



Key Treatment Tools to Achieve Ideal Esthetic Results for Maxillary Central Incisor Crowns

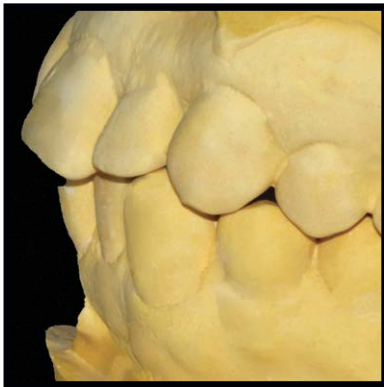
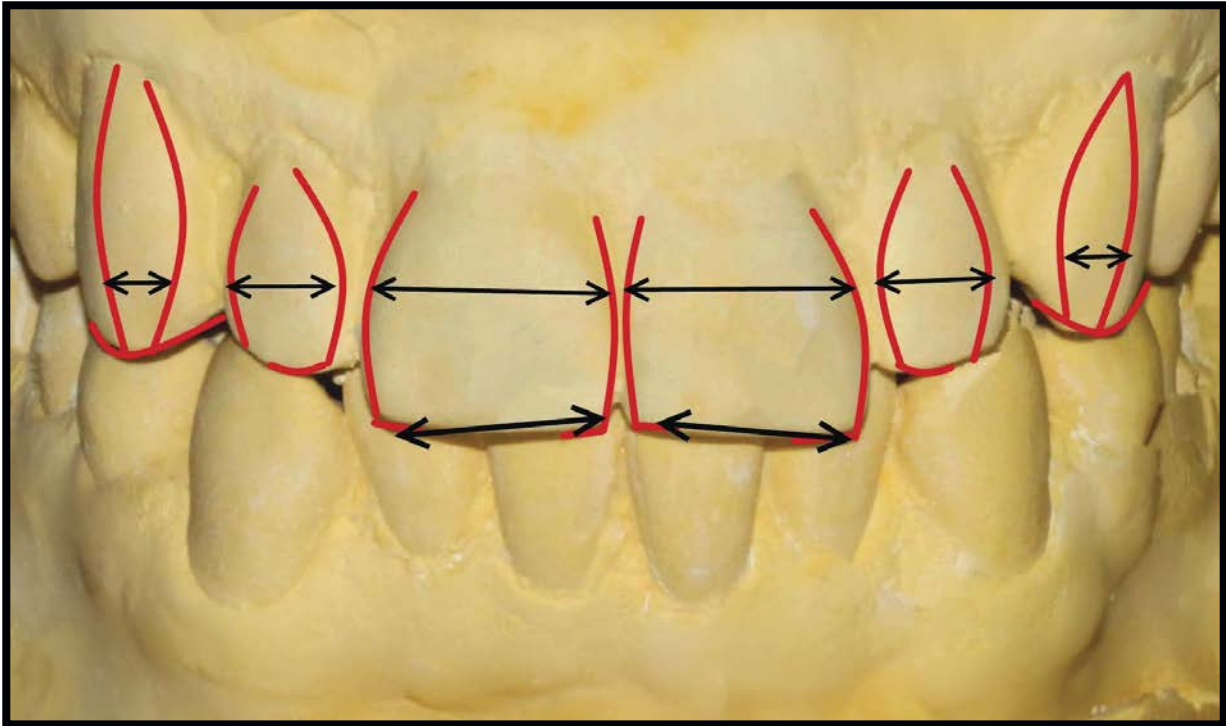
A Case Report

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Abstract

Patients with unesthetic restorations involving the central incisors present a great challenge and should be carefully evaluated. An esthetic wax-up and mock-up are essential in these cases to facilitate communication among the dentist, patient, and laboratory technician. Modern tools such as high-quality photography and digital scanning can supplement this communication and enable the duplication of the esthetic plan as outlined by the wax-up. This case report describes the replacement of unesthetic central incisor crowns as well as the tools used to achieve a predictable and satisfactory result.

Key Words: esthetic technique, smile design, porcelain anterior esthetics, diagnostic wax-up and mock-up



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Introduction

When planning a new smile, the factors that can be mostly controlled by the dentist are the anterior teeth, including their form, size, and shade; this is referred to as *dental esthetics* or *micro esthetics*. Other factors such as facial form and balance, gingival esthetics, lips, and symmetry are not entirely under the control of the dentist, but they do affect esthetic choices regarding the teeth and may have a dramatic effect on the final outcome. These interrelationships are referred to as *macro esthetics*.

