



Master's Degree in Dental Medicine

Systematic Review

The Flow Composite Resin Injection Technique.

**The innovative smile harmonization technique: a
systematic review**

“The Flow Composite Resin Injection Technique.

**A inovadora técnica de harmonização do sorriso: uma
revisão sistemática”**

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Porto, 2025.

If you can dream it, you can do it.

Walt Disney

ABBREVIATIONS INDEX

FIT – The Flow Injection Technique

UDMA – Urethane Dimethacrylate

Bis-MEPP – Bisphenol A Polyethoxy Methacrylate

TEGDMA – Triethylene Glycol Dimethacrylate

Bis-GMA – Bisphenol A-Glycidyl Methacrylate

FCRIT – Flow Composite Resin Injection Technique

VPS – Polyvinyl siloxane

PTFE – Polytetrafluoroethylene

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I. Abstract

1. Introduction

In the last few years, the demand for and focus on aesthetics by patients and dentists have increased exponentially. Consequently, Aesthetic and Conservative Dentistry has been compelled to evolve to achieve patients' expectations. Thus, "The Flow Injection Technique" emerged to facilitate and enhance the dentist's work while ensuring proper dental anatomy and aesthetics.

2. Objective

The follow systematic review aims to evaluate how "The Flow Injection Technique" is the most viable, faster, effective, and reproducible option as an alternative approach to conventional restorative techniques.

3. Materials and Methods

The bibliographic research was conducted using the MEDLINE (PubMed), Scopus, and Web of Science databases, based on the PRISMA checklist guidelines and the PICO methodology. The search was limited to a five-year time frame (2020-2025) and to articles in Portuguese and English, and 22 articles were selected.

4. Results and Discussion

"The Flow Injection Technique" was first described by *Douglas A Terry* as a minimally invasive, practical, and effective approach, which has gained space in the recent years. This technique can be applied not only to enhance the attractiveness of a smile by altering dental anatomy and aesthetics but also to restore function and vertical dimension of occlusion.

This technique does not require advanced manual skills; however, proper planning and material selection are crucial. A highly filled flowable composite is included among the recommended materials. This technique, when supported by appropriate planning and execution, achieves an immediate result of high functional and aesthetic standards.

Flow composite resin restorations can be performed in a single appointment, while also being easier to repair or replace when needed, what is relatively cost-effective. Nevertheless, direct composite restorations present certain limitations, including greater wear over time, loss of anatomical form, and lower colour stability when compared to ceramics restorations.

5. Conclusion

The development of this systematic review revealed that “The flow injection technique” is a viable alternative for performing minimally invasive treatments in aesthetic rehabilitation, in the detriment of conventional techniques. This is a highly positive conclusion, since both high-filled flowable resins and the technique itself have gained prominence in recent years.

Keywords

“Resin”, “Composite”, “Resin composite”, “*G-aenial Universal Injectable®*”, “Flow”, “Flowable”, “Injection”, “Injectable”, “Technique”, “Dentistry”.

II. Resumo

1. Introdução

Nos últimos anos, a procura e a exigência estética, por parte dos pacientes e médicos dentistas, têm vindo a aumentar de forma exponencial. Deste modo, a Medicina Dentária Estética e Conservadora viu-se obrigada a evoluir neste sentido para ser capaz de acompanhar as expectativas dos pacientes. Assim, a técnica de resina *flow* injetável - “The Flow Injection Technique” – surgiu para facilitar e tornar mais eficaz o trabalho do médico dentista, assegurando a anatomia e estética dentária.

2. Objetivo

O presente trabalho visa avaliar de que forma a técnica “Flow Injection Technique” é a opção de escolha mais viável, mais rápida, eficaz e reprodutível, para uma abordagem alternativa às técnicas restauradoras convencionais.

3. Material e Métodos

A pesquisa bibliográfica foi realizada com um auxílio das bases de dados MEDLINE (*Pubmed*), *Scopus* e *Web of Science*, com base nas diretrizes da checklist *PRISMA* e da metodologia *PICO*. A pesquisa foi limitada por um intervalo de tempo de cinco anos (2020-2025), pelos idiomas português e inglês e foram selecionados 22 artigos.

4. Resultados e Discussão

“The Flow Injection Technique” foi descrita pela primeira vez por *Douglas A Terry*, como uma técnica minimamente invasiva, prática e eficaz, que tem vindo a ganhar espaço nos últimos anos. Efetivamente, esta técnica pode ser aplicada não só para melhorar a atratividade de um sorriso, alterando a anatomia e

estética dentária, mas também para restaurar a função e a dimensão vertical da oclusão.

Esta técnica não requer competências manuais avançadas; no entanto, um planeamento adequado e a seleção criteriosa do material são fundamentais. Entre os materiais recomendados encontra-se a resina fluida altamente carregada. Quando sustentada por um planeamento e execução corretos, esta técnica permite obter um resultado imediato com elevados padrões funcionais e estéticos.

As restaurações com resina composta fluida podem ser realizadas numa única consulta, sendo também mais fáceis de reparar ou substituir quando necessário, o que as torna uma opção relativamente económica. No entanto, as restaurações diretas em resina composta apresentam algumas limitações, incluindo maior desgaste ao longo do tempo, perda da forma anatômica e menor estabilidade de cor quando comparadas com as restaurações cerâmicas.

5. Conclusão

Com a elaboração da presente revisão sistemática foi possível perceber que a “The Flow Injection Technique” é uma alternativa viável para realizar tratamentos minimamente invasivos na reabilitação estética, em detrimento das técnicas convencionais. É uma conclusão bastante positiva, uma vez que quer as resinas *flow* injetáveis de alta carga, quer a própria técnica tem vindo a ganhar palco nos últimos anos.

Palavras-chave

“Resin”, “Composite”, “Resin composite”, “*G-aenial Universal Injetable*®”, “Flow”, “Flowable”, “Injection”, “Injectable”, “Technique”, “Dentistry

III. Introduction

i. Aesthetic and Conservative Dentistry

In the recent years, Aesthetic Dentistry has been forced to evolve, mainly in the field of Restorative Dentistry. This is a result of trying to keep up with the exponential increase of the demand and aesthetic requirements of the patients, whose main objective is to improve the attractiveness of their smile. ⁽¹⁾

In Aesthetic dentistry, the main trends focus on minimally invasive treatments, aiming to preserve as much of the tooth structure as possible, removing only what is necessary to achieve aesthetically pleasing results. In this way, Conservative and Aesthetic Dentistry need to be hand-in-hand to perform a natural and singular smile.⁽²⁾

Focusing on Restorative Dentistry, dental restorations are required to faithfully simulate the characteristics of the natural teeth and to have physical and chemical properties capable of withstanding the forces of chewing, without compromising dental aesthetics. In fact, wear resistance and the abrasive impact on opposing teeth are the key factors in ensuring the longevity of dental restorations.⁽³⁾

ii. Techniques and Restorative Materials

Dental veneers are commonly used in restorative and aesthetic dentistry and can be produced using ceramic or composite resin materials. Composite resin veneers can be produced by two techniques: the direct technique, applied chairside or the indirect technique, which involves laboratory processing.⁽⁴⁾

Amongst the mentioned options, ceramic veneers are often preferred due to their well-established effectiveness, long-term aesthetic results, and favourable biomechanics.⁽⁵⁾ However, it's necessary the dental laboratory's input and multiple visits to the clinic, which means additional costs to the treatment, which could limit access for a few patients.⁽⁶⁾

Meanwhile, composite veneer popularity has increased over the last few years with improved material properties. Composite veneers offer several benefits, including ease of repair and cementation, higher flexural modulus, reduced treatment time and cost,⁽⁷⁾ and lower opposing tooth abrasiveness compared to more traditional prosthetic options.⁽⁸⁾

Using the direct technique, tooth preparation is often unnecessary, unlike the indirect technique, where "no-preparation" veneers are rarely employed. However, it has been well reported that the freehand direct technique is highly technique-sensitive and time-consuming for the dentists, even for highly skilled clinicians.⁽⁹⁾ This is particularly true for anterior teeth, where the accuracy of the restoration's form plays a crucial role in both aesthetics and function.⁽¹⁰⁾

Flow Composite Resin Injection Technique

Given these limitations of the freehand technique, and with recent advances in technology, a new technique has been described in the literature: "The Flow Composite Resin Injection Technique", as also known as "The Flow Injection Technique" (FIT).⁽¹¹⁾

The execution of this technique does not require a high level of manual dexterity from the dentist, but rather careful planning and appropriate material selection. Furthermore, the most important advantages of this method are predictability, repetitiveness, simplicity, teeth preservation, reduced chair time, and financial viability for patients.⁽¹²⁾

This technique was first suggested by *Douglas A Terry* as a non-invasive technique. The initial step involves creating a diagnostic model (wax-up), which is then replicated in the patient's mouth as a mock-up. This mock-up is applied directly to the tooth structure without any pre-preparation, with the assistance of a pre-perforated transparent silicone (polyvinylsiloxane - VPS) matrix. Flowable composite resin is pumped through these perforations. The last step involves light-curing the resin, finishing, contouring, and polishing of the direct restorations.⁽¹³⁾

As for the disadvantages, they are most often related to the improper selection of materials, which can impact both, the durability and the aesthetics of the final outcome. Discoloration of composite resins remains one of the main esthetic drawbacks, which may require retreatment. Furthermore, high precision is required in the fabrication of the VPS matrix to avoid interference in the tooth interfaces. The silicone matrix's transparency and the correct alignment of the perforations are also crucial factors that must not be neglected.⁽¹⁴⁾

Flow/Injectable Composite Resin

Originally, flowable resins are low-viscosity composites with less filler particle content and thus are more fluid and flexible - essential properties for optimal adaptation to the tooth structure.⁽¹⁵⁾

Flowable resin-based composites are regular composites with less filler content, 37% to 53% by volume, compared to the usual 50% to 70% volume of filler in regular hybrid micro-filled composites. Due to their lower filler content, certain limitations exist for this type of material, including reduced wear resistance, strength, and colour stability relative to medium-viscosity composites, which are more commonly used and commercially available.⁽¹⁵⁾

In response to these limitations, researchers using nanotechnology, developed a new chemical composition for flowable resins. This led to the manufacture of a highly filled flowable resin, for example *Filtek Supreme XTE Flowable Restorative* with 65wt% inorganic filler⁽¹⁶⁾, *G-aenial Universal Injectable*⁽¹⁷⁾ and *G-aenial Universal Flow* with 69 wt% and *Tetric 2 EvoFlow Bulk Fill* with 80wt%.⁽¹⁶⁾

It is distinguished by its high aesthetics and longer-lasting gloss retention, enhanced strength and wear resistance, controlled flow and adaptability, cutting-edge silanization technology, improved stability and higher availability of shades.⁽¹⁸⁾

This newly created group of resins, injectable composite resins, has been gaining popularity, particularly when used in the flowable resin technique known as "The Flow Injection Technique." ⁽¹⁴⁾

In this way, "The Flow Injection Technique", when complemented by an adequate planning and execution, allows an immediate result characterized by a high functional and aesthetic quality, with lightweight and efficient workflow.

iii. Objectives

Therefore, the objectives of this study are:

- a) To assess the viability of "The Flow Injection Technique" in smile harmonization, identifying advantages and disadvantages in comparison with other techniques.
- b) To seek to identify which flowable resin is the most suitable for "The Flow Injection Technique".
- c) To evaluate whether the thickness, the material, and the transparency of the silicone matrix influence the success of "The Flow Injection Technique".

iv. Hypothesis

Following this line of thought, the hypothesis proposed for this study is: "When well planned and executed, "The Flow Injection Technique" is an innovative smile harmonization technique".

IV. Materials and Methods

i. Databases and Search Strategy

This systematic review was conducted with the support of the electronic databases MEDLINE/PubMed, Elsevier/Scopus and Web of Science, intending to obtain publications that discuss the aesthetic and effectiveness of “The Flow Injection Technique”, using injectable flowable resin-composites.

The research was employed using the Boolean operators “AND” and “OR” interspersed with the following keywords: “Resin”, “Composite”, “Resin composite”, “G-aenial Universal Injectable®”, “Flow”, “Flowable”, “Injection”, “Injectable”, “Technique”, “Dentistry”.

The inclusion and exclusion criteria mentioned at Table 1 were applied across all the afore mentioned research databases.

Inclusion Criteria	Exclusion Criteria
Articles in which the treatment applied involves injectable flowable resin using exclusively the “flow injection” technique.	Articles in which the treatment applied involves non-flowable resins.
	Articles that use “flow injection technique” combined with another additional technique.
Articles that include aesthetic evaluation (shape, colour and/or translucency) and/or functional assessment and/or durability.	Articles whose language is neither Portuguese nor English.
Articles published in the last 5 years.	Revisions, books, books chapters, theses, and dissertations.

Table 1: Inclusion and exclusion criteria.

ii. Research Question

This systematic review was conducted in accordance with the guidelines of PICO methodology, whose criteria are outlined in Table 2. From this, the following research question was formulated: **“Is “The Flow Injection Technique” a viable alternative for performing minimally invasive**

treatments in aesthetic rehabilitation, as opposed to conventional techniques?”.

