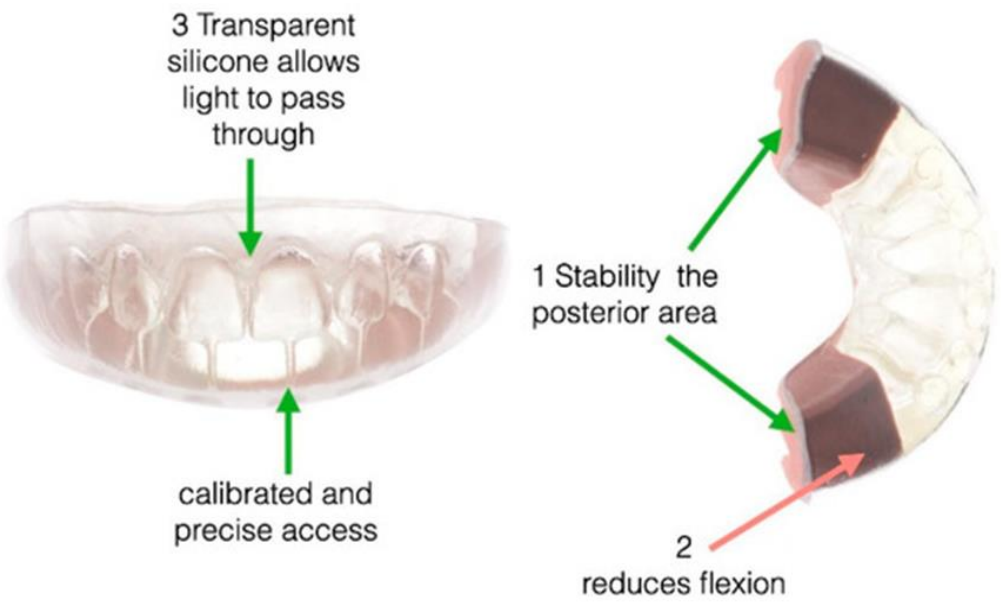
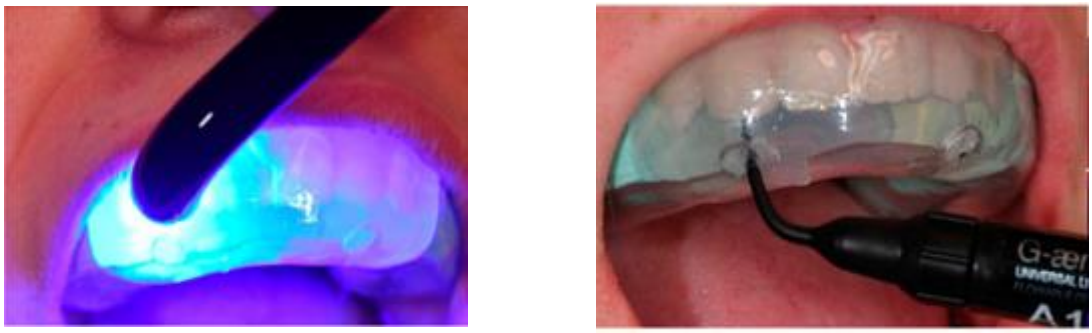



**Figure 3.** The three-layer silicon index's parts.

The teeth were first prepared by etching and applying a bonding agent. Using the previously fabricated silicone index as a template, the A1 shade flowable composite (G-ænial Universal Injectable, GC America, Illinois, USA) was incrementally injected to reconstruct the desired anatomical contours. Polymerization was performed with an Elipar™ Deepcure-L LED curing light (3M, Minnesota, USA; 430–480 nm, 1470 mW/cm²). Any surplus composite was carefully trimmed with a scalpel or fine bur to prevent overhangs that could trap plaque or irritate the periodontium. A multi-step finishing and polishing protocol was then applied to optimize surface smoothness and aesthetic appearance. This process involved the use of fine-grit flame-shaped burs (Komet Dental, Lemgo, Germany), sequential 3M discs of varying grits, and Soniflex handpiece finishing tips (Kavo, Biberach, Germany). The restorations were finally polished using a combination of goat-hair wheels, diamond polishing paste, and Sof-Lex spiral instruments to achieve a high-gloss, uniform surface **(Figure 4)**.





