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Semi-(In)direct Composite Resin CAD/CAM Restorations

Bridging the Gap Between Direct and Indirect Techniques

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Abstract

Biomimetic restorations must have the utmost respect for hard tissue integrity and provide superior clinical service. Composite resins play a major role in achieving these goals. Resin-based materials' minimally invasive nature and cost-effectiveness are also making them increasingly popular for use with CAD/CAM systems, particularly when direct techniques are challenging to apply (e.g., cervical margins in dentin, large shrinking volume, and costs for the indirect technique are prohibitive). In anterior teeth, the milled product can be esthetically improved by histo-anatomical reduction of the CAD/CAM dentin base (i.e., incisoproximal cutback) and freehand covering with a generic enamel layer. With both anterior and posterior semi-direct techniques, patients can be treated either semi-directly in a single clinical session or semi-indirectly in two clinical sessions. This article presents semi-(in)direct composite resin approaches—valuable new tools in the restorative armamentarium—as viable, predictable, time- and cost-effective alternatives that bridge the gap between direct and indirect techniques.

Key Words: semi-direct, semi-indirect, composite resin, incisoproximal cutback, high-performance polymers

Introduction

Anterior restorative options in the 1980s and early 1990s were limited to either very basic composite resin techniques or full-coverage crowns. Although porcelain veneers were already available, they were primarily used for restorations to replace or recreate the dental enamel layer. The work of Andreasen et al.[1,2] and Walls et al.[3,4] sparked the expansion of veneer indications for more challenging situations such as severely worn and fractured anterior teeth (i.e., anterior Type III bonded porcelain restorations) after in vitro and clinical validation.[5-7] The first chairside computer-aided design/computer-aided manufacturing (CAM/CAM) system CEREC (Dentsply Sirona; Charlotte, NC), was available at this time. CEREC stands for CERamic REConstruction, and much of the initial focus was on the single-session fabrication and delivery of a posterior ceramic inlay/onlay.[8] However, it would later evolve into one of the most robust systems among numerous similar competing products. Since it integrates intraoral and extraoral steps, the CEREC system joined an existing family of approaches called semi-direct techniques. The original semi-direct approaches were developed for the posterior dentition through various intraoral or extraoral inlay techniques using composite resins;[9-11] they were also used in the anterior dentition for veneers (i.e., the direct-indirect technique).[12]

Advantages of Using Semi-Direct Approaches with Resin-Based Materials

Semi-direct approaches are extremely valuable because they bridge the gap between direct and indirect restorations from economic, tissue conservation, and practical standpoints. New possibilities for this hybrid technique appeared when the first composite resin CAD/CAM block was launched in 2001.[13] Composite resin blocks can overcome the brittleness and abrasiveness inherent to ceramic materials. When compared to porcelain blocks, the original composite resin block (Paradigm Z100, 3M; St. Paul, MN) exhibited substantial advantages,[14-20] as follows:

- millability in thin layers (more conservative and better at preventing marginal chipping)
- more efficient milling (faster and with less wear of the milling burs)
- favorable mechanical resistance
- enamel-friendly wear
- minimal risks of pre-cementation fracture
- ease of delivery and reparability.

Thanks to their favorable characteristics, CAD/CAM resin-based materials continue to gain popularity for use in the anterior dentition. A number of manufacturers now offer resin-based blocks, all with the ability to enhance the polymerization/physical properties by heating and pressure, hence their designation as high-performance polymers (HPPs). In addition to the advantages mentioned above, the material's customization process—the base is milled from a low-translucency block using a cutback technique, some coloring, and placement of a generic translucent enamel layer—is fast, relatively simple, and delivers an extremely sophisticated effect.[21,22] Depending on the workflow, treatment can be completed in one clinical session (semi-directly) or two clinical sessions (semi-indirectly).

Indications for Use: Patient and Clinician Considerations

The patient must be informed about invasiveness and cost-effectiveness compared to direct composite resins and indirect ceramics, knowing that anterior indirect ceramic restorations always provide the best performance in the long term. However, the decision to use bilaminar CAD/CAM HPP restorations is justified by their minimally invasive nature (i.e., no preparation or only micro preparation is needed), much lower cost, and total clinician control over the final composite layering result. Contrast these benefits to indirect porcelain veneers, which require a more substantial economic commitment and collaboration with a skilled ceramist since porcelain does not allow favorable results when simplified layering or paint-on techniques are used.