P: <i>Population</i>	Oral rehabilitation using “The Flow Injection Technique”.
I: <i>Intervention</i>	“The flow injection technique” with injectable flowable resins.
C: <i>Comparison</i>	“The flow injection technique” as opposed to conventional techniques.
O: <i>Outcome</i>	“The flow injection technique” is a viable alternative.

Table 2: Development of the research question according to the PICO methodology.

iii. Criteria for Study Selection

Following the search strategy, after extracting the articles into EndNote 21®, all duplicates within the same research databases and across all databases mentioned before were excluded.

The remaining articles were initially selected based on their title and subsequently based on their abstract. During this phase, were included only the articles focusing on the aesthetic rehabilitation of teeth using injectable flowable resins, with “The Flow Injection Technique” as the sole approach.

Eligible articles were full and independently read. Only complete articles available in PDF format were selected. The sample composition for this systematic review, presented in Figure 1, was conducted in accordance with the criteria outlined in the PRISMA (“The Preferred Reporting Items for Systematic Review and Metanalysis”) checklist.

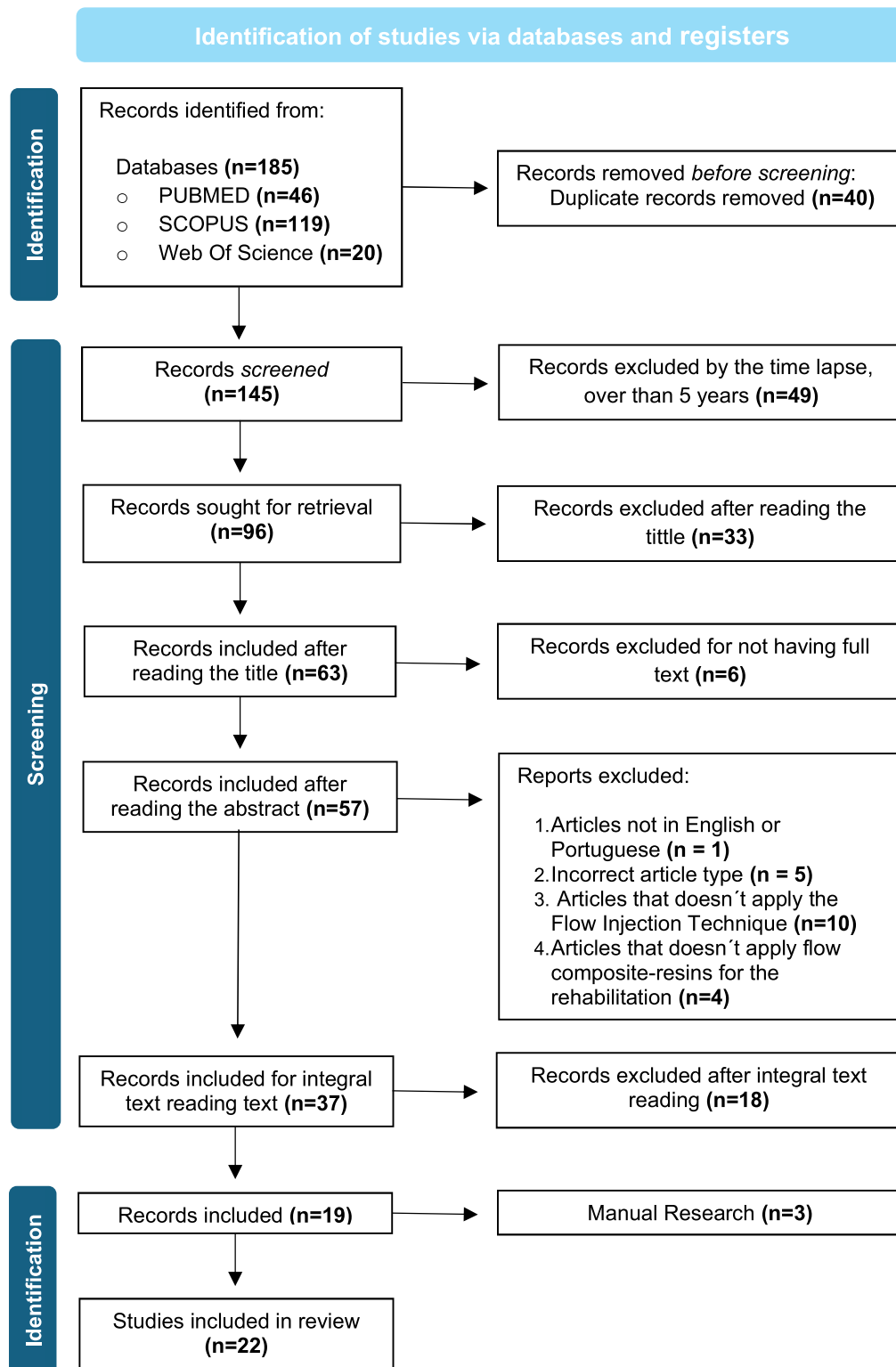


Figure 1: PRISMA Guidelines.

iv. Assessment of risk of bias

The methodological quality assessment of the studies included in this systematic review was conducted according to the design of each study.

For the in vitro studies, the QUIN Tool (Quality Assessment Tool for In Vitro Studies) was used to assess the methodological quality, risk of bias, of the laboratory studies. This tool is based on 12 criteria and provides a percentage-based classification of the risk of bias into three categories: low risk (>70%), moderate risk (50%–70%), and high risk (<50%).

The application of the QUIN Tool showed that most studies had a low risk of bias, indicating a solid methodological quality in the procedures adopted. Although certain recurring limitations were identified like not reporting the use of blinding or measures to reduce observer bias. Additionally, in some cases, randomization procedures were either not implemented or not explicitly described. Furthermore, information regarding the operators—such as their identity, level of experience, or calibration—was frequently lacking.

In the case of clinical studies classified as case reports or case series, a formal risk of bias assessment was not performed. This decision is justified by the inherent methodological limitations of these study designs, which typically lack essential elements such as comparison groups, randomization, and control of confounding variables—precluding the application of standardized quality assessment tools. Nonetheless, these studies were included in the descriptive synthesis of the evidence and acknowledged as representing a lower level of evidence, in accordance with the hierarchy of evidence-based medicine.

V. Results

Based on the PRISMA criteria, the present systematic review included a total of 19 articles retrieved from the previously mentioned electronic databases, along with 3 articles obtained through manual search, resulting in a total of 22 articles. The manually retrieved studies were included due to their high relevance and essential contribution to the topic.

The articles were categorized into *in vitro* studies, clinical case reports, and manually retrieved research, with twelve, six, and three results, respectively.

To enhance the accuracy of the review, *in vitro* studies were further divided into the following groups: “Flowable/injectable composite resins properties”, Table 3, “Finishing/Polishing Techniques”, Table 4 and “Index-key properties”, Table 5. *In vitro* studies were listed by author and year of publication, and summarized according to their aim, materials, results and risk of bias.

Concerning the clinical case reports, although also listed by author and year, they were summarized by objective, follow-up period, materials used, polymerization protocol, polishing techniques, and conclusions. The results are presented in Table 6.

Regarding the manually retrieved articles, illustrated in Table 7, since they were all clinical case reports, they were analysed in the same manner as the case reports obtained from the electronic databases.

Author/Year	Type of Article	Aim	Materials	Results	Risk of bias
Bai et al (2024) ⁽¹⁹⁾	<i>In Vitro</i>	Evaluate and compare the chemical and optical stability of four restorative composite materials: two injectable resins, one flowable resin and one compomer.	- G-aenial Universal (GU). - Beautifil Injectable XSL (BI). - Supreme Flowable (FS). - Dyract Flow (DF).	Injectable composite resins (GU, BI) and conventional flowable resin (FS) were more chemically and aesthetically stable than the compomer (DF). Material choice directly influences the durability, aesthetics, and biocompatibility of the restoration. Compomers are not recommended for use in aesthetic regions or where there is high functional demand.	Moderate
Basheer et al (2024) ⁽²⁰⁾	<i>In Vitro</i>	Evaluate specific physical and mechanical characteristics of newly produced high-strength flowable composites, comparing them to those of traditional multipurpose dental composites.	- G-aenial Universal FLO. - G-aenial Universal Injectable. - Beautifil Injectable. - Beautifil Flow Plus. - Filtek Z350 XT.	Not all injectable composites are suitable for high-stress areas. G-aenial Universal FLO is a good option for cervical lesions and areas with high aesthetic and adaptability demands, due to its high flexural strength and reduced microleakage. Material selection should be based on the intrinsic qualities of each composite to facilitate longevity and clinical success.	Low
Checchi et al (2024) ⁽¹⁷⁾	<i>In Vitro</i>	Evaluate the surface roughness and wear resistance of highly filled flowable and compare them with conventional packable composites. It also examined how polymerization time would affect those properties.	- Clearfil Majesty (CMf). - G-aenial Universal Injectable (GUF). - Clearfil Majesty (CM). - G-aenial A'CHORD (GU).	Flowable composite wear resistance increases with higher filler content, reaching that of conventional composites. Surface roughness was higher after chewing simulation, but flowables still recorded lower final roughness than packable composites, with the optimum achieved by GUF. Longer curing times enhanced mechanical properties of all tested materials.	Low
Chen et al (2024) ⁽³⁾	<i>In Vitro</i>	Evaluate the mechanical, wear, antibacterial, and biocompatibility properties of injectable composite materials.	- G-aenial Universal (GU). - Beautifil Injectable XSL (BI). - Supreme Flowable (FS). - Dyract Flow (DF).	GU showed the highest flexural strength and elastic recovery across all phases. It also had the thinnest biofilm and the smoothest, most uniform surface. All tested injectable flowables exceeded the recommended flexural strength threshold, suggesting wider clinical use and improved long-term performance.	Low

Elsahn et al (2023) ⁽²¹⁾	<i>In Vitro</i>	Evaluate and compare the mechanical properties of occlusal veneers made from various injectable and CAD/CAM composite materials under simulated oral conditions.	- Beautiful Injectable X (BF). - G-aenial Universal Injectable (GU). - SonicFill 2 (SF). - Cerasmart (CS).	GU injectable veneers were more durable and less affected by aging than CS-milled veneers, when SF and BF showed significant surface degradation. Material performance is dependent on composition, with GU being more resistant to aging effects, whereas BF and SF may be less suitable for clinical use in occlusal veneers due to their degradation under stress.	Low
Ludovichetti et al (2022) ⁽¹⁶⁾	<i>In Vitro</i>	Evaluate and compare the depth of cure (DOC) of two bulk-fill flowable composites, two conventional flowable composites and one high strength universal injectable composite	- Filtek Bulk Fill. - Tetric EvoFlow Bulk Fill. - Filtek Supreme XTE. - G-aenial Flo X. - G-aenial Universal Injectable.	Bulk-fill flowable composites showed significantly greater depth of cure (DOC) compared to traditional flowables and high-strength injectable composites. Both bulk-fill flowables and the high-strength injectable composite showed similar hardness values, which were significantly higher than those of conventional flowable composites.	Low
Vulović et al (2024) ⁽²²⁾	<i>In Vitro</i>	Evaluate and compare the impact of acidic environments on the surface characteristics of highly filled flowable resin composites.	- G-aenial Universal Flo (GUF). - G-aenial Universal Injectable (GUL). - Tetric EvoFlow (TEF). - Filtek Supreme Flowable (FSF).	GUL showed lower surface roughness (SR) and higher surface hardness (SH) than GUF and FSF, both before and after exposure to acidic environments. Acidic media, particularly grape juice (GI), significantly increased SR and reduced SH in all tested materials.	Low

Table 3: Articles selected (flowable/injectable composite resins properties).

Author/Year	Type of Article	Aim	Materials	Results	Risk of bias
Degirmenci et al (2023) ⁽²³⁾	<i>In Vitro</i>	Evaluate the optical properties of flowable and injectable composites after polishing, such as translucency (translucency parameter [TP], TP(00)), opalescence (OP BW), chroma (C*ab), refractive index (RI), and change in surface roughness (Ra, Rz).	- G-aenial Anterior. - G-aenial Universal Flo. - G-aenial Universal Injectable. - Silicon carbide paper. - Sof-Lex. - CLEARFIL Twist DIA.	Composites with varying viscosities showed different optical properties, such as refractive index, translucency, opalescence, and chroma. Polishing affected translucency, and surface smoothness depended on the material, with the best result from a flowable composite polished with Sof-Lex system.	Low
Uctasli et al (2023) ⁽²⁴⁾	<i>In Vitro</i>	Assess the colour stability of six commercially available restorative resin composites following exposure to commonly consumed beverages. The effect of repolishing on stained composites was also evaluated.	- Filtek™ Universal Restorative. - SDR flow+. - EverX Flow. - G-aenial A'CHORD. - G-aenial Universal Flo. - G-aenial Universal Injectable.	Colour stability was affected by both the composite type and beverage. Coffee and wine caused the most staining, especially in SDR Flow+, showing the highest ΔE values. Machine polishing led to significantly lower ΔE values compared to hand polishing for certain materials, including SDR flow+, everX Flow, G-aenial Universal Flo, and G-aenial Universal Injectable. Repolishing reduced discoloration, and results varied by material, emphasizing the need for material-specific care.	Low
Vulović et al (2023) ⁽²⁵⁾	<i>In Vitro</i>	Evaluate the effect of different finishing and polishing procedures on surface roughness and microbial adhesion and viability of <i>Streptococcus mutans</i> on novel highly filled composites for injectable mold technique.	- G-aenial Universal Flo (GUF). - G-aenial Universal Injectable (GUI). - Tetric EvoFlow (TEF). - Filtek Supreme Flowable (FSF). - Sof-Lex Discs. - Sof-Lex Spirals. - OneGloss. - PoGo.	GUI and GUF exhibited smoother surfaces, especially when polished with Sof-Lex Discs and Spirals, compared to Filtek Supreme Flowable and Tetric EvoFlow. Smoother surfaces, like those of GUI, resulted in lower <i>Streptococcus mutans</i> adhesion, while materials containing bis-GMA, bis-MEPP, and TEGDMA showed greater bacterial accumulation.	Low

Table 4: Articles selected (*Finishing/Polishing Techniques*).