a) b)

**Figure 4. a**) Gradual application of flowable composite material. **b**) Light-curing procedure.

The treatment process extended over a period of 22 months and culminated in the patient expressing satisfaction with the improved appearance of her smile **(Figure 5)**. The integration of the digital workflow enabled the simultaneous fabrication and delivery of the retainer at the conclusion of the conservative restorative procedure.



a)



b)



c)

**Figure 5.** a) Refined contouring of teeth 12 and 22. b) Frontal view illustrating the final occlusion. c) Occlusal perspective highlighting the palatal surfaces of the reconstructions on teeth 12 and 22.

A follow-up conducted six months after the procedure showed healthy gingival tissue, maintained periodontal integrity, and stable color of the restored teeth 12 and 22. The patient reported high comfort and satisfaction with the treatment. At a six-year review, clinical assessment revealed no bleeding on probing, normal probing depths, healthy periodontal status, and excellent oral hygiene **(Figure 6)**.



**Figure 6.** Frontal view of final occlusion in a six-year follow-up control.

*Case 2*

*Patient presentation*

A 12.3-year-old boy attended an orthodontic consultation expressing concern about the aesthetic appearance of his smile. Clinical evaluation identified underdeveloped lateral incisors with limited prominence and unerupted maxillary canines (teeth 13 and 23) **(Figure 7)**.



a)



b)

**Figure 7.** a) Frontal view of the patient's teeth in full occlusion. b) Close-up illustrating the small lateral incisors (12 and 22) and their atypical morphology.

The patient's medical background revealed no systemic illnesses, and he followed a generally healthy lifestyle. Caries risk assessment, including dietary habits, indicated a low-risk profile.

*Clinical findings*

The patient presented with an overall skeletal Class I pattern, showing a minor inclination toward Class III. His facial structure was oval with balanced symmetry and a slightly convex profile. Molar and canine relationships were consistent with Class I occlusion, and the dental midlines were well aligned. Spacing was observed in both dental arches, but no crowding was present. The dentition was free of active carious lesions throughout the anterior and posterior teeth **(Figure 7)**.

*Diagnosis and assessment*

A full set of diagnostic records—including intraoral photographs, radiographs, and dental casts—was collected for evaluation **(Figure 8)**. Digital software platforms, both commercial and open-source, were used to virtually adjust tooth dimensions and morphology to guide treatment planning and simulate the expected aesthetic outcome.



a)



b)

**Figure 8.** a,b) Radiographic assessment of the patient's dentition.

*Treatment options considered*

Two potential treatment strategies were assessed to address both the patient's malocclusion and aesthetic concerns. The first strategy focused on space closure and correction of the Class III tendency prior to restorative intervention. The second strategy involved pre-orthodontic direct restoration of teeth 12 and 22, followed by a 24-month orthodontic treatment plan including space management and subsequent placement of upper and lower retainers. Based on his preferences, the patient opted for the second approach.

2.2.5. Treatment Procedure

After digitally finalizing the target tooth morphology, a temporary resin mock-up was initially placed intraorally to evaluate aesthetics and function, with minor adjustments made according to patient feedback. Once the desired result was achieved, the definitive silicone mould was produced from the final wax-up. A thermally formed plastic tray secured the silicone stent over the relevant teeth **(Figure 9)**. Teflon tape was used to protect adjacent teeth from composite overflow.

The lateral incisors were etched, treated with bonding agent, and incrementally restored using flowable composite applied through the silicone index. Each layer was light-cured before removal of excess material to prevent plaque retention or gingival irritation. Finishing and polishing followed a meticulous protocol to ensure a smooth surface and long-term aesthetic stability, employing tools and materials analogous to those used in Case 1 **(Figure 10)**.



**Figure 9.** Placement of the thermoformed retainer over the silicone tray on the upper left quadrant. The lower-left image shows the final wax-up model used to fabricate the triple-layer silicone index. The right-hand image displays the lower dental arch.





a)



b)



c)

**Figure 10.** a) Isolation of the upper central incisors using Teflon to prevent unintended composite flow. b) Placement of the silicone index in the patient's oral cavity, demonstrating how its transparency allows visualization of the composite filling the mould. c) Light-curing of the composite restoration.

