The Inverse Injection Layering Technique

PART 2
Anatomical Form Defines Esthetics

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Abstract
The inverse injection resin composite layering technique provides a simplified, precise, and predictable method for developing natural esthetic composite restorations, while reducing chair time. This technique is a unique indirect/direct process of predictably translating the anatomical form of a diagnostic wax-up or of the natural dentition of a preexisting diagnostic model into composite restorations. There are myriad applications for this technique using a highly filled flowable resin composite. The future clinical applications of this novel technique may provide clinicians and technicians with alternative approaches to various clinical situations, while allowing them to deliver improved and predictable treatment to their patients. This article illustrates the use of this injection technique for developing anatomical form while using a cut-back technique with direct bonding to enhance the color for the most difficult esthetic challenge—the single maxillary central.

Key Words: inverse injection layering technique, anatomical form, direct stratification, anatomical morphological thinking, nanocomposite flowables

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Introduction

The restoration of the single anterior tooth represents a complex challenge for the patient, technician, and clinician in both composite restorative resins and porcelain systems. The challenge exists in attempting to achieve true harmony of the primary esthetic parameters (i.e., color, shape, and texture). While porcelain design relies on stone models, photographs, diagnostic wax-ups, and the clinician's laboratory narrative description to the technician, direct restorative resin reconstruction relies on the surrounding dentition for reproduction. Increased patient demand for optimal esthetics with less invasive procedures has resulted in alternative approaches to myriad clinical applications in the anterior region.[1] The inverse injection layering technique,[2-8] using a diagnostic wax-up or the anatomical form of the natural dentition of a preexisting diagnostic model and a clear vinyl polysiloxane (VPS) matrix material, is an indirect/direct process for establishing restoration shape, physiologic contour, color, and texture.

Form Defines Color

The advent of esthetic restorative materials requires the clinician to include color in the traditional restorative equation.[9,10] Due to advances in materials science and adhesive technology, the restorative concept has evolved to posit that form follows function[11,12] and anatomical form precedes and defines color. While form has been described in three dimensions (height, length, and width),[13,14] color provides a more complex description of the optical properties of both the tooth and restorative material. The successful determination and transfer of color to an esthetic reproduction of the natural dentition depends on the clinician's understanding of the interrelation of these optical properties to the anatomical morphology of the tooth.[9]

Since composite does not have hydroxyapatite crystals, enamel rods, and dentinal tubules, the final composite restoration requires the clinician to develop an illusion of the way light is reflected, refracted, transmitted, and absorbed by these microstructures.[10,15,16] Thus, a similar orientation of enamel and dentin is required as the restoration is created. Since a silhouette of the cavity form is highlighted by the darkness of the oral cavity (i.e., "shine-through"), it is necessary to use an opacious dentin replacement with higher color saturation. To recreate the maverick colors in the incisal third, tints and modifiers are applied at different regions of the tooth according to the contralateral central. This technique of internal characterization of tints within the incisal matrix utilizes color variation to emphasize the tooth form and instill the definitive restoration with a three-dimensional effect. To reproduce the optical effects of the enamel, a translucent composite encapsulates the inner dentin core and alters the quantity and quality of the light as it is reflected. This article describes the restoration of a single maxillary central utilizing this restorative concept of "form defines color," which is achieved by employing a combination of the inverse injection layering technique with the conventional direct stratification process.