Author/Year	Type of Article	Aim	Materials	Results	Risk of bias
Kouri et al (2023) ⁽⁹⁾	<i>In Vitro</i>	Evaluate the discrepancy between the diagnostic wax-up and the resulting direct veneers using different matrices.	- 48 identical misaligned models. - 12 3D-printed wax-ups. - 48 clear Exaclear VPS matrices. - 12 custom matrices" every other tooth". - G-aenial Universal Injectable, GC Corporation (A2). - Gradia Direct hybrid composite (A2). - Ena Heat conditioning device. - Bluephase Style light curing unit, Ivoclar, Vivadent.	Flowable composites adapt easily with minimal stress, achieving accurate veneers using one or two clear matrices. Individual matrices with pre-heated composite were less accurate, especially in incisal and middle thirds. Accuracy improved when combined with a clear tray. Overall, using flowable resin with one or two matrices is the most precise method for high-demand cases.	Low
Machado et al (2024) ⁽²⁶⁾	<i>In Vitro</i>	Analyse the compression modulus, translucency, and light-curing irradiance transmittance of four transparent polyvinyl siloxane (PVS) materials used in the injection moulding technique at different thicknesses and assess the correlation between colour parameters and irradiance transmittance.	- Affinity Crystal (Clinician's Choice, London, ON, Canada). - Clear Bite Matrix (DenMat, Lompoc, CA). - Exaclear (GC America, Alsip, IL). - Memosil 2 (Kulzer, South Bend, IN).	Affinity and Memosil 2 provided better mold stability due to higher compressive modulus. Exaclear had the best translucency and light transmittance. Light-curing efficiency depended on material type and thickness, with translucency positively linked to light transmission. Thicker or less translucent matrices may need extended curing times for effective polymerization.	Low
Zhu et al (2025) ⁽¹⁰⁾	<i>In Vitro</i>	Evaluate the impact of VPS (Vinyl Polysiloxane) index thickness on the accuracy of direct restorations using the composite injection technique. Accuracy was assessed in terms of trueness (the difference between the result and the ideal model) and precision (the consistency across multiple attempts).	- VPS index with 2mm of thickness (n=12). - VPS index with 4mm of thickness (n=12). - VPS index with 6mm of thickness (n=12).	The accuracy of direct restorations using the composite resin injection technique, including both trueness and precision, improved with increased VPS index thickness. However, no significant difference was found between the 4 mm and 6 mm indices, A VPS index thickness of 4 mm is the minimum required and sufficient to achieve clinically acceptable accuracy, ensuring satisfactory aesthetic and functional outcomes with the composite injection technique.	Low

Table 5: Articles selected (Index-key properties).

Author/ Year	Aim	Follow-up	Materials	Polymerization	Finishing/ Polishing	Conclusion
Brinkmann <i>et al</i> (2020) ⁽²⁾	Describe the conservative management of generalised tetracycline stains by means of the injectable composite resin technique. The objective was to camouflage the tetracycline dental stains and the shape, size and position of the teeth. The anterior region and first premolars in both mandible and maxilla were restored.	24 months	- Impressions: heavy and light body polyvinyl siloxane (3M Express). - Wax-up: analogue/conventional. - Mock-up: A1 shade self-curing resin for provisional restorations (3M Protemp 4). - Silicone Key: transparent silicone (Exaclear, GC Corporation). - Etch: 38% orthophosphoric acid. - Adhesive: G-Premio Bond, GC Corporation. - Flow Composite: G-aërial Universal Injectable, GC Corporation.	- 40 seconds (s) with the silicone key. - 20s on the buccal surfaces, after removal of the key, excess resin, and application of glycerine gel.	- 12D scalpel blade. - Dental probe. - Diamond bur. - Polishing discs. - Interproximal strips. - Rubber polishers. - Diamond polishing paste.	Injectable composite veneers are an effective, affordable, and conservative alternative to ceramic veneers when case selection is appropriate. However, more long-term studies with proper protocols are needed to confirm their reliability. Still, this case demonstrated that satisfactory results can be maintained over a 24-month period, if proper case selection, treatment planning, and workflow are carefully followed.
Hosaka <i>et al</i> (2021) ⁽²⁷⁾	Replacement of mandibular central incisors with a direct fixed dental prosthesis made of resin, using a bilayer composite resin injection technique.	3 months	- Impressions: digital scanner (TRIOS 3; 3Shape A/S). - Wax-up: digital articulator (3Shape Dental System; 3Shape A/S). - Mock-up: Three-dimensional print casts (VarseoWax Model; BEGO GmbH). - Silicone Key: dentin index and enamel index, clear polyvinyl siloxane (EXACLEAR; GC Corp). - Etch: 37% phosphoric acid (K-ETCHANT Syringe). - Adhesive: 2-step self-etch adhesive system (CLEARFIL SE BOND 2). - Flow Composite: dentin shade (EverX Flow; GC Corp; enamel-shade (G-aërial Universal Injectable, E1 shade; GC Corp).	- 60s in the labial and lingual directions, with the dentin index. - 60s in the labial and lingual directions, with the enamel index. - 60s on both sides, after removing excess.	- 12D scalpel blade.	The short-term outcome was excellent, suggesting that this technique may be suitable for provisional or short-term definitive restorations. This approach significantly reduces technique sensitivity and chair time while providing precise and predictable results, especially when combined with a digital workflow. The digital process also accelerated laboratory procedures and enhanced the overall accuracy of the technique.

Hosaka et al (2020) ⁽²⁸⁾ Restorative treatment of anterior teeth is often needed after orthodontics to enhance aesthetics and function. This case report highlights a minimally invasive, direct approach using the composite injection technique combined with a digital workflow for post-orthodontic recontouring.	- Impressions: digital scanner (TRIOS 3; 3Shape A/S). - Wax-up: digital articulator (3Shape Dental System, 3Shape A/S). - Mock-up: 3D-printed (Varseo, Varseowax, BEGO GmbH & Co., Bremen, Germany)). - Silicone Key: clear polyvinylsiloxane (Exaclear, GC Corp.). - Etch: 37% phosphoric acid. - Adhesive: universal adhesive (G-Premio Bond, GC Corp.). - Flow Composite: G-aenial Universal Injectable, E1 shade (GC Corp).	5 months - 60s from both labial and palatal direction, each restoration. - 12D scalpel blade.	The composite injection technique offers a simple, cost-effective, and non-invasive alternative for complex anterior tooth recontouring. Combined with a digital workflow, it ensures precision and efficiency. The clinical outcome was excellent, with no signs of wear or soft tissue inflammation.
Salem et al (2021) ⁽²⁹⁾ This case report describes the treatment of a young Egyptian swimmer with tooth sensitivity caused by erosive wear. The anterior teeth were restored using the injectable composite resin technique to relieve symptoms and improve aesthetics.	- Impressions: Heavy and light condensation silicone impression material (Silaxil, LASCOD). - Wax-up: analogue/conventional. - Mock-up: self-curing resin for provisional restorations. - Silicone Key: clear polyvinyl siloxane material (DENU Trans Sil). - Etch: phosphoric acid. - Adhesive: light-cured universal adhesive (G-Premio Bond, GC Corp.). - Flow Composite: G-aenial Universal Flo, GC Corp,	8 weeks - 20s, according to manufacturer instructions. - Abrasive discs and a polishing kit (DIACOMP® PLUS RA, EVE Ernst Vetter GmbH).	At 8 weeks, the patient showed no sensitivity, was fully satisfied, and had minimal inflammation due to brushing technique. Proper hygiene was reinforced. The case highlights the importance of thorough patient history for effective risk assessment and supports the injection moulding technique as a simple, effective, and aesthetic option for restoring anterior teeth affected by erosive wear.

Provide a detailed overview of the entire process—from initial planning to final restoration—of a straightforward case using the injection technique with flowable composite resin. It also includes a comparison with alternative methods and highlights the benefits of incorporating a digital workflow. David Geštakovski (2021)⁽¹⁾	10 months	- Impressions: Digital scanner. - Wax-up: Digital software and 3D printed. - Mock-up: Polyvinyl siloxane (PVS) putty silicone index (Exaflex; GC) and resin-based material (Protemp; 3M); - Silicone Key: Transparent polyvinylsiloxane silicone (Exactear; GC). - Etch: 35% phosphoric acid (Ultra-Etch; Ultradent). - Adhesive: dental adhesive (G-Premio BOND; GC). - Flow Composite: AE (G-aenial Universal Injectable).	- 12 scalpel blade. - Interproximal stipes (Epitex; GC). - Diamond finishing burs and EVA handpiece burs and polished with polishing rubbers. - Flame shaped carbide bur. - Polishing spirals (Soft-Lex; 3M). - Silicone polishing brush. - Diamond polishing paste (DiaPolisher Paste; GC).	The injectable technique combines the simplicity and low cost of direct bonding with the precision and aesthetics of ceramic veneers, making it especially suitable for minimally invasive cases where predictability is key. However, for cases requiring high mechanical strength and long-term stability, ceramic veneers remain the gold standard.
		- Impressions: Condensation silicone (Speedex, Coltene, Allstaten). - Wax-up: silicone index (Zetalabor, Zhermack). - Mock-up: Resin-based material. - Silicone Key: Transparent silicon index (Elite transparent, Zhermack) - Etch: 35% phosphoric acid (Ultra Etch, Ultradent). - Adhesive: Adhesive system (ScotchBond, 3M Oralcare). - Flow Composite: Flowable resin composite (G-aenial Universal Flo BW, GC Corporation).	- Abrasive discs (Soft-Lex, 3M Oralcare). - Interproximal sandpaper strips (Epitex, GC). - Finishing rubbers (Prudent). - Polishing rubbers (Astropol Pink Ivoclar Vivadent). - Polishing paste (Enamelize, Cosmedent) on a felt disk (Diamond Flex, FGM).	The injectable technique enables precise anatomical replication with a simple, aesthetic, and functional outcome. However, limited colour stability and staining after one year are drawbacks. While it's a valuable clinical option, it doesn't replace conventional layering in anterior cases. Ongoing maintenance and patient follow-up are essential.
Use the composite resin technique with a flowable material to address esthetic concerns caused by irregular tooth anatomy, along with a finishing and polishing protocol to manage staining observed after one year of function. Ypei Gia et al (2021)⁽¹⁴⁾	1 year	- Impressions: Condensation silicone (Speedex, Coltene, Allstaten). - Wax-up: silicone index (Zetalabor, Zhermack). - Mock-up: Resin-based material. - Silicone Key: Transparent silicon index (Elite transparent, Zhermack) - Etch: 35% phosphoric acid (Ultra Etch, Ultradent). - Adhesive: Adhesive system (ScotchBond, 3M Oralcare). - Flow Composite: Flowable resin composite (G-aenial Universal Flo BW, GC Corporation).	- Abrasive discs (Soft-Lex, 3M Oralcare). - Interproximal sandpaper strips (Epitex, GC). - Finishing rubbers (Prudent). - Polishing rubbers (Astropol Pink Ivoclar Vivadent). - Polishing paste (Enamelize, Cosmedent) on a felt disk (Diamond Flex, FGM).	The injectable technique enables precise anatomical replication with a simple, aesthetic, and functional outcome. However, limited colour stability and staining after one year are drawbacks. While it's a valuable clinical option, it doesn't replace conventional layering in anterior cases. Ongoing maintenance and patient follow-up are essential.

Table 6: Clinical case reports selected.