Several factors are considered when establishing teeth dimensions (incisocervical length, mesiodistal width, and labiolingual depth), including phonetics, occlusion, the amount of tooth display as guided by the lips and the smile arc, the general average teeth measurements, and the ratio between the length and width of each individual tooth as well as the relation between the lengths and widths of teeth to each other.^{1,2} The maxillary central incisors are the focal point of an esthetic smile and create the central dominance. Therefore, discrepancies in the central incisors are the most noticeable and negatively affect esthetics more than the rest of the anterior teeth. Maxillary central incisors are the widest of all anterior teeth with the smallest maxillary mesioincisal embrasure. Additionally, they can indicate an individual's age through the incisal edge morphology: children with newly erupted centrals will have mamelons; younger adults' incisal edges are straight, nicely rounded, and relatively thin with no mamelons; and older individuals will exhibit wear resulting in flatter, thicker edges. In an esthetic makeover, the central incisors are the first teeth designed and restored, as their size and form act as a guide for the remaining teeth. The average length of the maxillary central incisor is 10 to 11 mm, and the width is 75 to 80% of its height. An alteration in this ratio may result in the central incisors appearing too wide or too long, which is very esthetically displeasing.^{2,3}

Another important concept when it comes to tooth appearance and size is the "face of the tooth" (i.e., the area on the facial surface that is bounded by the line angles as viewed from the facial aspect). Shadows are created as light strikes the line

angles, and the face of the tooth is the only area that reflects light. Therefore, the size of the face of the tooth determines the perceived size of the facial surface. Improper position or contour of the transitional line angles will result in a tooth or restoration that appears wider or narrower. Teeth that are identical in size may appear dissimilar if the line angles are not mirror images because light is being reflected from a smaller or larger surface.⁴ Thus, placement of line angles in esthetic dentistry is of key importance and can be used as a powerful tool in situations when increased width of teeth creates a less than optimal result by placing the line angles toward the midline or vice versa. Other techniques that can change the apparent teeth widths involve repositioning the labial height of contour, changing the rounding of the point angles (and therefore the incisal embrasure size), changing the width and depth of the developmental depressions, and creating horizontal or vertical grooves.³

Esthetic Wax-Ups and Mock-Ups

An esthetic wax-up is a diagnostic procedure in which planned restorations are developed in wax on a diagnostic cast to determine optimal clinical and laboratory procedures necessary to achieve the desired esthetics and function.⁵ The result of this process is a three-dimensional model of teeth built in wax that represents the desired contours of the teeth to be restored.⁶ The esthetic wax-up enables the achievement of predictable results and patient satisfaction. As the planned treatment can be visualized, changes can be made easily in wax and patients are able to see the proposed form of the restorations and express their opinions. The wax-up can also be used to create an indirect mock-up (also known as a *secondary diagnostic mock-up*) for more accurate visualization and fine-tuning of the final restorations as well as for laboratory communication. The introduction of digital technology has made it possible to digitally scan prefabricated diagnostic wax-ups and create final restorations that essentially duplicate the wax-up's form, which has already been deemed satisfactory by the dentist and patient. Intraoral mock-ups are indispensable in complex cases and provide the added advantage of visualizing and realizing the treatment outcome in the patient's mouth before final restorations are fabricated and/or irreversible procedures are performed. A direct mock-up can be fabricated with resin composite or autopolymerizing acrylic resin intraorally and is usually employed for teeth requiring simple restorative treatment. Indirect mock-ups are used when more extensive tooth coverage is planned; in these cases, provisional restorations serve as indirect mock-ups and thus provide an excellent tool for evaluating the patient's esthetic needs. Some patients demand a high level of restorative dentistry to achieve esthetics and function. Elective restorative dentistry should not be undertaken without a clear understanding of the patient's expectations and the limitations of restorative therapy. The utilization of mounted diagnostic casts and esthetic wax-ups and mock-ups is well documented and ensures a predictable end result, and patients are more likely to accept treatment after their use.⁷



The diagnostic/esthetic wax-up was essential given the patient's history of having three sets of crowns fabricated in the past, all of which he found unsatisfactory."