Case Report

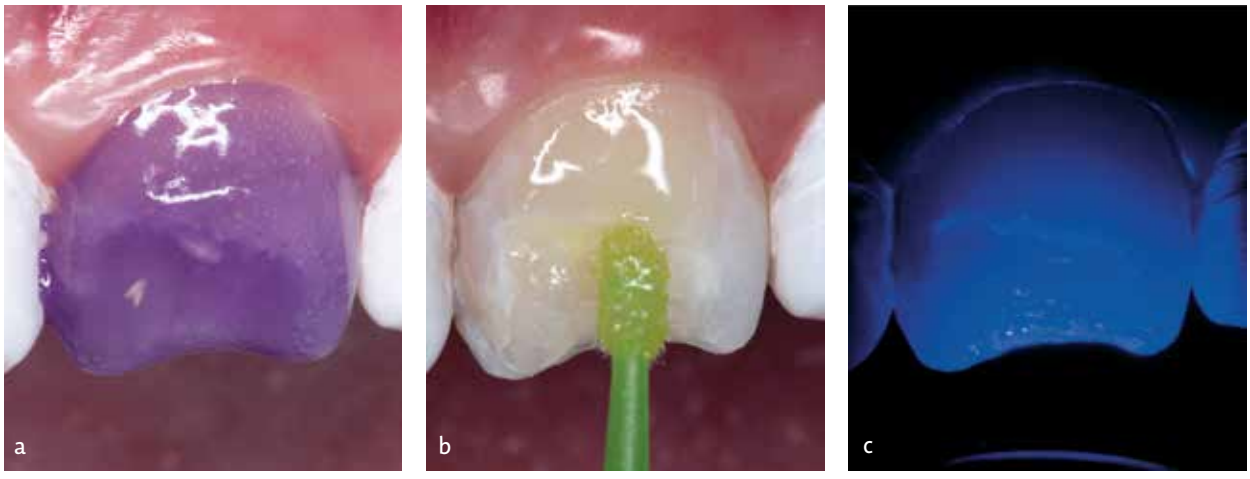
Initial Appointment

Preparation: Figures 1a and 1b show preoperative views of a patient and her fractured maxillary left central incisor (#9). A diagnostic wax-up was created to restore the original form and contour of this tooth and to position it in the optimal facial plane with the adjacent maxillary right central incisor (#8) **(Fig 2)**. A conservative intraenamel veneer preparation was performed **(Figs 3a & 3b)** and an adhesive surface preparation was accomplished using the total-etch technique **(Figs 4a-4c)**.

Figures 1a & 1b: Preoperative views of the patient.

Figure 2: The diagnostic wax-up to restore the original form and contour of #9 and to position it in the optimal facial plane with #8.

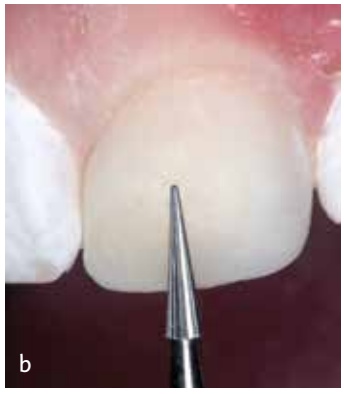
Figures 3a & 3b: A conservative intraenamel veneer preparation was performed.



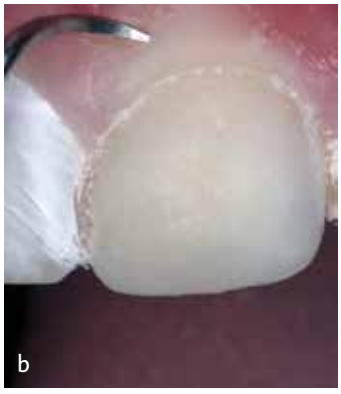
Figures 4a-4c: An adhesive surface preparation was accomplished using the total-etch technique.

Figures 5a & 5b: The clear VPS matrix designed from the diagnostic wax-up was placed over the anterior segment of the maxillary arch and a series of flowable resin composites were injected through a small opening above the prepared tooth using the inverse injection layering technique.

Figure 6: The resin composite was cured through the clear resin matrix on the incisal, facial, and lingual aspects.



Figures 7a & 7b: Upon removal of the matrix, the composite sprue was removed with carbide finishing burs.



Figures 8a & 8b: The excess polymerized resin composite was removed by scoring with a scalpel blade and the excess polymerized material was removed with a scaler.