Author/ Year	Aim	Follow-up	Materials	Polymerization	Finishing/ Polishing	Conclusion
Terry <i>et al</i> (2019) ⁽¹³⁾	To present and illustrate the Inverse Injection Layering Technique using a highly filled flowable resin composite for the aesthetic restoration of a single anterior tooth, focusing on precision, efficiency, and natural aesthetics.	12 years	- Impressions: Alginate.	- 40 seconds through the clear matrix from incisal, facial, and lingual aspects. - 40s after each step of tinting and composite application.	- Carbide finishing burs (ET6, Bras seller USA).	The inverse injection technique allows precise reproduction of the wax-up, creating highly aesthetic, natural-looking restorations. It is efficient, minimally invasive, and reproducible. Internal tinting enhances optical effects. Although more research is needed, 12 years of clinical use show excellent long-term aesthetic and functional outcomes.
			- Wax-up: analogue/conventional.		- 12D Scalpel blade.	
			- Mock-up: ---		- 30-fluted pyramid-shaped finishing bur (DET3 and H274, Brasseler).	
			- Etch: 37.5% Phosphoric Acid (Gel Etchant, Kerr).			
			- Adhesive: G-Premio Bond (GC America).			
- Silicone key: Clear VPS Matrix: Exaclear (GC America).		- Silicone points and hollow cups.				
- Flow Composite: G-aenial Universal Flo, shades AO1 (opaquing dentin) and B1 (translucent enamel).		- Goat hair wheel.		- Diamond polishing paste.		
-				- Sof-Lex spirals.		
David Geřtakovsk (2019) ⁽¹²⁾	To demonstrate the use and clinical effectiveness of the injectable composite resin technique, with slight modifications, for minimally invasive aesthetic and functional rehabilitation—specifically to close diastemas, improve tooth visibility, and establish proper guidance in lateral mandibular movement.	24 months	- Impressions: alginate.	- Initial flash cure: 3s. - Final light cure: 40s from buccal and incisal aspects through the silicone index. - Glycerine gel applied post-matrix: 20s.	- Scalpel.	The injectable technique provided stable, aesthetic, and functional results over 2 years with minimal invasiveness. Modifications enhanced control, and flowable composites showed excellent adaptability. Though less aesthetic than ceramics, it is reversible, cost-effective, and efficient—an excellent alternative when properly planned.
			- Wax-up: analogue/conventional.		- Dental probe.	
			- Mock-up: resin-based provisional material in the A2 shade (Pro temp, 3M Espe).		- EVA handpiece.	
			- Silicone Key transparent PVS (Mem osil 2, Heraeus Kulzer).		- Interproximal strips.	
			- Etch and Adhesive single-component adhesive (G-aenial Bond, GC).		- Polishing rubbers and brushes.	
- Flow Composite: Beautiful Flow Plus F03, Medium Viscosity, Shofu Dental.		- Polishing paste.				

Coachman et al (2020)⁽¹⁵⁾ To present an improved version of the direct injection technique using flowable composites and a digital workflow, offering a predictable, efficient, and minimally invasive option for anterior restorations—especially when full-mouth indirect options are not feasible.	- Impressions: Intraoral scanner. - Wax-up: DSD application, NEMO Smile design 3Dsoftware (Nemotec Company, Madrid, Spain). - Mock-up: 3D-printed model. - Silicone Key: Clear PVS trays made from 3D-printed models. - Etch: 38% phosphoric acid. - Adhesive: Adhesive Universal (Ivoclar Vivadent); - Flow Composite: Tetric Evoflow Bleach L, Ivoclar Vivadent).	- Nº12 scalpel. - Finishing burs. - Rubber cups. - Sof-Lex discs (3M ESPE, St Paul, MN, USA). - Polishing wheels and pastes. The improved injection technique is a minimally invasive, cost-effective, and aesthetic solution for anterior restorations. Enhanced by a digital workflow, it ensures precision and predictability. While flowables are not ideal for high-stress areas, they are suitable for aesthetic cases when expectations are managed, offering a practical alternative to indirect ceramic treatments.
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Table 7: Manually found articles

VI. Development

i. Composite Resin

Composite resins can be classified into three main categories based on their viscosity: flowable, conventional (medium-viscosity), and condensable (high-viscosity) composites.⁽³⁰⁾ Additionally, most contemporary resins fall under specific subcategories such as macro-filled, micro-filled, hybrid, micro-hybrid and nano-filled, based on filler particle. Furthermore, composite resins can also be classified according to their load (low, medium or high) and by their activation mode: photoactivated or chemically activated, with the last one is no longer in used.⁽¹⁵⁾

The physical and handling properties of composite-resins are largely determined by the type, size, and amount of filler particles.⁽¹⁷⁾ Flowable composites, originally characterized by their lower filler content, offer superior adaptability due to their enhanced flowability and flexibility, though they present reduced mechanical strength and increased wear susceptibility.⁽²³⁾

Technological advancements have been made with the aim of overcoming the limitations of flow resins. Allied with nanotechnology, experts have managed to develop densely nano-filled flowable composites, increasing inorganic filler content.⁽³¹⁾ Smaller filler particles permit better packing, reducing internal voids and allowing more uniform stress distribution. A high-volume fraction of filler particles increases wear resistance, reduce surface degradation, and provide a more durable restoration. These characteristics not only enhance mechanical behaviour, but also influence polymerization efficiency, which is closely associated with flexural strength.^(17, 23)

The most distinctive feature of injectable composites from flow composites is their use of full-coverage silane coating technology combined with ultrafine barium fillers measuring 150 nm, while maintaining a high filler load. At the same time these materials maintain an optimal viscosity and excellent adaptation, making them particularly suited for injection techniques.⁽²³⁾

The main monomers used in resin composites are UDMA, Bis-MEPP, TEGDMA, and Bis-GMA, each contribute distinct properties that affect the material's clinical performance.

UDMA provides good biocompatibility, low viscosity, and flexibility, improving marginal adaptation and reducing microleakage. It also shows low water sorption but is less stable against oxidation and can reduce the degree of polymerisation when used alone. It is widely employed in advanced composites such as *G-ænial Universal Flo*, *G-ænial A'CHORD*, and *everX Flow*.^(20, 24)

Bis-MEPP allows for high filler loading, improved dimensional stability, and colour retention, making it suitable for aesthetic restorations. However, it is more expensive and less studied than traditional monomers. It is a key monomer in *G-ænial Universal Injectable* and *G-aenial A'CHORD* and serves as an alternative to Bis-GMA.⁽¹⁶⁾

TEGDMA improves handling by lowering viscosity and increasing polymer conversion, but also contributes to high water sorption, polymerisation shrinkage, and has higher cytotoxic potential in large amounts. It's commonly found in composites like *Filtek Supreme XTE*, *Beautifil Injetável XSL*, and *everX Flow*.^(17, 24)

Bis-GMA offers strong mechanical properties and wear resistance, but due to its high viscosity and hydrophilicity, it requires diluent monomers and may lead to greater water uptake and discoloration. Its connection to bisphenol A raises biocompatibility concerns, though no clinical toxicity has been proven. It's used in many resin composites, including *Filtek Z350 XT* and *Tetric EvoFlow*.^(16, 19)

The monomer composition greatly influences the mechanical, aesthetic, and biological behaviour of resin composites. A balanced formulation is essential for achieving long-lasting and effective restorations.⁽¹⁹⁾

ii. Composite Resin: Properties

Flexural Strength and Modulus of Elasticity

Flexural strength refers to the maximum capacity of a material to resist fracture when subjected to a bending load. It is expressed in MPa and assessed based on the maximum load the material can withstand before breaking. According to ISO 4049:2019 the minimum flexural strength allowed is 80 MPa.⁽³⁾ Flexural strength gives information of a composite's structural reliability and its ability to resist fracture under occlusal (biting) forces.⁽²⁰⁾

Modulus of elasticity, or elastic modulus (flexural modulus) represents the stiffness of the material during bending, basically it's the ability of the material to deform elastically (without breaking). It is expressed in GPa.⁽³⁾ It reflects the stiffness of a composite and its capacity to endure occlusal forces without significant elastic deformation. Higher values indicate stiffer materials.⁽²⁰⁾

These properties depend on the type of resin matrix, degree of cross-linking and polymerization, as well as the type, size, and amount of filler content.⁽²⁰⁾

Associated with them, is the concept of deflection, which means how much a material deforms (in mm, for example) when a force is applied.⁽³⁾

A material's behaviour under load can be divided into two phases: elastic and plastic deformation. Before reaching the elastic limit - elastic deformation - deformation is reversible, and all absorbed energy is stored elastically. After this limit is exceeded, plastic deformation, materials suffer a permanent change. In this phase, energy is partially stored and partially dissipated. Deflection occurs throughout both phases, increasing progressively until fracture (Figure 2).⁽³⁾

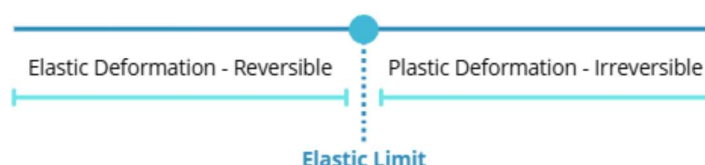


Figure 2: Resume of Elastic and Plastic Deformation.

Surface Hardness

Surface hardness refers to a material's ability to resist permanent deformation and surface wear. This property is affected by factors such as the composition of the resin matrix, the extent of cross-linking achieved during polymerization, and the type, size, and quantity of filler particles. Generally, materials with greater cross-linking density and higher filler loading exhibit superior surface hardness.⁽²⁰⁾ This parameter is critical for assessing the durability and wear resistance of resin composites.⁽¹⁶⁾

Mechanical and Wear Resistance

Improved wear resistance in resin composites is closely associated with a higher filler load. The volume percentage of filler particles plays a fundamental role in determining how much a material will wear over time. When filler particles are positioned closer together, there is less space for the organic matrix—the component most susceptible to wear. Larger filler particles reduce the amount of resin matrix and are more tightly packed, which also contributes to enhanced wear resistance.⁽¹⁷⁾

Unlike traditional flowable composites, highly filled flowable resins contain filler particles in similar size and volume percentages to those found in conventional composites.⁽¹⁷⁾

To further enhance wear resistance, several strategies can be applied: increase the overall filler volume; use smaller filler particles for better packing; improve the degree and depth of polymerization of the resin matrix; strengthen the bonding between the matrix and the filler (via silane coupling agents) and minimize the hardness difference between the resin matrix and the filler particles.⁽³⁰⁾

Surface Roughness

Surface roughness is a critical parameter in restorative dentistry, as it directly influences both the clinical performance and longevity of resin

composites. Higher surface roughness promotes biofilm formation and plaque accumulation, which can accelerate surface degradation and facilitate bacterial colonization, ultimately leading to secondary caries over time.⁽²⁰⁾

Surface roughness is largely determined by the filler size and content within the composite. Smooth surfaces not only enhance aesthetics but also contribute to the mechanical stability and durability of the restoration. In contrast, irregular surfaces may result in food impaction, plaque retention, gingival irritation, and recurrent decay.⁽¹⁷⁾

It is known that lower roughness values correlate with smoother and more clinically stable surfaces⁽¹⁶⁾, however composites with higher inorganic filler content and reduced organic matrix yielded smoother surfaces, particularly when polished using multi-step polishing systems.⁽²¹⁾

Polymerization: Depth of Cure

Polymerisation is a fundamental process that directly affects the mechanical strength, biocompatibility, and clinical longevity of resin-based composites. It is defined by the effective conversion of monomers into polymer chains. A higher degree of polymerisation, improves resistance to wear and fracture, enhances colour stability, and increases overall durability. However, it is also accompanied by polymerisation shrinkage stress, a multifactorial phenomenon that may compromise the marginal integrity of bonded restorations.
(17)

Depth of cure is defined as the maximum thickness of resin that can be adequately cured under specific light-curing conditions. It is influenced by several factors, including the type, size, and amount of filler, as well as the material's shade and thickness and the irradiation parameters (intensity, duration, and distance from the light source).

Insufficient polymerisation leads to a decline in the mechanical properties of composites and increases the risk of cytotoxicity, due to the presence of residual monomers in the material. In clinical terms, incomplete polymerisation and excessive shrinkage are significant contributors to long-term failures, such

as secondary caries and restoration loss, highlighting the importance of optimising polymerisation protocols.

Furthermore, translucency is governed by the volume and size of filler particles, as well as the refractive index mismatch between fillers and resin. Larger fillers, by reducing the filler–matrix interface, enhance light transmission and photo-initiator activation, improving polymerisation and optical clarity.⁽¹⁶⁾

Chemical and Optical Stability

Chemical stability is a multifactorial property closely linked to parameters such as microleakage, water sorption, contact angle, and wettability, all of which impact the optical behaviour and clinical performance of resin composites. These factors collectively influence stain resistance, and bacterial accumulation on restorations.

Microleakage is primarily associated with the material's modulus of elasticity (ME). Composites with a high ME are less flexible and more prone to stress concentration at the adhesive interface during polymerisation, increasing the risk of marginal leakage. In contrast, materials with a lower modulus exhibit better stress accommodation and adaptation to cavity walls, reducing microleakage.⁽²⁰⁾

Composites with higher hydrophilicity and increased resin matrix content are more susceptible to water absorption, which acts as a carrier for stains and promotes plasticisation, microcrack formation, and interfacial debonding. These effects compromise not only the aesthetic stability but also the mechanical integrity of the restoration.⁽²⁴⁾

Furthermore, excessive water sorption and solubility contribute to material expansion, structural weakening, and long-term failure. Water also facilitates the release of monomers and filler particles, impairing optical properties, biocompatibility, and longevity. While wettability is essential for adhesion, materials with lower surface free energy may provide improved resistance to external staining and biofilm accumulation.⁽¹⁹⁾

Biocompatibility

Biocompatibility refers to how well resin-based restorations interact with the biological environment of the oral cavity. In the presence of constant humidity, these materials are exposed to hygroscopic and hydrolytic degradation, which can result in the release of ions and residual monomers, particularly in cases of incomplete polymerisation or resin matrix breakdown. Both the composition of the resin matrix and the efficiency of the polymerisation process play a crucial role in determining the material's biocompatibility. ⁽³⁾

Since resin composites lack intrinsic antibacterial properties, they are prone to bacterial adhesion and biofilm formation. Unreacted monomers can enhance bacterial proliferation, especially of cariogenic species. The accumulation of biofilm at the tooth–restoration interface increases the likelihood of secondary caries, which remains one of the leading causes of failure in resin-based restorations. ⁽³⁾

iii. Direct restorative techniques

The Flow Composite Resin Injection Technique

The *Flow Composite Resin Injection Technique* (FCRIT) was first described by *Douglas A Terry* as the “reverse injection” technique, which basically came about as an alternative to the “free hand” technique using injectable resins.⁽¹⁾ Through it, clinicians can achieve high-quality restorations that balance form, function, and patient expectations.⁽¹³⁾

The technique is indicated in a wide range of clinical scenarios, however, has limitations and contraindications that must be considered. Both are represented at Table 8. ⁽¹⁰⁻¹²⁾

Indications	Contraindications
Diastema closure (small).	Black triangle closure - Unstable periodontal status or active inflammation.
Small tooth reshaping (e.g., peg laterals, little asymmetries).	Deep subgingival margins or lack of supragingival access.
Aesthetic rehabilitation with preserved enamel.	High caries risk patients without excellent oral hygiene.
Cases requiring reversible, non-invasive interventions.	Bruxism or parafunctional habits, unless combined with occlusal guards.
Functional corrections (e.g., lateral guidance, occlusal plane harmonization, establishing incisal edge length prior to esthetic crown lengthening, increasing VDO).	Extensive discoloration or cases demanding significant colour masking (due to limitations in polychromatic layering).
Patients with financial or biological constraints avoiding ceramics.	Severe crowding or rotation where index adaptation is compromised.