Modern Materials and Tools in Esthetic Dentistry

There are a number of materials and tools today that enable the attainment of ideal esthetic results. These modern materials and tools allow structural tooth damage to be almost “reversible,” as dentists can restore a patient’s smile to a perfectly natural appearance, making it nearly impossible to detect the restorative material. Among the materials with the greatest impact in esthetic dentistry are lithium disilicates. Lithium disilicate crystal ceramics offer outstanding esthetics, high strength, and the ability to be cemented or adhesively bonded. Because of the fairly low refractive index of lithium disilicate crystals, this material can be very translucent.⁸ Machinable lithium disilicate ceramic blocks became commercially available in 2006 (IPS e.max CAD, Ivoclar Vivadent; Amherst, NY) with a partially crystallized blue-violet color. The partially crystallized state allows the block to be milled more easily and more rapidly during the computer-aided design/computer-aided manufacturing (CAD/CAM) process without excessive diamond bur wear or damage to the ceramic crystal.⁹ Lithium disilicates offer shade variability and are available in different translucencies; in addition, the material allows extrinsic staining, glazing, and characterization, which further enhances the esthetic outcome.¹⁰

Modern digital dentistry tools can provide several possibilities in terms of esthetic rehabilitation. These tools include high-quality digital photography, which can be used for smile analysis, laboratory communication, and virtual smile design; and digital scanning, which enables the creation of a virtual cast and subsequent CAD/CAM restoration creation process that can be done chairside or in the laboratory.¹¹

Thorough studies have been performed in the esthetic zone to determine the different factors that contribute to esthetics as well as different treatment tools and materials that can help achieve satisfactory results.^{3,6} This article presents a case report of a patient who presented with unesthetic maxillary central incisor crowns—which had been replaced three times in the past—and the key treatment-planning tools that were used to achieve an optimal esthetic result and patient satisfaction.

Case Report

Patient Complaint and History

A 44-year-old male presented to the University of Kentucky College of Dentistry’s faculty practice clinic unhappy with the appearance of his smile (Figs 1 & 2). The patient’s main concern was the crowns on teeth #8 and #9, which he described as “too long” and “odd-looking.” Clinical examination revealed porcelain-fused-to-metal (PFM) crowns with satisfactory proximal contacts, occlusion, margins, and shade. The patient had good oral hygiene and was considered at low risk for caries, with a healthy periodontium. The crowns had been fabricated 13 years earlier by the patient’s previous dentist; they were the third set of crowns on these teeth, none of which he had found



Figure 1: Preoperative smile.



Figure 2: Preoperative bite.

esthetically pleasing. Periapical radiographs revealed that the teeth had not received root canal treatment, and there was no notable periapical pathology. The patient recalled the original reason for receiving the crowns was the fracture of the teeth due to childhood trauma; he was unable to provide older photographs of his previous crowns or his original teeth. A discussion was initiated with the patient regarding additional details that he found unpleasant about his crowns, and he could not pinpoint a specific reason of why they seemed “odd-looking”; however, when asked if they seemed bulky and too wide, he agreed.

Diagnostics Casts and Analyses

Diagnostic casts were made using irreversible hydrocolloid impression material (Jeltrate Alginate, Dentsply Sirona; Milford, DE) and poured with Type 3 dental stone (Buff Stone, Whip Mix; Louisville, KY). An arbitrary hinge axis facebow transfer and maxillomandibular relationship were obtained and used to articulate the diagnostic casts in a semi-adjustable arcon articulator (4641Q, Whip Mix). A photo analysis and cast analysis were completed, and faults in the appearance of the central incisor crowns were identified as follows:

- The line angles were placed too far distally, making the central incisors appear too wide in relation to the remaining anterior teeth.
- The point angles were too square in comparison with the remaining anterior teeth, which were more rounded.
- The incisal edges were inclined mesially, making the crowns appear longer.
- Both of the central incisors were too proclined labially, with #9 being further proclined (Figs 3-5).
- The two central incisors were unequal in length due to the uneven position of the gingival margin, measuring 11.5 mm for #8 and 10 mm for #9.
- The crowns were too opaque and lacked translucency and natural characterization.