Inverse injection layering technique: The clear VPS matrix (Exaclear, GC America; Alsip, IL) designed from the diagnostic wax-up **(Fig 5a)** was placed over the anterior segment of the maxillary arch and an opacious flowable resin composite (G-aenial Universal Flo shade AO1, GC America) was initially injected through a small opening above the prepared tooth, followed by a translucent B1 shaded flowable resin composite via the inverse injection layering technique[2] **(Fig 5b)**. The resin composite was cured through the clear resin matrix on the incisal, facial, and lingual aspects for 40 seconds each **(Fig 6)**. Upon removal of the matrix, the composite sprue was removed with 8- and 30-fluted carbide finishing burs (ET6, Brasseler USA; Savannah, GA) **(Figs 7a & 7b)**. The excess polymerized resin composite was removed by scoring with a scalpel blade (Bard-Parker #12, Becton Dickinson; Franklin Lakes, NJ) and the excess polymerized material was removed with a scaler **(Figs 8a & 8b)**.

Finishing and polishing: The gingival tissue was retracted with a gingival protector (8A, Hu-Friedy; Chicago, IL) and the tooth–resin composite interface was finished using a tapered finishing diamond and a 30-fluted pyramid-shaped finishing bur (DET3 and H274, Brasseler) **(Figs 9 & 10)**. The facial surfaces were polished with silicone points and the gingival region was polished with silicone hollow cups. A goat hair wheel and diamond polishing paste were employed to further refine the surface luster of the resin composite and a high surface reflectivity was accomplished with a dry cotton buff applied with an intermittent staccato motion. The completed resin composite veneer with optimal anatomical form is shown in **Figure 11**. The inverse injection layering technique allowed the establishment of harmonious proportions of the composite restoration and the surrounding dentition, establishing optimal esthetic parameters.

Figure 9: The gingival tissue was retracted with a gingival protector and the tooth–resin composite interface was finished using a tapered finishing diamond.

Figure 10: The lingual tooth–resin composite interface also was finished using a pyramid-shaped finishing bur.

Figure 11: The completed resin composite veneer with optimal anatomical form.

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Figure 12: The definitive restoration was completed using a composite cut-back technique; a corrugated chamfer was placed around the entire margin with a long tapered diamond.

Figure 13: The entire composite surface was etched.

Figure 14: Silane was applied to the prepared surface of the composite using a sable brush and lightly air-dried.

Figure 15: A universal adhesive was applied, allowed to dwell, then air-dried and light-cured.

Figure 16: Internal characterization was performed using a diluted white tint placed along the incisal edge, in the proximal regions, and in the body with a round sable brush and then light-cured.

Figure 17: A diluted gray tint was placed along the incisal edge and in the proximal regions with a round sable brush and then light-cured.

Figure 18: For the final artificial enamel layer, a translucent shaded nanoparticle hybrid composite was applied, smoothed into an ideal anatomical contour, and light-cured.

Follow-Up Appointment

Etching and bonding: At the following visit, the definitive restoration was completed using a composite cut-back technique. After isolation with a dental dam, the artificial enamel layer of the resin composite veneer was removed, and a corrugated chamfer 0.3 mm in depth was placed around the entire margin with a long tapered diamond (DET9, Brasseler) **(Fig 12)**. The entire composite surface was etched with 37.5% phosphoric acid (Gel Etchant, Kerr; Orange, CA) for 15 seconds and rinsed for 5 seconds **(Fig 13)**. Etching of the existing composite cleans the surface. Silane was applied to the prepared surface of the composite using a sable brush and lightly air-dried **(Fig 14)**; a universal adhesive (G-Premio Bond, GC America) was then applied to the prepared composite surface and allowed to dwell for 10 seconds, air-dried for 5 seconds, and light-cured for 10 seconds using an LED curing light **(Fig 15)**.