Table 8: Indications and Contraindications of the flow injection technique. ⁽¹⁰⁻¹²⁾

Advantages and Disadvantages

The technique is inherently non-preparatory, often requiring no reduction of enamel, preserving the natural tooth structure. This conservative nature aligns with modern principles of biomimetic and minimally invasive dentistry. ^(1, 14)

By transferring a diagnostic wax-up through a transparent silicone index, the technique allows precise replication of the desired morphology. ⁽¹²⁾ This makes it less operator-dependent than freehand techniques and allows standardization across cases. ⁽¹⁵⁾

It is significantly more affordable than ceramic veneers, providing an accessible option for patients seeking aesthetic improvements without the cost of indirect treatments. ⁽²⁸⁾

The clinical performance of modern injectable composites is considered acceptable, and in cases of wear or fracture, their functionality can be reliably restored through simple repair procedures. In this sense, their reversibility gives the option for this technique to also be considered semi-permanent and, if the patient wish to replace direct restorations with indirect ones in the future, replacement will not be complicated. ⁽²⁸⁾

Flowable resins, generally have lower wear resistance, hardness, and colour stability than ceramic alternatives.⁽²³⁾ Cases report staining and discoloration within 1 year,⁽¹⁴⁾ requiring maintenance and optimal polishing (prevent staining, plaque accumulation and bacterial adhesion).⁽²⁵⁾

Although more reproducible than freehand approaches, success heavily depends on the precision of the wax-up, the silicone index quality, and the photopolymerization protocol.⁽¹⁾ Errors in these steps may result in overflows, marginal gaps, or inadequate anatomy.⁽¹⁵⁾ Despite promising short-term outcomes (up to 2–3 years), clinical longevity data beyond 3 years is limited, particularly when compared to ceramic restorations. ⁽¹⁾

Advantages	Disadvantages
Minimally invasive.	Lower long-term colour stability.
Cost-effective.	Require repolishing.
Predictable and reproducible.	Depends on the precision of the wax-up and index.
Doesn't need manual dexterity.	Frequent maintenance.
Good aesthetic outcomes.	Good aesthetic outcomes.
Short chair time.	
Easily repairable.	
Digital workflow integration.	

Table 9: Advantages and Disadvantages of the FCRIT.

iv. Types of FCRIT

“Single Tooth Injection”

This technique consists of restoring a single tooth using only one transparent VPS index, which is previously fabricated with a single perforation corresponding to the tooth being treated.

A strategy to prevent unwanted overflow onto adjacent teeth was used by Geštakovski (2021) and Terry *et al.* (2019) (*Figure 3*)⁽¹³⁾ by employing PTFE tape

on the neighbouring teeth. This technique ensures that the injected composite remains confined to the targeted area, preserving interproximal contours and reducing the need for extensive finishing and polishing.^(1, 13)

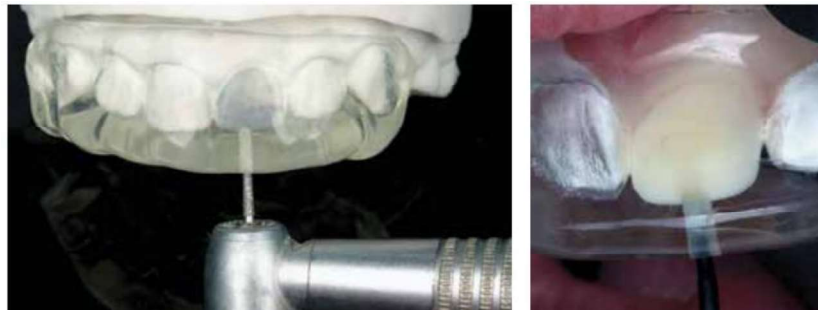


Figure 3: The clear VPS matrix was positioned over the maxillary arch, and flowable resin was injected through an access point using the inverse injection layering technique. Terry et al. (2019).

“Full Arch Injection”

This approach consists of the simultaneous restoration of several teeth, usually in the anterior sector, using a single silicone index that covers all the elements involved.⁽²⁸⁾

Hosaka et al. (2020), as they wanted to re-anatomise the two lateral incisors and the two maxillary canines, chose to do one quadrant at a time (e.g. 12, 13) and placed Teflon tape on the teeth in the next quadrant (e.g. 22,23) (Figure 4).⁽²⁸⁾

This type of technique is clinically efficient, because it reduces the number of sessions, since it's used a single silicone it's possible to maintain the anatomical references and symmetry between teeth. However, although this technique can be applied to individual teeth, it is often performed on teeth, which increases the risk of material overflow in the interproximal areas. To counter this disadvantage, retraction cord, PTFE tape, ties, or even high demand for rubber dam isolation and precision in positioning the index.^(1, 28)

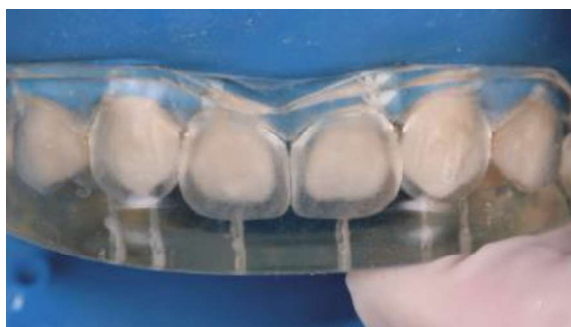


Figure 4: Checking the silicone index adjustment. Hosaka *et al.* (2020).

“Alternated Teeth Injection”

In this technique, the teeth are restored in an alternating sequence (e.g., 14, 12, 21, 23), and there are two ways to perform it: using either one or two VPS models.

When using a **single** VPS index, there are two options of wearing it: one described by Geštakovski (2019) and other by Ypei Gia *et al.* (2021).

Regarding the first one, mock-up spacers are placed on the adjacent teeth to preserve proximal contact and anatomical accuracy during the injection (Figure 5).⁽¹²⁾ Concerning the second one, instead of mock-ups, PTFE tape is placed on the adjacent teeth. The index is fabricated in the same way as for the other’s techniques, but instead of being used only once, it is applied in two separate stages (Figure 6).⁽¹⁴⁾



Figure 5: Mock-ups (space holders) prepared for treatment. Geštakovski (2019).

For example, Ypei Gia *et al.* (2021) planned to restore teeth from 14 to 23, so PTFE tape was placed on teeth 13, 11, 22 and 24. Then, the silicone index was properly fitted in the patient's mouth, and composite was injected through the perforations corresponding to teeth 14, 12, 21 and 23. After light curing and polishing those restorations, the same protocol was followed for the remaining teeth. ⁽¹⁴⁾



Figure 6: Different phases of the clinical case with initial and final photo. Ypei Gia *et al.* (2021).

An enhanced and more precise variation of the injection technique was described by Coachman *et al.* (2020), using **two** silicone indices. It involves initially performing a wax-up on alternating teeth, followed by taking an impression with transparent VPS to create the first silicone index (Figure 7(A))⁽¹⁵⁾. Once this step is complete, the wax-up is finalized for the remaining teeth, and a second VPS index is fabricated to reflect the complete wax-up (Figure 7(B)).⁽¹⁵⁾

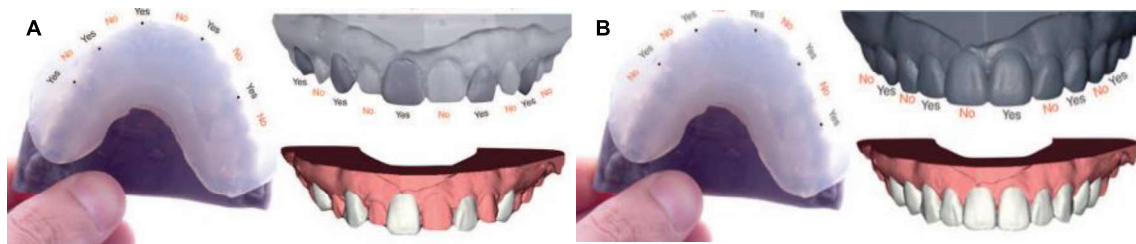


Figure 7: Partial digital wax-up, 3D-printed model, and first silicone index produced (A); Complete digital wax-up, 3D-printed model, and second silicone index produced (B). Coachman *et al.* (2020).

After proper isolation, etching, and adhesive application (Figure 8)⁽¹⁵⁾, the first index, “every other tooth”, is positioned in the patient’s mouth. It must fit tightly, ensuring a proper seal between the waxed and unwaxed teeth. This seal prevents the flowable composite from spilling into the embrasures or spreading onto adjacent teeth, allowing for precise polymerization within the designated waxed areas. Once the first set of restorations is cured and finished, the second index, with full wax-up, is applied to complete the remaining teeth using the same procedure (Figure 9(B)).⁽¹⁵⁾



Figure 8: Etching and bonding procedures for the first set of teeth to be restored. Coachman et al. (2020).

Between the first and second index, isolation of the teeth not involved in the initial wax-up must be performed using PTFE tape, chosen for its ultra-thin profile, which does not interfere with the accurate seating of the transparent VPS index. However, special attention is required during placement, as the tape tends to fold easily, potentially creating unwanted creases that could affect the final contour of the composite restorations (Figure 9(A)).⁽¹⁵⁾

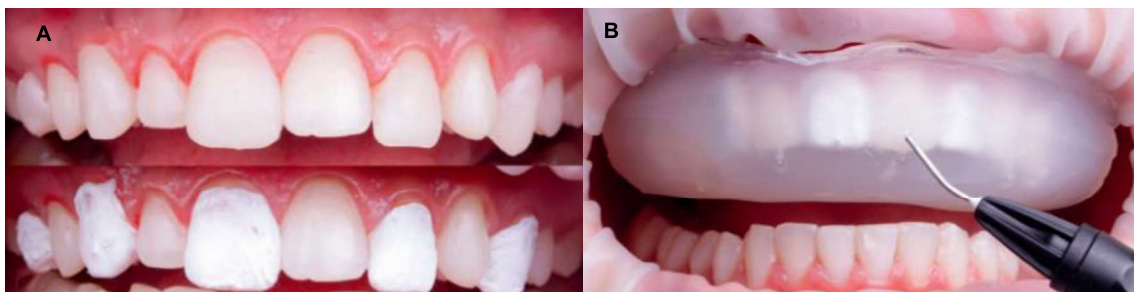


Figure 9: Clinical status after restoration, finishing, and polishing of the first set of teeth (A). Injection of flowable composite resin for the restoration of the second set of teeth using the second silicone index (B). Coachman et al. (2020).

“Bi-layering Injection”

Hosaka *et al.* (2021) employed this technique as a temporary or short-term definitive aesthetic solution for the replacement of missing anterior teeth. However, the same approach can be adapted to clinical scenarios involving remaining tooth structure, where a bilayer reconstruction, comprising both dentin and enamel, is needed. ⁽²⁷⁾

The bi-layering technique is characterized by using two transparent silicone indices were fabricated: one representing the dentin core (Figure 10(A)) ⁽²⁷⁾ and another for the final anatomical enamel contour (Figure 10(B)). ⁽²⁷⁾

In this specific case, small injection channels were created in the incisal regions of both indices and on the labial centre of the enamel index, which were cleaned with a micro-brush. ⁽²⁷⁾

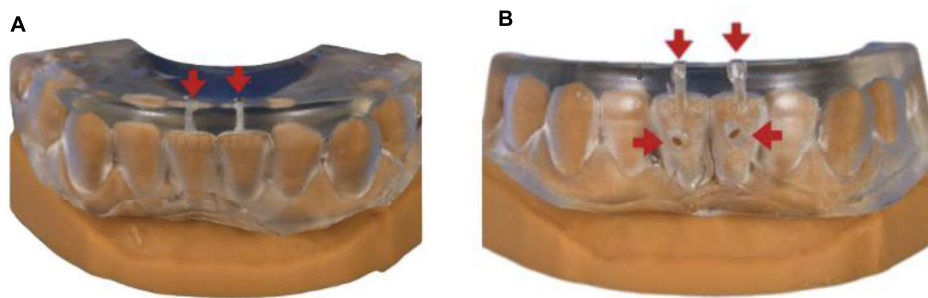


Figure 10: Clear polyvinyl siloxane dentin index (A). Enamel index (B). Small openings prepared for composite resin injection (red arrows). Hosaka *et al.* (2021).