Case Presentation

The male patient's maxillary anterior teeth were first restored using a fully operational "test-drive" mock-up in polymethyl methacrylate (PMMA) to ensure his satisfaction with function, comfort, phonetics, and esthetics. The therapeutic choice was made after the patient gave informed consent regarding the three options (i.e., direct, indirect, and semi-direct) and their respective cost, tissue conservation, and maintenance considerations. As a result, a combined approach was chosen to treat the maxillary anterior dentition; the direct approach was justified on the right lateral incisor and canine (#7 and #6) due to the minimal volume of those restorations, while much larger defects (i.e., in volume and surface) supported the use of the semi-direct CAD/CAM approach on the central incisors (#8 and #9).

"The most crucial component of these procedures is the use of the wax-up and mock-up during the diagnostic phase."

Figures 1a-1c: Baseline view of patient's smile. (a, b) As indicated by the dotted line, note the canting of the smile line compared to the interpupillary line and (c) the large existing restorations on the central incisors.

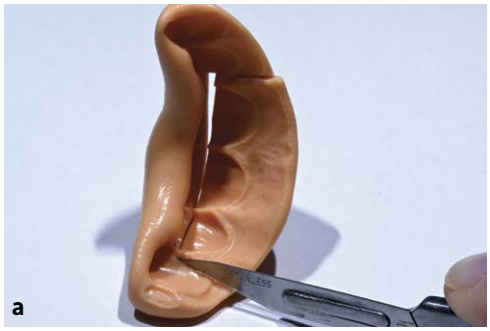
The patient's maxillary anterior teeth exhibited wear and chipping, as well as canting of the smile line, all of which significantly affected the smile's esthetics **(Figs 1a-1c)**. Additionally, the central incisors had previously received large composite resin restorations that showed considerable discoloration and microleakage.

Diagnostic Phase

Following data collection and consideration of the patient's requests, diagnostic models were used to develop a wax-up (in the interim, the patient performed nightguard vital bleaching). This blueprint was tested in vivo by fabricating a PMMA mock-up intraorally (New Outline, anax USA; Ardmore, OK) following a technique as previously described **(Figs 2a-4d)**. Using this method, the mock-up could be bonded and worn continuously while maintaining normal function.[23] The patient was allowed to keep the mock-up for approximately 10 days to ensure safe verification and patient approval of function, comfort, phonetics, and esthetics. A harmonious balance was achieved between the facial landmarks, the lip line, and other soft tissues **(Figs 4c-6b)**.

Restorative Phase I (Direct)

The restorative phase began with the noninvasive ("no-prep") replacement of the mock-up on lateral incisor (#7) and canine (#6) using direct composite resin in the Natural Layering Technique, guided by a lingual silicone index **(Figs 5a-6b)**.[24] Once these two restorations were completed, an optical impression was made to be stored in the CEREC software's "Biogeneric Copy" folder.



Figures 2a & 2b: Silicone indexes from the diagnostic wax-up. At least two consecutive silicone indexes are needed—one for (a) checking the available space created by the wax-up (note the specific horizontal sectioning) and (b) one for application of the PMMA resin.