Fabrication of the Esthetic Wax-Up

When the central incisors on the diagnostic cast were trimmed with acrylic burs, the amount of reduction was notably greater on tooth #9, as it was further proclined labially. An esthetic

wax-up was fabricated with diagnostic opaque white wax (Hi-Tech Wax; Ontario, CA) (Figs 6 & 7) following recent guidelines.^{3,4} The line angles were relocated closer to the midline, and the point angles were created relatively round (Fig 8). These changes were made to reduce the size of the face of the tooth, achieve harmony with the remaining anterior dentition, and create a symmetrical smile. Narrow developmental depressions were created to enhance the desired narrower appearance of the teeth. The lengths of the central incisors were matched to the canines, achieving a convex smile arc (Fig 9).

Treatment Plan

The esthetic wax-up was presented to the patient with a thorough explanation of the changes that were made, and he was generally pleased with the new design. A discussion was initiated regarding the different lengths of the central incisors caused by the uneven gingival margin position. Due to his low smile line, he was not interested in corrective periodontal surgeries. According to the fabricated wax-up, the final desired lengths of

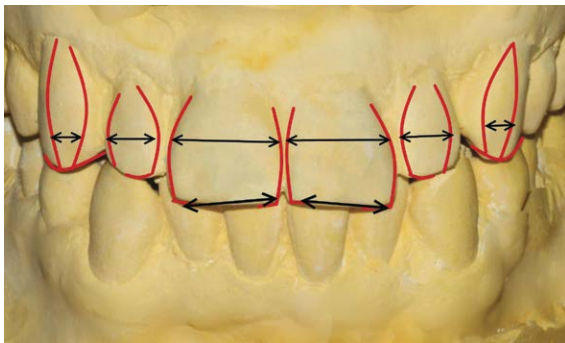


Figure 3: The distance between line angles and canine labial ridges (red lines) control the perceived appearance of teeth. The central incisors' line angles are placed too far distally, making the teeth appear too wide and lacking harmony with the remaining anterior teeth. The central incisors' point angles are too square compared with the more rounded point angles on the remaining anterior teeth. Black arrows indicate the width of teeth and mesially inclined central incisal edges.



Figure 4: Diagnostic cast: Lateral view showing excessively proclined central incisor PFM crown (#9 is more proclined).



Figure 5: Diagnostic cast: Occlusal view showing excessively proclined central incisor PFM crown (#9 is more proclined).



Figure 6: Esthetic wax-up: facial view.



Figure 7: Esthetic wax-up: proximal view.

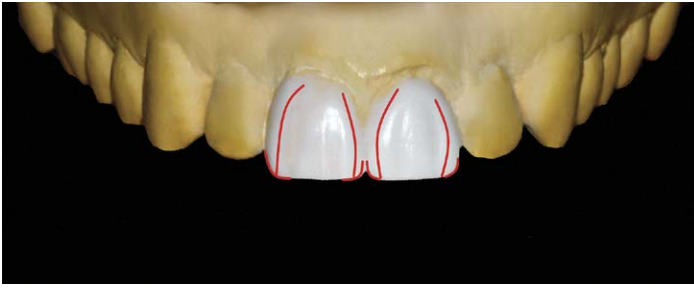


Figure 8: Esthetic wax-up: The line angles are located further toward the midline; the point angles are rounder to achieve more harmony with the adjacent teeth.

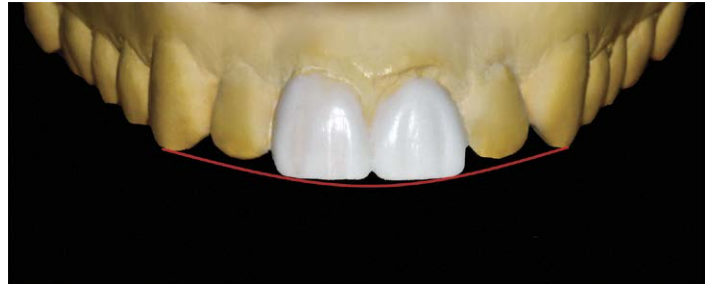


Figure 9: Esthetic wax-up: The central incisors' lengths are matched to the canine teeth to achieve a convex smile arc.

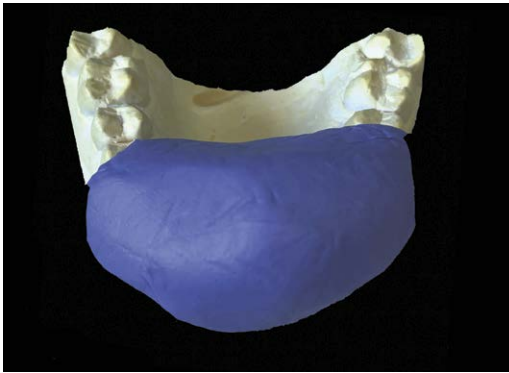


Figure 10: Fabricating the silicone matrix by applying putty VPS to the diagnostic cast.