After the preoperative assessment recorded and the virtual smile design created, a diagnostic wax-up must be prepared, followed by a labial and incisal cutback to define the ideal dentin shape and provide 0.5 mm of space for the enamel layer (Figure 11).⁽²⁷⁾

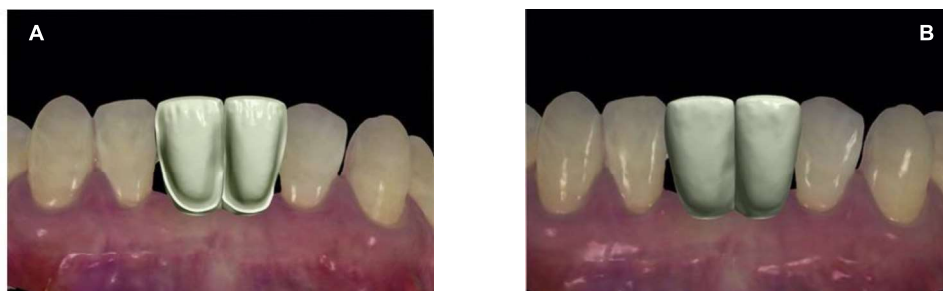


Figure 11: Digital waxing of dentinal core cutback (A). Anatomic contour digital waxing (B). Hosaka *et al.* (2021).

Then, etching and adhesive application must be performed directly on the teeth to be restored, rather than on the adjacent teeth, as was done in Hosaka's original clinical case. First, the dentin index is placed and fibre-reinforced flowable composite in dentin shade is injected through the incisal openings. After the light-curing and the excess removed, enamel index is positioned, and flow injectable resin, in enamel shade, is injected through labial and incisal ports. ⁽²⁷⁾

Although bi-layering injection technique requires a more comprehensive digital workflow, it substantially reduces technique sensitivity and chair time, while simultaneously delivering predictable and high-level aesthetic outcomes. The use of two different composite shades allowed for greater accuracy in mimicking the natural tooth structure, enhancing the realism and integration of the restoration. ⁽²⁷⁾

VII. Discussion

i. Resins versus Ceramics

Dental veneers are commonly used to correct aesthetic concerns such as tooth shape, colour, symmetry, and position. However, in cases of extensive structural compromise, full-coverage crowns may be more appropriate.⁽³²⁾

Current literature reveals a lack of consensus regarding the ideal choice of restorative material, whether composite resin or ceramic,⁽⁷⁾ with the decision depending on clinical goals, aesthetic demands, patient expectations, financial and time-related costs as well as the dentist's ability handle the chosen material or technique.⁽¹⁵⁾

Dental veneers can be fabricated from ceramic or composite resin materials,⁽⁴⁾ with ceramic veneers typically requiring tooth preparation, meaning prior reduction of the dental structure. Partial ceramic veneers, a more recent development, allow for more conservative preparation but still rely on the same indirect techniques, necessitating laboratory involvement and increased cost and chair time.⁽⁶⁾

It is well established that ceramic veneers offer advantages such as excellent aesthetics, long-term predictability, biocompatibility, and favourable biomechanical behaviour.⁽⁵⁾ However, ceramics absorb less stress before fracturing, high elastic modulus, renders them more brittle and prone to fracture under stress. In contrast, composite resins, have superior stress dissipation capacity, what leads to higher fracture resistance.^(6, 33)

With advances in adhesive systems and resin formulations, direct composite veneers have emerged as a conservative alternative, particularly for minimally invasive treatments.⁽²⁸⁾ Composite veneers are also largely attributed to significant improvements in their physical and mechanical properties.⁽²⁰⁾

Composite veneers restorations present several clinical advantages, including less removal of dental tissue, can be performed in a single appointment, while also being easier to repair or replace when needed, what is relatively cost-

effective.⁽⁷⁾ ⁽³⁴⁾ Nevertheless, direct composite restorations present certain limitations, including greater wear over time, loss of anatomical form, and lower colour stability compared to ceramics.⁽⁶⁾

Moreover, both ceramic and composite veneers are vulnerable to chemical and mechanical degradation from factors like acidic exposure and biofilm accumulation, which can affect their longevity and surface quality.^(35, 36)

Gresnigt et al. (2021) evaluated the fracture strength and failure modes of laminate veneers, partial laminate veneers, and composite restorations after aging. Their findings align with existing literature showing that ceramics, due to their higher elastic modulus (65–90 GPa), renders them more brittle and prone to fracture under stress, compared to composite resins, which exhibit a lower modulus (1.6–12.4 GPa) and greater resilience (Figure 12). ⁽⁶⁾

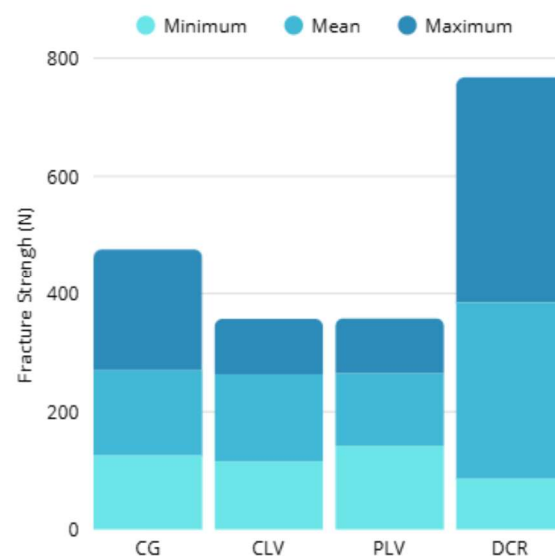


Figure 12: Fracture strength minimum, mean and maximum values expressed in Newtons (N) for: Control group, natural teeth (CG) - 271 (± 100); Conventional Laminate Veneer (CLV) - 264 (± 66); Partial Laminate Veneer (PLV) - 266 (± 69); Direct Composite Resin (DCR) - 385 (± 225). Adapted from Gresnigt et al. (2021).

ii. Composite Resin: Properties

Flexural Strength and Modulus of Elasticity

The study by Chen *et al.* (2024) evaluated four composite resins — GU (*G-ænial Universal Injectable*), FS (*Filtek Supreme*), BI (*Beautifil Injectable*), and DF (*Dyract Flowable Compomer*) — for flexural strength and modulus of

elasticity. GU exhibited the highest values in both properties, regardless of the water storage period. The overall performance ranking was GU > FS > BI > DF. These mechanical properties were significantly influenced by the inorganic filler content, particle morphology, and resin matrix composition. The complete silane coating technique used in GU enhanced the filler-matrix bond, contributing to superior mechanical performance.⁽³⁾

The study by Checchi *et al.* (2024) did not directly assess flexural strength or modulus of elasticity. However, it highlighted that highly filled flowable composites such as *G-ænial Universal Injectable* (GU) and *G-ænial Universal Flo* (Guf) exhibit mechanical behaviour compatible with occlusal restorations, suggesting satisfactory performance under functional loads.⁽¹⁷⁾

These findings are corroborated by Basheer *et al.* (2024), who reported that *G-ænial Universal Flo* exhibited significantly higher flexural strength compared to other tested flowable resins, although all materials presented lower elastic modulus values than the conventional nanohybrid composite *Filtek Z350 XT*.⁽²⁰⁾

Surface Hardness

Surface hardness was assessed by Ludovichetti *et al.* (2022) using the Vickers microhardness method. Bulk-fill composites showed higher hardness values compared to conventional flowables. *G-ænial Universal Injectable* demonstrated intermediate hardness, yet still superior to conventional flowable composites.⁽¹⁶⁾

Similarly, Basheer *et al.* (2024) found that *G-ænial Universal Flo* exhibited a hardness of 37.81 VHN, which was lower than the control composite *Filtek Z350 XT* (70.13 VHN), but higher than *G-ænial Universal Injectable* (27.49 VHN), indicating significant differences among the tested materials.⁽²⁰⁾

Mechanical and Wear Resistance

Checchi *et al.* (2024) observed that highly filled flowable composites demonstrated wear resistance comparable to traditional packable composites,

provided that the filler content was equivalent. GU and GUf showed good performance in occlusal areas due to their high filler loading (82% and 69% by weight, respectively).⁽¹⁷⁾

Chen *et al.* (2024) also highlighted that nanocomposite exhibited superior wear resistance compared to compomers, possibly due to their higher flexural strength and elastic recovery capacity.⁽³⁾

Elsahn *et al.* (2023) tested four groups: *Beautiful Injectable X* (BF), *G-ænial Universal Injectable* (GU), *SonicFill 2* (SF), and the *CAD/CAM-milled composite Cerasmart* (CS). GU exhibited the lowest volumetric wear ($1.9 \pm 0.26 \text{ mm}^3$), indicating the highest wear resistance among all materials tested. SF showed the highest wear ($10.4 \pm 1.44 \text{ mm}^3$), followed by BF ($5.8 \pm 0.75 \text{ mm}^3$), and CS ($3.7 \pm 1.12 \text{ mm}^3$). GU's superior filler-matrix bonding, facilitated by full-coverage silane coating and ultrafine barium fillers—contributed to its better performance in resisting wear.⁽²¹⁾

Surface Roughness

Ludovichetti *et al.* (2022) reported that *Tetric EvoFlow* had the roughest surface, which may affect its polish ability and long-term surface integrity. In contrast, *G-ænial Universal Injectable* and *G-ænial Flo X* exhibited smoother surfaces, suggesting superior finish and potentially better clinical performance in aesthetic areas.⁽¹⁶⁾

Checchi *et al.* (2024) measured surface roughness before and after simulated mastication using a precision profilometer. GUf exhibited the lowest final roughness values among the tested materials, showing minimal surface alteration.⁽¹⁷⁾

Elsahn *et al.* (2023) provided further insight by evaluating surface roughness before and after thermomechanical cycling, and the results suggest that GU offers the most stable surface characteristics among injectable composites when subjected to aging protocols.⁽²¹⁾

Polymerization: Depth of Cure

The same study by Ludovichetti *et al.* (2022) showed that bulk-fill composites achieved an average depth of cure greater than 4 mm, significantly exceeding that of conventional composites (ranging between 2.58–2.84 mm). The high-strength injectable composite (*G-ænial Universal Injectable*) presented intermediate values, confirming its clinical suitability for slightly thicker increments. ⁽¹⁶⁾

Chemical Stability and Optical Stability

Basheer *et al.* (2024) conducted microleakage tests in Class V cavities, demonstrating that *G-ænial Universal Flo* had the lowest microleakage scores among the tested materials. This suggests greater chemical stability and lower water sorption under thermocycling conditions. ⁽²⁰⁾

Uctasli *et al.* (2023) investigated the colour stability of six composite resins after immersion in commonly consumed beverages. *G-ænial Universal Flo* and *A'CHORD* showed significant colour change after immersion in acidic beverages, especially coffee and wine. However, repolishing was effective in reducing ΔE values. These findings indicate moderate to good optical stability, influenced by factors such as monomer type and surface porosity. ⁽²⁴⁾

Bai *et al.* (2024) evaluated the chemical and optical stability of four restorative materials. *G-ænial Universal Injectable* showed the best overall performance, with low water sorption and solubility, high translucency - closely resembling natural enamel - and good colour stability. *Filtek Supreme Flowable* had the most stable colour, while *Beautiful Injectable* and *Dyract Flow* (DF) showed greater colour changes and higher ion release. DF performed the worst, with high water uptake, poor translucency, and optical instability, becoming opaquer over time. ⁽¹⁹⁾

Biocompatibility

Chen *et al.* (2024) evaluated cell viability and the morphology of *Streptococcus mutans* biofilms on the tested materials. GU and FS resins

demonstrated better biocompatibility and favourable cellular responses, with low toxicity levels and suitable cell adhesion characteristics. ⁽³⁾

iii. The Resin-Composite Flow Injectable Technique

Based on the literature provided, the injectable resin composite technique follows a meticulously defined protocol that encompasses three key phases: planning, patient preparation, and injection technique. The integration of digital workflows and the selection of appropriate materials are essential for the success of this minimally invasive approach.

1. Planning Phase (Impressions, wax-up, mock-up)

The planning stage is pivotal and initiates the entire workflow. It encompasses diagnostic, functional, and aesthetic evaluations.