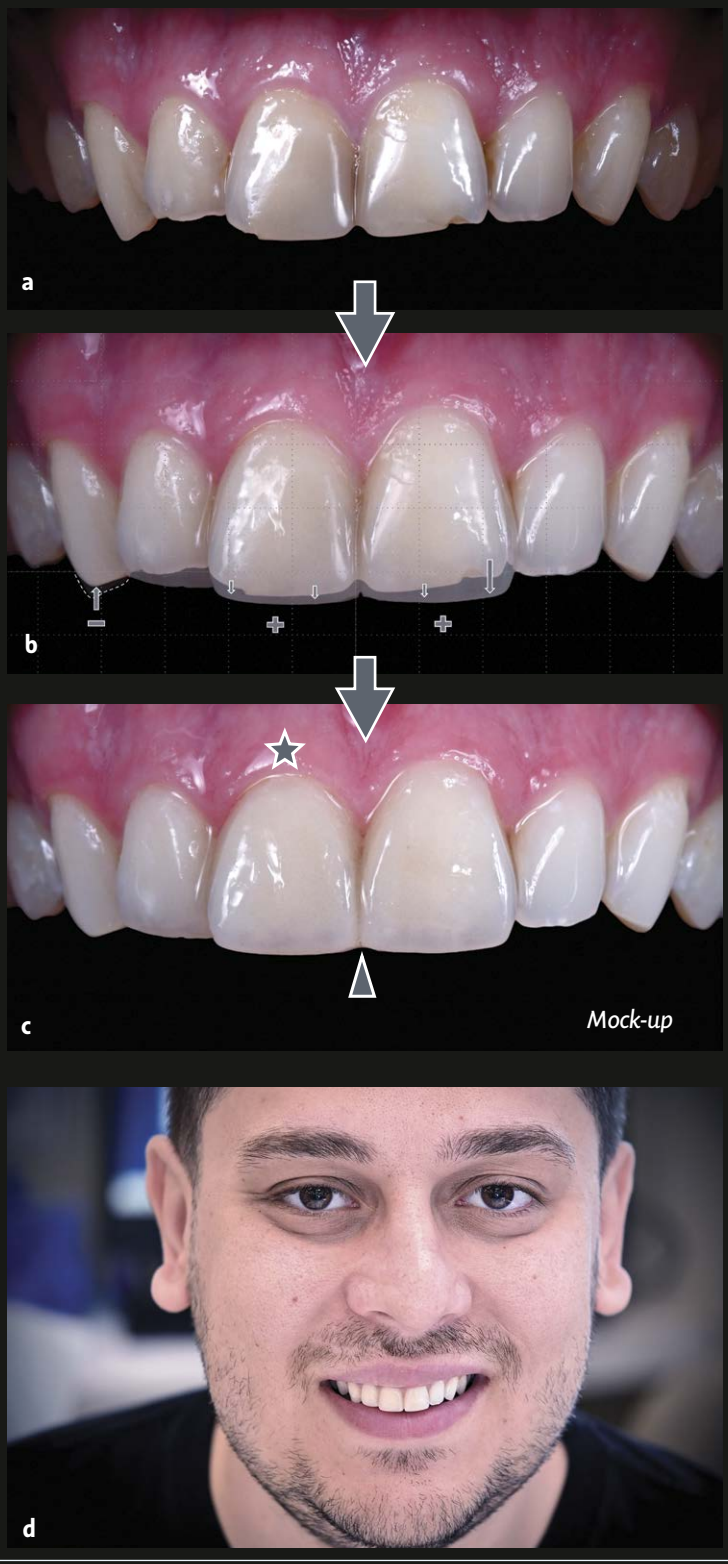
Figures 3a-3c: Mock-up fabrication. The first step is to (a) ensure adequate clearance for the mock-up when the labial index is used. Regular dentin-like PMMA resin (New Outline Dentin Shade, anax USA) was mixed and loaded in the second silicone index, pressed over the teeth, and (b, c) trimmed, colored, and glazed (New Outline Skin Glaze).

Restorative Phase II (Semi-Indirect)

The "Biogeneric Copy" data included the mock-up, which had been maintained on the central incisors. The mock-up was used as a preparation guide following a calibrated reduction technique similar to that applied for traditional veneer preparations **(Figs 7a-8c)**.[25] The existing lingual restorations were also removed and replaced with direct composite resin. Special care was taken to retract the gingiva around the right central incisor (#8) to extend the preparation and compensate for the height discrepancy with left central incisor (#9) **(Figs 4c, 7e & 8c)**. Immediate dentin sealing (IDS)[22] was performed on all exposed dentin using a gold standard filled adhesive system. The preparations consisted of a 0.2-mm chamfer at the facial and distal aspects. The mesial preparation was extended more lingually to include part of the lingual restorations. This very conservative preparation approach was possible because HPP blocks can be milled with extremely thin margins **(Figs 9a-9h)**.[16]

A stone cast (from a polyvinyl siloxane impression with retracted soft tissues) was generated, and a new set of optical data was stored in the CEREC software's "Preparation" folder. The resulting computations generated the two restorations **(Figs 9a-9h)**, which were milled using resin nano ceramic blocks (Lava Ultimate LT, 3M). After removal of the sprue, the two veneers were fitted onto the stone cast, followed by a labio-proximo-incisal cutback to create clearance for the placement of coloring resins and a translucent enamel layer. The cutback involved only the labioincisal edge, leaving the linguoincisal edge intact for guidance.

The entire labial surface was then conditioned for bonding, which involved airborne-particle abrasion with an intraoral adhesive and sandblast-coating system (CoJet, 3M [or aluminum oxide 50 µm at 30 psi]) followed by the application of a silane-only solution (e.g., Silane, Ultradent; South Jordan, UT) for 20 to 40 seconds. The silane was thoroughly air-dried and heat-dried for one minute at 212°F before the application and polymerization of the coloring resins (a touch of 50/50 blue/lavender mix [Kolor+ Plus, Kerr; Orange, CA]) at the deepest part of the proximoincisal cutback. It is important to wet the entire labial surface with adhesive resin before applying the protective translucent enamel layer (a generic enamel) and restoring the original labial volume. Following polymerization and air-blocking of the enamel layer, the restorations can be tried in the mouth and adhesively luted. Luting procedures were carried out under rubber dam isolation and involved the same treatment as the intaglio surface (i.e., CoJet/silane/heat-drying/adhesive-wetting).