Internal characterization: Internal characterization was performed according to the appearance of the contralateral tooth and a shade-mapping diagram. A diluted white tint (Kolor Plus, Kerr) was placed along the incisal edge, in the proximal regions, and in the body with a #1 round sable brush **(Fig 16)** and light-cured for 40 seconds; this stabilizes the color and prevents mixing of the tints. A diluted gray tint (Kolor Plus) was then placed along the incisal edge and in the proximal regions with a #1 round sable brush **(Fig 17)** and light-cured for 40 seconds. It is the color variation from these modifiers and tints that creates the three-dimensional effect and the nuances within the incisal edge.

Final enamel layer: The final artificial enamel layer, a translucent shaded nanoparticle hybrid resin composite (G-aenial Sculpt), was applied, adapted with a long-bladed interproxi-

Figure 19: The completed resin composite veneer demonstrates ideal anatomical form and color.

Figure 20: The postoperative result reflects a balance in form and color between the maxillary centrals, creating a natural esthetic smile in harmony with the patient's personality.

mal instrument, smoothed into an ideal anatomical contour with a #1 flat sable brush **(Fig 18)**, and light-cured for 40 seconds. The completed resin composite veneer demonstrates ideal anatomical form and color **(Fig 19)**. Note the nuances in the incisal edge created by using the composite cut-back technique. The postoperative result reflects a balance in form and color between the maxillary centrals, creating a natural esthetic smile reflective of the patient's personality **(Fig 20)**.

Summary

Many clinicians and technicians think that creating an esthetic restoration is simply a matter of adding ceramics or composite to a substrate, but much more is required. Esthetic restoration of the single central incisor as demonstrated in this clinical application requires an understanding of the dimensions of color, the optical properties of light, the color of the substrate, and how the biomaterials and tooth structure have different refractive indices and optical properties. By using anatomical morphological thinking, it is possible to integrate all of these to create the illusion of natural esthetics.[8]

Furthermore, advances in adhesive dental technology have dramatically changed the limitations of directly placed composite restorations. Continuing technological breakthroughs allow clinicians not only to comprehend the building blocks of the ideal composite restoration but also to implement and maximize the potential of new materials to achieve more predictable and esthetic results. These developments promise to simplify the clinical applications for esthetic and restorative techniques while expanding the treatment possibilities for a wider range of clinical situations, ultimately improving the level of oral health care provided to today's patients. Although the long-term benefits of this novel injectable composite technique remain to be determined, the clinical results achieved by the primary author in the last 12 years and the supporting empirical data[7,17-28] for these next-generation nanocomposite flowables are extremely promising.

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References

1. Terry DA, Leinfelder KF. An integration of composite resin with natural tooth structure: the Class IV restoration. Pract Proced Aesthet Dent. 2004;16(3):235-42.

2. Terry DA, Powers JM, Blatz MB. The inverse injection layering technique. J Cosmetic Dent. 2018 Spring;34(1):48-62.

3. Terry DA. Developing a functional resin composite provisional. Am J Esthet Dent. 2012;2(1):56-65.

4. Terry DA, Powers JM, Mehta D. A predictable resin composite injection technique, part 1. Dent Today 2014 Apr;33(4):96,98-101.

5. Terry DA, Powers JM, Mehta D, Babu V, Usha HL, Santosh A, Kida Y, Wakatsuki H. A predictable resin composite injection technique, part 2. Dent Today. 2014 Aug;33(8):80-5.

6. Terry DA, Leinfelder KF, Geller W. Provisionalization. In: Aesthetic and restorative dentistry: material selection and technique. Houston: Everest; 2009. p. 318-28.

7. Terry DA. Restoring with flowables. Chicago: Quintessence Pub.; 2017. p. 160-1.

8. Terry DA, Geller W. Esthetic and restorative dentistry: material selection and technique. 3rd ed. Chicago: Quintessence Pub.; 2018. p. 141-7, 428-30, 450-1, 474-9, 609-10.

9. Terry DA, Geller W, Tric O, Anderson MJ, Tourville M, Kobashigawa A. Anatomical form defines color: function, form, and aesthetics. Pract Proced Aesthet Dent. 2002 Jan-Feb;14(1):59-67.