Thermoformed retainers were provided immediately following the restorative procedure.

A two-year follow-up confirmed stable and satisfactory results, with no bleeding, abnormal probing depths, occlusal discrepancies, or alterations in tooth morphology or shade. The patient exhibited high tolerance and satisfaction with the treatment **(Figure 11)**.



a) b)

c)

**Figure 11.** a) Frontal view displaying the final occlusal alignment. b) Close-up of the reshaped upper lateral incisors (teeth 12 and 22). c) Occlusal perspective illustrating the palatal surfaces of the reconstructed teeth.

The injectable composite resin technique offers a minimally invasive and efficient approach for patients seeking aesthetic improvements, especially for subtle reshaping or re-anatomization of teeth [20]. These case reports illustrate the practical use of this method for modifying tooth morphology in pediatric patients, providing an accessible and cost-effective alternative to traditional ceramic veneers. Unlike ceramics, composite restorations are easier to repair or replace and can be polished during follow-up visits to maintain aesthetic quality [21].

Recent innovations in flowable composite materials have substantially enhanced their mechanical properties, including flexural strength, wear resistance, elasticity, and polishability [22, 23]. High-filler composites (up to 69 wt%) demonstrate uniform filler distribution, contributing to durable and wear-resistant restorations [24–28].

Successful implementation of the IMT requires careful isolation of the tooth surface without using rubber dam clamps, which could interfere with the thermoformed tray. A 1 mm thick thermo-printed tray with strategic support areas ensures accurate composite placement. Warming the composite optimizes viscosity and handling, while controlled slight gingival overflow reduces air entrapment and guarantees even adaptation in interproximal and marginal regions. Prolonged light-curing compensates for potential gaps between the curing light and material, ensuring complete polymerization [29]. Post-procedural polishing with rubber instruments preserves tooth morphology and enhances surface finish. Restoration longevity may also be influenced by patient-specific factors such as age, oral habits, and the extent of the restorative work.

Photopolymerization protocols have been extensively studied and are critical for ensuring restoration durability [30, 31]. While slight differences exist between resin brands, these generally do not compromise longevity, allowing clinicians to select materials based on handling preference [32, 33]. In these cases, G-ænial Universal Injectable (GC Corporation) was used according to manufacturer instructions and supported by scientific evidence [7, 34, 35]. This material also shows reduced bacterial adhesion due to its smooth surface, which is further enhanced with Sof-Lex Spiral polishing instruments [36].

Proper composite placement within the gingival sulcus is essential to prevent inflammation. Mechanical barriers and supragingival wax-up margins help avoid subgingival flow, eliminate the need for retraction cords, and minimize gingival trauma [10].

Careful patient selection is crucial for the success of the IMT. Ideal candidates are those with small diastemas, minor spacing issues, or slightly retruded teeth [37]. The presented cases, featuring irregular tooth dimensions and morphology, demonstrate how the IMT provides an effective additive restorative solution

for achieving aesthetic and functional improvements in young patients.

## Conclusion

- The injection moulding technique (IMT) offers a conservative, additive restorative option that is particularly advantageous when minor aesthetic or morphological adjustments are required.
- Success with the IMT relies on careful treatment planning, precise execution, judicious case selection, and adherence to detailed placement and polishing protocols to ensure predictable and reproducible results.
- The technique has proven effective in pediatric patients both at the initiation and completion of orthodontic therapy.
- For orthodontists, the IMT serves as a valuable adjunct, aiding in the resolution of tooth size discrepancies, correction of morphological anomalies, and refinement of overall occlusion.
- The method enables simultaneous functional and aesthetic improvements, enhancing both orthodontic outcomes and patient satisfaction with smile aesthetics.
- Integration with digital workflows allows for streamlined clinical procedures, including the fabrication and delivery of thermo-printed retainers or aligners within the same session, optimizing efficiency and reducing treatment time.
- Additional longitudinal clinical studies are recommended to evaluate the durability, longevity, and broader applicability of the IMT in diverse patient populations.

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