Figures 4a-4d: Mock-up fabrication (continued). Comparative views of (a) baseline, (b) superimposed baseline and mock-up, and (c) the mock-up itself. The mock-up was added on the central incisor (#8) and the right lateral incisor (#7); the right canine was adjusted with a minor enameloplasty to correct the canting. The incisal embrasure between the centrals needed to be opened (see triangle in c), and there was a residual discrepancy between the gingival levels (see star in c). Note the use of interdental brown/ochre resins to soften the optical transition with the soft tissues and provide the illusion of individual units. (d) After minor adjustments and embrasure refinement, the patient's facial harmony was enhanced. The canting is no longer present, and the patient is entirely satisfied.

Figures 5a & 5b: Direct restorations. The right lateral incisor and canine (#7 & #6) were restored directly due to small volume corrections. (a) A bilaminar shade guide (Inspiro, Edelweiss DR; Zug, Switzerland) was used to select the appropriate shade. Note that some flowable composite resin was temporarily added to #6 to recreate the missing labial central ridge. (b) The mock-up was sectioned to remove the PMMA from the lateral incisor; the flowable composite resin was also removed from #6.

Figures 6a & 6b: Direct restorations (continued). Guided by a lingual silicone index of the preoperative situation, the natural layering technique was (a) used to mold lingual enamel. (b) The situation after this first restorative phase with the mock-up on the central incisors was scanned and stored in the software.

TIPS

Beginner

Not all restorations have to be either direct or indirect. New solutions are available with semi-(in) direct restorations when using CAD/CAM systems.

Intermediate

CAD/CAM restorations can be milled in composite resin blocks, which feature numerous advantages over ceramic ones: faster milling with less wear of the milling bur, millability in thinner layers (requires less preparation clearance), more precise margins, less wear to antagonist enamel, increased flexibility, and damping behavior.

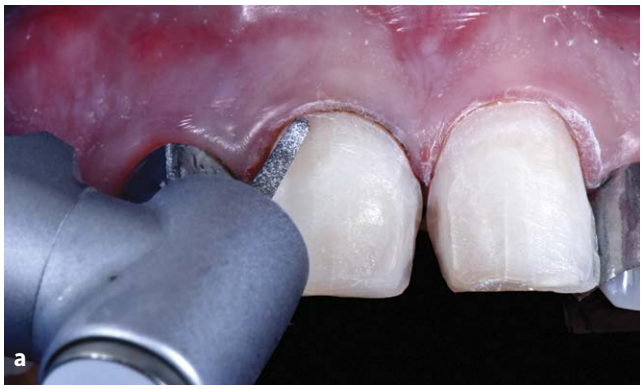
Advanced

Customization of anterior composite resin CAD/CAM restoration is easily possible through a systematic incisoproximal reduction ("U" shape), conditioning of the surface (air abrasion, silane, heat drying), and placement of resin coloring effects (blue lavender) and adhesive resin plus a translucent layer (filter) of generic enamel composite resin.

Figures 7a-7e. Tooth preparations. The mock-up is used as a reduction guide with (a, b) calibrated round diamonds for grooves and (c, f) a tapered round-end bur for the chamfer. The preparations included a light 0.3-mm chamfer at the facial and mesial aspects while the distal contact was maintained only (note the smaller size of the round diamond bur for the cervical reduction in b). (d) The preparation outline was moved more apically using a retraction cord on the right central incisor (note the use of a bimanual technique to place the cord in so as to push the gingiva and obtain symmetry with the left central incisor [e, star]). The lingual aspect of the central incisors was also restored during this session.

The enamel and IDS surfaces were airborne-particle abraded and etched with phosphoric acid; all surfaces (tooth and intaglio of the restoration) were covered with adhesive resin. The thermo-modified luting technique (i.e., a preheated microhybrid restorative material acts as luting cement) facilitates stabilization during the cleanup of excess resin. Unlike what is normally done for bonded porcelain restorations, fine-tuning the shape and texture of bilaminar CAD/CAM HPP restorations can be easily achieved after delivery. Basic finishing tools included articulating paper (lightly rubbed to reveal the surface texture), diamond burs, and silicone polishing points/spiral brushes.