10. Terry DA. Natural aesthetics with composite resin. Mahwah (NJ): Montage Media Corp.; 2004. p. 4-19.

11. Sorenson DA. Form follows function: occlusion based rationale for esthetic dentistry. J Indiana Dent Assoc 1998 Summer;77(2):25-30.

12. Schlott WJ. Form follows function. J Am Dent Assoc. 1999 Nov;130 (11):1562,1564.

13. Baratieri LN, de Andrada MAC, Monteiro S Jr, Cardoso AC, Polidoro JS, de Andrada RC, de Sousa CN, de Castro Brandeburgo P, Sanford Lins JR, de Andrade CA. Dentistica: procedimentos preventivos e restauradores [Dentistry: preventive and restorative procedures]. 2nd ed. Sao Paulo: Quintessence Pub.; 1992. Portuguese.

14. Clark EB. Tooth color selection. J Am Dent Assoc. 1933;Jun;20(6):1065-73.

15. Terry DA. Developing natural aesthetics with direct composite restorations. Pract Proced Aesthet Dent. 2004 Jan-Feb;16(1):45-52.

16. Touati B, Miara P, Nathanson D, editors. Color and light transmission. In: Aesthetic dentistry and ceramic restoration. London: Martin Dunitz; 1999. p. 39-60.

17. Baroudi K, Silikas N, Watts DC. Edge-strength of flowable resin-composites. J Dent. 2008 Jan;36(1):63-8.

18. Attar N, Tam LE, McComb D. Flow, strength, stiffness and radiopacity of flowable resin composites. J Can Dent Assoc. 2003 Sep;69(8):516-21.

19. Gallo JR, Burgess JO, Ripps AH, Walker RS, Bell MJ, Turpin-Mair JS, Mercante DE, Davidson JM. Clinical evaluation of 2 flowable composites. Quintessence Int. 2006 Mar;37(3):225-31.

20. Karaman E, Yazici AR, Ozgunaltay G, Dayangac B. Clinical evaluation of a nanohybrid and a flowable resin composite in non-carious cervical lesions: 24-month results. J Adhes Dent. 2012 Aug;14(5):485-92.

21. Sumino N, Tsubota K, Takamizawa T, Shiratsuchi K, Miyazaki M, Latta MA. Comparison of the wear and flexural characteristics of flowable resin composite for posterior lesions. Act Odontol Scand. 2013 May-Jul;71(3-4):820-7.

22. Torres CRG, Rego HM, Perote LC, Santos LF, Kamozaki MB, Gutierrez NC, Di Nicolo R, Borges AB. A split-mouth randomized clinical trial of conventional and heavy flowable composites in Class II restorations. J Dent. 2014 Jul;42(7):793-9.

23. Gallo JR, Burgess JO, Ripps AH, Walker RS, Maltezos MB, Mercante DE, Davidson JM. Three-year clinical evaluation of two flowable composites. Quintessence Int. 2010;41(6):497-503.

24. Bayne SC, Taylor DF, Heymann HO. Protection hypothesis for composite wear. Dent Mater. 1992 Sep;8(5):305-9.

25. Turssi CP, Ferracane JL, Vogel K. Filler features and their effects on wear and degree of conversion of particulate dental resin composites. Biomaterials. 2005 Aug;26(24):4932-7.

26. Lim BS, Ferracane JL, Condon JR, Adey JD. Effect of filler fraction and filler surface treatment on wear of microfilled composites. Dent Mater. 2002 Jan;18(1):1-11.

27. Cadenaro M, Marchesi G, Antoniolli F, Davidson C, De Stefano Dorigo E, Breshci L. Flowability of composites is no guarantee for contraction stress reduction. Dent Mater. 2009 May;25(5):649-54.

28. Yamase M, Maseki T, Nitta T, KimishimaT, Nara Y. Mechanical properties of various latest resin composite restoratives [abstract 464]. J Dent Res 89(special issue A):2010. **jCD**