Regarding the intraoral impressions, Geštakovski *et al.* (2021) and Hosaka *et al.* (2020) describe the use of intraoral scanners (e.g., *TRIOS 3*) as a preferred method in digitally equipped clinics, providing high accuracy and efficiency for 3D printing of diagnostic models. ^(1, 28) Salem *et al.* (2021) and Ypei Gia *et al.* (2021) report using alginate or condensation silicone to obtain initial impressions, which are then poured in stone for manual wax-ups. ^(14, 29)

The planning begins with an aesthetic and functional analysis of the case. A Digital Smile Design (DSD) process is frequently employed, often using systems such as 3Shape or DSDApp, to simulate the desired outcome. This step allows the bio-copy of ideal morphology. Alternatively, a manual wax-up may be created on a stone cast when digital resources are unavailable. ^(1, 15)

Before proceeding, a mock-up is fabricated using bis-acryl materials or *Protemp* resin. It is trailed intraorally to validate aesthetic parameters, phonetics, occlusion, and functional movements. ⁽²⁹⁾

When carrying out the diagnosis and wax-up, it is necessary to understand symmetry and dominance, this means it's essential to know the average length of the teeth (Figure 13) ⁽³⁷⁾ and how they vary according to age and gender. The

concept of proportion follows a gradual dimensional progression from the central incisors to the canines, a concept often referred to as the golden proportion. The principles of dental aesthetics rely on achieving harmonious proportions between the teeth and a balanced relationship between the white architecture (teeth) and the architecture (gum tissue).⁽³²⁾

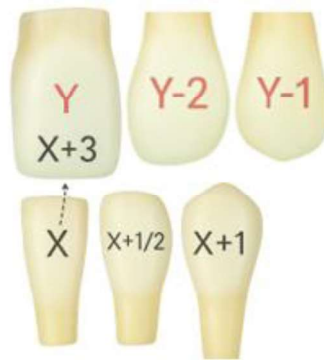


Figure 13: Average length of the teeth.
Pascal Magne (2004).

In addition, it is crucial to assess certain parameters such as: the midline, position of the incisal edges of the upper central incisors; tooth exposure at rest; maxillary occlusal plane; gingival exposure; gingival levels and tooth lengths (proportions); smile line and mouth corridors; tooth alignment; zeniths, contact areas and axial inclinations; tooth shape and surface texture; position of the lower teeth.⁽¹³⁾

2. Patient Preparation: Clinical Readiness (Periodontal assessment, tooth whitening, isolation)

Proper clinical preparation ensures favourable bonding and long-term tissue health.

Gingival health must be optimal, and is a prerequisite.⁽¹²⁾ Gingivectomy or laser-assisted contouring may be required if hypertrophic papillae or an irregular zenith line are observed.⁽²⁸⁾

Prior to restoration, bleaching (16% carbamide peroxide) is advised to harmonize shades. A two-week waiting period post-whitening allows shade stabilization and optimal bond strength. In some cases, rubber dam isolation is

applied when multiple restorations are planned. However, no matter how thin the rubber dam is, it always takes up space, which was not considered when the matrix was made. This can lead to a misalignment of the matrix, which translates into a misaligned restoration. ^(1, 28)

Each tooth, to be restored, is individually isolated using PTFE tape and gingival cords. This prevents contamination and controls the flow of resin, especially in the sulcus. ⁽¹⁴⁾

3. Injection Technique: Materials and Protocol

3.1 Transparent Silicone Index Fabrication

The transparent silicone index used in the injectable resin composite technique plays a crucial role in transferring the morphology of a wax-up to the final restoration. The fabrication process, material selection, and especially thickness is decisive for the accuracy, functionality, and aesthetic outcomes.

The most used material is transparent vinyl polysiloxane (VPS), with *Exaclear* (GC) being the most studied and clinically preferred due to its high translucency and manageable elasticity. These properties allow sufficient light-curing through the index and enable visualization of resin flow during injection. According to Machado *et al.* (2024), *Exaclear* demonstrates superior translucency and light irradiance transmittance compared to other VPS materials, such as *Affinity Crystal*, *Clear Bite*, and *Memosil 2*.⁽²⁶⁾

The thickness of the VPS index significantly impacts its accuracy, rigidity, and curing efficiency. Zhu *et al.* (2025) showed that 4 mm thickness is the minimum and sufficient to achieve clinically acceptable trueness and precision. There were no significant improvements in accuracy between 4 mm and 6 mm indices, although 2 mm was deemed insufficient due to deformation and dimensional inaccuracy. ⁽¹⁰⁾

Thicker indices (≥ 6 mm) improve rigidity but reduce light transmittance, requiring longer curing times. According to Machado *et al.* (2024), irradiance through 4 mm of *Exaclear* was sufficient to reach a radiant exposure of 10 J/cm² within 13–14 seconds, supporting adequate polymerization. ⁽²⁶⁾

The fabrication process begins with a digital or manual wax-up of the ideal tooth morphology. The stone model or 3D print is then hydrated or cleaned to eliminate surface tension and prevent air entrapment. When applicable, a customised 3D-printed tray is used to ensure a uniform silicone thickness (typically 4 mm) ⁽¹⁰⁾ and to incorporate vertical stops for precise seating during polymerisation.⁽⁹⁾

The VPS material (e.g., *Exaclear*) is injected into the tray and positioned over the model, followed by polymerisation in a pressure chamber at 0.3 MPa for 20 minutes to prevent the formation of voids and to optimise adaptation. After full setting (typically after 24 hours), access holes are created in the incisal or buccal areas using a diamond bur to allow precise injection of the flowable composite resin. These entry points must be cleaned with a micro-brush to ensure unobstructed resin flow and optimal bonding performance.^(9, 26)

Spadoni *et al.* (2025) used a three-layer transparent silicone index was employed to precisely replicate the diagnostic wax-up in direct composite restorations. This complex index was composed of three distinct layers:

- Layer 1: to provide structural stability in the posterior region.
- Layer 2 to serve to minimise flexural deformation during handling and injection.
- Layer 3: to enhance light transmission for effective polymerisation.

They were strategically placed perforations at the incisal edges ensuring a calibrated and controlled resin flow during the injection phase. The index was fabricated using *EXACLEAR GC* Transparent Silicone (durometer hardness ~60 Shore-A) for the moulding template, *ERCO-DURE* thermoformed plates (2–3 mm thickness) for final retention and stabilisation, and *LASCODE ERGASIL* Double Paste A + B silicone (70 Shore-A hardness) to enhance stability and sealing (Figure 14).⁽⁵⁾

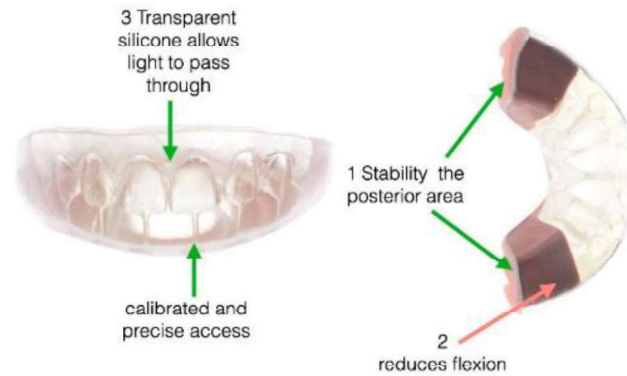


Figure 14: The three-layer silicon index's parts. Spadoni et al. (2025).

3.2 Tooth Preparation and Adhesion

Prior to any adhesive step, the tooth surfaces must be cleaned and isolated to ensure optimal adhesion. Cleaning is performed using prophylactic pastes (fluoride-free) or air-polishing devices (e.g., sodium bicarbonate) to eliminate plaque and debris.⁽²⁷⁾ Isolation is achieved using a rubber dam or, alternatively, gingival retractors and PTFE tape (Teflon) to protect adjacent teeth from unintentional bonding.⁽²⁸⁾

Etching is performed using 35(14)–38% phosphoric acid on enamel surfaces, being the 37% phosphoric acid the most accurate choice.⁽²⁸⁾ Etching time ranges from 15 to 30 seconds, depending on the material and manufacturer's instructions. The operator must be careful to avoid etching exposed dentin, as this may compromise bond durability or increase sensitivity.⁽²⁷⁾

Universal adhesives are widely used in the injectable technique due to their versatility and compatibility with both etch-and-rinse and self-etch modes. *G-Premio Bond* (GC Corp)⁽²⁸⁾ and *CLEARFIL SE BOND 2* (Kuraray Noritake)⁽²⁷⁾ are commonly applied using a micro-brush, then gently air-thinned and light-cured for 10–20 seconds.⁽²⁹⁾

3.3 Composite Injection

G-ænial Universal Injectable (GU) is the most appropriate resin for the FCRT, especially when aiming for: high mechanical resistance (flexural strength

and wear)^(3, 21), predictable aesthetic outcomes⁽¹³⁾, reliable biocompatibility⁽³⁾ and chemical stability^(19, 24). It provides a superior balance of handling, performance, and aesthetic integrity, making it ideal for both anterior and posterior restorative applications.

In this phase of the technique, after the VPS matrix is well adjusted to the remaining tooth structures, the highly filled flowable resin is injected through the index perforations. It is crucial that the injection is carried out slowly and continuously, to avoid air bubbles, until the material slightly overflows, ensuring complete fill. ⁽¹⁾

After injecting the flow resin, light-curing takes place. The light curing process can start with an initial pre-curing (optional), which consists of light curing for 2-3 seconds to remove excess with a probe or scalpel blade number 12⁽¹⁴⁾. Then, with the index still in place, principal light-curing begins, for 40 to 60 seconds per side (buccal and palatal/lingual). The lamp should be perpendicular to the index surface to maximise light penetration. ⁽²⁸⁾ Finally, after removing the index, additional light curing is carried out for 20-40 seconds per side to ensure complete polymerisation of the interproximal areas and cervical margins.⁽²⁹⁾ It is also recommended to irradiate the incisal or proximal edges to reach shaded or thickened areas of the index.⁽¹⁴⁾

3.4 Finishing and Polishing

The finishing and polishing protocol in the context of the injectable composite resin technique plays a critical role in achieving long-term aesthetic success, surface integrity, and biological compatibility. Several key studies, including Degirmenci *et al.* (2023), Vulović *et al.* (2023), and Uctasli *et al.* (2023), provide evidence-based guidance on optimal procedures, tools, and materials for finishing injectable composites such as G-ænial Universal Injectable.

The final surface of a composite restoration significantly affects optical properties (translucency, gloss, chroma), surface roughness, which influences plaque accumulation and bacterial adhesion (notably *Streptococcus mutans*), colour stability and resistance to staining, wear resistance and marginal

adaptation. A smooth, polished surface reduces staining and enhances aesthetics, particularly in anterior restorations.⁽²³⁾

After removing the transparent silicone index, initial finishing, the gross excess must be removed with a scalpel blade n°12 and fine-grit diamond burs.⁽²⁾ The interproximal areas can be addressed with finishing strips.^(2, 14)

According to Degirmenci *et al.* (2023) the best-performing polishing systems are *Sof-Lex™ Discs* (3M ESPE) with aluminum oxide and a multi-step system (medium, fine, ultra-fine), and *Sof-Lex™ Spirals* with elastomer plus aluminium oxide and a two-step system. *OneGloss™* (Shofu) and *PoGo™* (Dentsply) are one-step polishers with silicon or diamond particles, and these left significantly rougher surfaces and promoted greater bacterial adherence, especially in flowable composites.⁽²³⁾

After index removal and initial finishing, is necessary apply glycerine gel to the buccal and interproximal surface and light-cure for 20 seconds to remove the oxygen-inhibited layer and improve surface hardness. Finally, remove the glycerine with a jet of water and air.^(2, 29)

In this way, after glycerine removal, the sequential polishing starts beginning with *Sof-Lex™ Discs* medium, then fine, and ending with ultra-fine (each for ~15–30 seconds). They must be operated at low speed (7,000–10,000 RPM) with moderate pressure to uniform Effect. Alternatively, or additionally, *Sof-Lex™ Spirals* can be used in two steps, fine and superfine (20 seconds each) under water coolant.⁽²⁵⁾

Then, to optimise the results, it is advisable to apply a fine or extra-fine polishing paste with aluminium oxide, silicon carbide or diamond, combined with a goat's hairbrush or rotating felt. After that the dentist should rinse thoroughly with water spray, dry and evaluate under good lighting for gloss and smoothness. If staining is detected over time, repolishing effectively reduces ΔE colour changes.⁽²⁴⁾

4. Injection Technique: Workflow

4.1 Follow-up

Regular clinical follow-up appointments are essential to monitor the integrity of restorations placed using the injectable technique. These reviews help detect early signs of surface staining, marginal deterioration, or wear that may compromise the restoration over time.

According to Ypei Gia *et al.* (2021), restorations placed using flowable resin composites showed signs of marginal staining and surface degradation after one year of service. The authors emphasize the importance of periodic follow-ups, recommending that patients be recalled every six months for evaluation and early intervention if needed.⁽¹⁴⁾

Similarly, Salem *et al.* (2021) advised routine check-ups, especially for patients exposed to higher risk factors such as erosion, recommending a three- to six-month recall for professional monitoring.⁽²⁹⁾

4.2 Re-polishing

Although highly filled injectable composites offer improved mechanical properties, they remain susceptible to gloss loss and superficial degradation in the oral environment.

To combat this, re-polishing or surface sealant application (glaze) can be considered in long-term maintenance to restore lustre and protect against micro-abrasion. In the case reported by Terry *et al.* (2019), the use of polishing pastes and soft brushes (e.g., goat-hair wheels) combined with a final dry buffing technique was shown to enhance surface reflectivity and prolong aesthetic performance.⁽¹³⁾

The aesthetic longevity of injectable resin restorations depends significantly on maintaining surface smoothness and gloss. Professional polishing using multi-step abrasive systems improves both the appearance and resistance to bacterial colonization, therefore is strongly recommended at each recall visit to preserve optical and biological performance.⁽²⁵⁾

iv. Limitations

Despite significant advancements in resin composite materials, notable limitations persist across the current body of literature.