Alternatively, a simplified technique would have been to deliver the CAD/CAM product first and then proceed to the cutback, characterization, and enamel layering intraorally. In this situation, the silane, intraorally applied, must not be heat-



Figures 8a-8c: Tooth preparations (continued). (a, b). Smooth preparation surfaces and transition line angles were obtained with flexible abrasive discs. Note the good symmetry of the gingival contour (c, dotted line) despite the slight coronal width discrepancy, which will be easily corrected through the mesial aspects of the future restorations.

dried. Instead, it should be left to dry for 5 minutes (possibly assisted by multiple 20-second applications of the polymerization light as a heat source), then colored and wet with the adhesive resin.

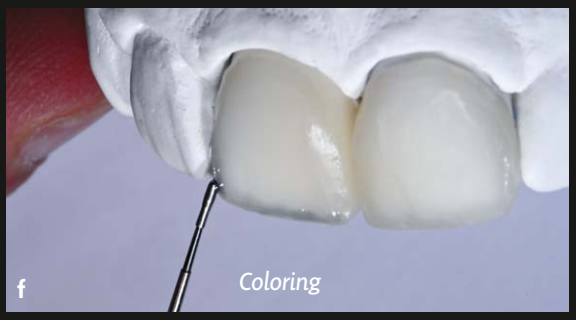
Upon completion, the patient's maxillary anterior teeth featured new clinical crown length, shape, and size (detailed delivery process and final result shown in **Figs 10a-10l**). As a result of his significantly rejuvenated smile, the patient was much more inclined to display his central incisors, which are now entirely visible even at lip rest, and his newly cohesive smile line in which the maxillary incisal edge line is in harmony with the lower lip line.

Summary

Thanks to the combination of direct and semi-(in)direct approaches, a simple anterior maxillary restoration was successfully completed in a minimally invasive manner that was affordable, satisfied the patient, and allowed the clinician to work in a systematic, step-by-step manner. The most crucial component of these procedures is the use of the wax-up and mock-up during the diagnostic phase. Clinicians must take particular care at this time to help ensure the most predictable and satisfactory outcomes.

As this article has demonstrated, when the presented treatment options are appropriate, justified, and have the patient's informed consent, they can provide the best possible outcomes regarding tissue conservation, maintenance, and cost. Semi-(in)direct composite resin restorations, which bridge the gap between direct and indirect techniques, offer viable, predictable, time- and cost-effective alternative options, making them valuable new tools in clinicians' restorative armamentarium.

"Semi-direct approaches are extremely valuable because they bridge the gap between direct and indirect restorations from economic, tissue conservation, and practical standpoints."



Figures 9a-9h: CAD/CAM "Biogeneric Copy" and customization. (a, b) Using the combination of the preparation data and the biocopy data, both central incisor restorations (#8 & #9) were designed, milled, and fitted on the master stone cast. (c, d) About 0.6 mm of the incisoproximal aspect of the labial surface was then reduced with a round diamond to create a dentin histo-anatomic shape with mamelons. (e, left) The entire labial surface was air-abraded and (e, right) silanated for 20 to 40 seconds, then (f, g) air-dried and heat-dried for one minute at 212°F. The deepest areas of the cutback were infused with blue/lavender colors and then polymerized. Adhesive resin was used to wet the entire labial surface before applying a thin enamel layer of composite resin (h) which was polymerized and air-blocked.


a


Air-abrasion + etching
b


Al2o3 /silicoating air-abrasion at 30 psi...
c


...and silane (air- and heat-dried)
d


Thermo-modified luting
e


f


g

Figures 10a-10l: Restoration delivery and finishing. Following (a) try-in and patient approval, a rubber dam was placed. (b) The tooth preparations were cleaned with air-abrasion, etched with phosphoric acid for 30 seconds, rinsed, and dried. (c,d) The same treatment previously used (i.e., CoJet/silane/heat drying) was applied to the restoration's intaglio surface, and adhesive resin wetting was applied to both the tooth and the restoration but not polymerized. (e) A preheated enamel-like microhybrid restorative (Herculite XRV, Kerr) was used as a luting agent. After carefully removing excesses, each surface was polymerized for at least 60 seconds (in 20-second increments) at a minimum of 1,000 mW/cm2; additional polymerization through a glycerin gel was also performed. (f, g) Surface texture was created with a coarse diamond bur following a specific protocol and then (h) polished with silicone point/spiral brushes. (i, j) The two-month postoperative images show a stark contrast with the baseline view (inset in j). (k, l) The final restoration demonstrates a highly "organic" color and beautiful texture.

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