One key issue is the lack of consensus regarding the ideal choice of composite resin, as different studies highlight varying strengths depending on the material's composition and clinical application. For instance, while Bai *et al.* (2024) reported superior chemical and optical stability for *G-aenial Universal Injectable* (GU), *Filtek Supreme Flowable* (FS) demonstrated better colour stability, and *Beautifil Injectable XSL* (BI) showed intermediate performance, reflecting variability in material behaviour under similar testing conditions and complicating material selection for clinicians.⁽¹⁹⁾

Furthermore, differences in light-curing protocols represent a methodological limitation across studies. Studies vary widely in terms of light intensity, curing time, direction of irradiation, and the use of glycerine gel to eliminate the oxygen-inhibited layer. For instance, Ypei Gia *et al.* (2021) recommended 30 seconds per surface⁽¹⁴⁾, while Terry *et al.* (2019) applied 40 seconds in multiple directions followed by glycerine application to enhance polymerization.⁽¹³⁾ These discrepancies can affect the depth of cure, cross-linking efficiency, and mechanical integrity of the restoration. Additionally, studies such as those by Ludovichetti *et al.* (2022) and Elsahn *et al.* (2023) adopted different irradiance values and curing devices, which introduces further methodological variability, complicating the clinical interpretation of performance outcomes.^(16, 21)

Perhaps the most critical limitation is the scarcity of long-term clinical studies evaluating the longevity and performance of restorations placed using the injectable composite technique. Most available evidence is derived from case reports or short-term follow-ups (up to 2 years).⁽²⁹⁾ Additionally, a notable lack of long-term *in vivo* studies limits understanding of the true longevity of injectable composite techniques. Most evidence is derived from short-term *in vitro* assessments that do not fully replicate the complex oral environment. As a result, extrapolation to clinical practice must be approached with caution, and further longitudinal, controlled clinical trials are warranted to assess durability and

predictability over time. Future longitudinal research is essential to validate the predictability of this technique in routine clinical practice.

v. Clinical implications

The injectable composite resin technique has demonstrated valuable clinical potential and continues to evolve in its application within daily practice, especially to newly graduated dentists. This technique offers a conservative, aesthetic, and cost-effective solution for the restoration of anterior teeth, particularly in cases involving diastemas, tooth wear, shape anomalies, and aesthetic corrections, without the need for extensive tooth preparation. Its ease of use and reproducibility make it highly applicable in general dental settings, especially when a wax-up and silicone index are available for guided execution.

Several refinements have been introduced to enhance the efficiency and predictability of the injectable composite resin technique:

- The use of digital wax-ups and 3D-printed models has improved the precision of anatomical reproduction and the fabrication of silicone indices.
- The bilayer technique, utilizing two separate silicone indices for dentin and enamel, enables more natural aesthetic layering, as highlighted by Hosaka *et al.* (2021)⁽²⁷⁾.
- The application of glycerine gel and multi-directional curing have enhanced the depth of cure and surface hardness.
- Isolation methods such as PTFE tape, retraction cords, and mock-up spacers have proven effective in maintaining interproximal integrity and reducing finishing time.
- A structured maintenance protocol involving six-month recall appointments, professional polishing, and re-glazing when needed helps preserve the aesthetics and longevity of the restorations.

VIII. Conclusion

In conclusion, this systematic review clarifies that:

The Flow Composite Injection Technique is a predictable and effective approach for achieving aesthetic and functional anterior restorations, particularly in cases demanding minimally invasive, affordable, and time-efficient treatment. While not a replacement for all restorative strategies, it represents a viable alternative to both freehand direct composites and indirect ceramics, particularly when guided by proper planning and executed within a structured clinical workflow.

Furthermore, careful evaluation of the clinical case is essential to ensure that both the selected technique and restorative material are appropriate and tailored to the specific needs of the patient.

Among the flowable composites evaluated, G-ænial Universal Injectable consistently demonstrated superior performance in terms of mechanical strength, wear resistance, surface smoothness, and chemical stability, offering an ideal balance between ease of application and long-term clinical performance. Therefore, polishing should not be viewed as a mere cosmetic step, but as a key phase in achieving long-term clinical success. However, it is essential to be familiar with other flowable composite resins, as each clinical case is unique, and a material that works well in most situations may not be the most appropriate choice for a specific case.

The quality of the silicone matrix plays a crucial role in the accuracy and success of the FIT. Although direct evidence is limited, existing literature and clinical observations suggest that the matrix's thickness, transparency, and flexibility significantly influence light transmission, material adaptation, and marginal integrity. An optimal matrix should be thin, clear, and dimensionally stable, accurately replicating the wax-up without deforming during injection or curing. Additionally, using standardized thickness and properly positioned vents and injection channels enhances procedural precision and minimizes errors.

The Flow Composite Injection Technique has demonstrated valuable clinical potential and continues to evolve in its application within daily practice, enhancing efficiency and predictability. Nevertheless, despite promising short-term outcomes, the technique still lacks long-term clinical evidence, regarding endurance and longevity. Further research is essential to confirm its durability and support its broader implementation in everyday dentistry.

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X. Attachments

Attachment I: QUIN Tool.

Criteria	Bai et al (2024)	Basheer et al (2024)	Checchi et al (2024)	Chen et al (2024)	Elsahn et al (2023)	Ludovichetti et al (2022)	Vulović et al (2024)
Study objective clearly defined and justified	2	2	2	2	2	2	2
Sample size calculation reported	0	2	2	0	2	2	2
Sampling method adequately described	2	2	2	2	2	2	2
Clear description of comparison groups	2	2	2	2	2	2	2
Detailed and reproducible methodology	2	2	2	2	2	2	2
Operator information and qualifications provided	1	1	1	1	1	1	2
Randomization of samples or procedures	0	2	1	1	2	1	2
Appropriate and validated outcome measurement methods	2	2	2	2	2	2	2
Blinded or calibrated outcome assessors identified	0	1	1	1	1	1	1
Blinding procedure adequately described	0	0	0	0	9	0	0
Appropriate statistical analysis	2	2	2	2	2	2	2
Clear, complete and consistent result presentation	2	2	2	2	2	2	2
Total score (0-24)	15	20	19	17	20	19	21
Percentage (0-100%)	62,5%	83,3%	79,2%	70,8%	83,3%	79,2%	87,5%

Attachment II: QUIN Tool (continuation).

Criteria	Degirmenci et al (2023)	Uctasli et al (2023)	Vulović et al (2023)	Kouri et al (2023)	Machado et al (2024)	Zhu et al (2025)
Study objective clearly defined and justified	2	2	2	2	2	2
Sample size calculation reported	2	1	2	2	2	1
Sampling method adequately described	2	2	2	2	2	2
Clear description of comparison groups	2	2	2	2	2	2
Detailed and reproducible methodology	2	2	2	2	2	2
Operator information and qualifications provided	2	2	2	2	1	1
Randomization of samples or procedures	2	2	2	1	0	2
Appropriate and validated outcome measurement methods	2	2	2	2	2	2
Blinded or calibrated outcome assessors identified	1	1	1	1	1	1
Blinding procedure adequately described	0	0	0	0	0	0
Appropriate statistical analysis	2	2	2	2	2	2
Clear, complete and consistent result presentation	2	2	2	2	2	2
Total score (0-24)	21	20	21	20	18	19
Percentage (0-100%)	87,5%	83,3%	87,5%	83,3%	75%	79,2%

Attachment III: Composite-Resins composition and characteristics.

Material	Type of Material	Resin component	Filler composition	Filler diameter	Filler Weight%
G-aenial Universal Flo (20, 23-25)	Flowable Nano-hybrid	UDMA, Bis-MEPP, TEGDMA	Silicon Dioxide, Strontium glass	200 nm	69%
G-aenial Universal Injectable (16, 17, 20, 21, 23-25)	Nano-filled High strength Injectable Flowable	UDMA, Bis-EMA, Methacrylate monomers	Silica, Barium glass	150 nm	69%
G-aenial Flo X ⁽¹⁶⁾	Micro-hybrid flowable Composite	UDMA, Bis-EMA derivatives	Silica, Barium glass	Not specified	69%
G-aenial Anterior ⁽²³⁾	Micro-hybrid conventional composite resin	UDMA, Bis-EMA derivatives	Strontium glass, Lanthanoid fluoride, Silica, Fumed Silica, Silica glass	850 nm	76%
G-aenial A'CHORD ^(17, 24)	Universal composite	Bis-MEPP, UDMA	Barium glass, Silicon dioxide, Lanthanide, Strontium	Not specified	79%-82%

Attachment IV: Composite-Resins composition and characteristics (continuation).

Material	Type of Material	Resin component	Filler composition	Filler diameter	Filler Weight%
Filtek™ Universal Restorative ⁽²⁴⁾	Nano-filled universal	AUDMA, AFM, DUDMA, and DDDMA	Silica and zirconia	Not specified	76.5%
Filtek Z350 XT ⁽²⁰⁾	Nanohybrid multipurpose	Bis-GMA, UDMA, TEGDMA, Bis-EMA,	Silica/Zirconia nanoclusters	5–20 nm	78.5%
Filtek Supreme XTE ⁽¹⁶⁾	Nano-filled flowable composite	BisGMA, TEGMA, Procrylat	Silica/Zirconia, Ytterbium trifluoride (YbF3)	Not specified	65%
Filtek Supreme Flowable ⁽²⁵⁾	Nano-filled flowable composite	BisGMA, TEGDMA, Procrylat	Ytterbium trifluoride (YBF3), Silicon dioxide (SiO2), Zirconia	Not specified	65%
Filtek Bulk Fill Flowable ⁽¹⁶⁾	Flowable bulk fill composite	BisGMA, BisEMA, Procrylat, UDMA	Silica/Zirconia, Ytterbium trifluoride (YbF3)	Not specified	64.5%
Beautiful Injectable X ⁽²¹⁾	Injectable Bioactive Giomer	Bis-GMA, TEGDMA, Bis-MPEPP	S-PRG fillers based on aluminofluoroborosilicate glass-Al2O3	0.8 µm	64%
Beautiful Injetável XSL ⁽³⁾	Injectable nanocomposite	Bis-GMA, UDMA, TEGDMA, HEMA	Aluminofluoroborosilicate glass	Not specified	63.6&
Beautiful Flow Plus x F00 ⁽²⁰⁾	Bioactive flowable Giomer	Bis-GMA TEGDMA	S-PRG fillers based on aluminofluoroborosilicate glass-Al2O3	0.8 µm	60%

Attachment V: Composite-Resins composition and characteristics (continuation).

Material	Type of Material	Resin component	Filler composition	Filler diameter	Filler Weight%
EverX Flow ⁽²⁴⁾	Short fibre reinforced flowable	Bis-EMA, TEGDMA, UDM	Short glass fiber, barium glass fillers	Not specified	70%
SDR flow+ ⁽²⁴⁾	Bulk fill flowable	TEGDMA, EBPADMA	Barium borosilicate glass	Not specified	68%
Tetric EvoFlow ⁽²⁵⁾	Nanohybrid flowable composite resin	Dimethacrylate	Barium (Ba) glass, Ytterbium trifluoride (YBF3), Silicon dioxide (SiO2), Mixed oxide copolymer	Not specified	57.5%
Tetric EvoFlow Bulk Fill ⁽¹⁶⁾	Nanohybrid flowable bulk fill composite resin	BisGMA, DMA	Barium alumino-fluoro-silicate glasses	Not specified	80%
Clearfil Majesty ES-2 ⁽¹⁷⁾	Nano-hybrid composite resin	10-Methacryloyloxydecyl dihydrogen phosphate (MDP)	Silanated barium glass	0.7 µm	66%
Clearfil Majesty ES Flow ⁽¹⁷⁾	Flowable nano-hybrid composite resin	Triethylene glycol dimethacrylate (TEGDMA), Hydrophobic aromatic dimethacrylate	Silanated barium glass, silanated colloidal silica	0.18–3.5µm	78%
Dyract Flowable Compomer Restorative ⁽³⁾	Flowable compomer	Phosphoric acid modified polymerizable monomers, carboxylic acid modified macromonomers	Strontium-alumino-fluoro-silicate glass	1.60 µm	63%
SonicFill 2 ⁽²¹⁾	Bulk-fill composite	Bis-GMA, TEGDMA, Bis-EMA	Silica, barium glass, YbF3, mixed oxides	0.4 µm	83.5%
Cerasmart ⁽²¹⁾	Resin matrix ceramic	Bis-MEPP, UDMA, dimethacrylate	Silica, Barium glass	<500nm	71%

Attachment VI: *Compressive modulus, translucency, and light curing transmittance and time of four clear polyvinyl siloxane (PVS) materials.⁽¹⁰⁾*

Material	Compressive Modulus	Translucency	Light Transmission	Curing Time (to 10 J/cm ²)
Exaclear	Lowest (9.6 MPa)	Highest	Best	~13-14s at 4 mm
Memosil 2	High (22.8 MPa)	Lowest	Lowest	>=24s at 4 mm
Clear Bite	Moderate (13.9 MPa)	Moderate	Moderate	~21-27s at 4 mm
Affinity Crystal	High (24.6 MPa)	Moderate	Moderate	~24-30s at 4 mm