Figure 11: Silicone matrix used to create the provisional restorations/indirect mock-ups.

the planned crowns were determined to be 10.5 mm for #8 and 9 mm for #9. The treatment procedure was explained to the patient in detail, including the possibility to make more adjustments during the procedure—specifically when provisional restorations were fabricated and during try-in—to ensure his satisfaction.

Treatment

Tooth preparation and fabrication of provisional restorations/indirect mock-ups: Based on the shade of the adjacent lateral incisors under daylight conditions, the desired shade of the new crowns was determined to be 2M1 (VITA Toothguide 3D-MASTER, Vita North America; Yorba Linda, CA). The patient was anesthetized, and the permanent crowns were removed one at a time by creating a slot labiolingually through each crown, and cutting them carefully using a coarse diamond bur (847-016C, Henry Schein; Melville, NY) in an electric handpiece under water coolant until tooth structure was reached and each crown was separated into mesial and distal halves. The segments were then pried apart using a Christensen crown remover (Hu-Friedy; Chicago, IL).¹² The remaining tooth structure was evaluated, and adjustments were made as needed. The labial

surface of tooth #8 was reduced by an additional 0.5 mm, while the labial surface of tooth #9 was reduced an additional 1 mm at the cervical and middle thirds and 1.2 mm at the incisal third to reduce proclination. The lingual surfaces and incisal edges were reduced by an additional 1 mm to achieve adequate clearance and fabricate final crowns with less proclination as well as lengths resembling those of the esthetic wax-ups. A subgingival shoulder finish line was created with a flat-end tapered diamond bur (847-016C) as all-ceramic crowns were planned.¹³

The shade of the teeth stumps was determined to be 4M2. The gingiva was adequately retracted using the double-cord retraction technique with cords sizes 00 and 0, then an impression of the preparations was taken employing a one-stage impression technique¹⁴ with light- and regular-body vinyl polysiloxane (VPS) impression material (Express, 3M; St. Paul, MN). A silicone matrix was created from the esthetic wax-ups using the putty VPS impression material and injected with autopolymerizing resin; temporary crown and bridge material (Integrity, shade B1, Dentsply Sirona) was then placed over the preparations to create the provisional restorations (Figs 10 & 11). The provisional restorations were thus considered as indirect mock-ups in this situation, and the patient was allowed to



Figure 12: Provisional restorations: facial view.



Figure 13: Provisional restorations: proximal view.



Figure 14: Final crowns at the try-in appointment.



Figure 15: Final crowns after custom shading procedure.

evaluate their form and length and identify areas of concern. The patient was very pleased, and no significant adjustments were made. The provisional restorations were cemented using temporary cement, excess cement was removed gently, a layer of sealer (PermaSeal, Ultradent Products; South Jordan, UT) was added and light-polymerized for a final glaze-type finish, and photographs were taken (Figs 12 & 13). The patient was given a week to determine whether he was satisfied with the provisional restorations' form and length before the laboratory initiated the fabrication of the final crowns.

Laboratory communication and permanent crowns fabrication: Information including the esthetic wax-ups, preoperative photographs, photographs of the provisionals, shade of adjacent teeth, and tooth stump shade was communicated to the laboratory technician. A laboratory prescription was completed for the fabrication of all-ceramic IPS e.max crowns for teeth #8 and #9 that resembled the esthetic wax-ups. The technician scanned the wax-ups (TRIOS intraoral scanner, 3Shape Dental Systems; Copenhagen, Denmark), and the crowns were milled from a medium-translucency A1 IPS e.max CAD block.

Crowns try-in and delivery: The final crowns were tried in the patient's mouth, and proper marginal fit, ideal proximal contacts, satisfactory form, and shade were examined (Fig 14). A custom shading procedure was performed with the assistance of the laboratory technician wherein white calcifications were added while the crowns were in the patient's mouth using ceramic pastes (GC Initial IQ Lustre Pastes NE, GC America; Alsip,

IL) to resemble the adjacent teeth and enhance natural appearance. The restorations were then removed and baked in a furnace (IBEX Dental Technologies; Richardson, TX) at 750°C (Fig 15). During the final delivery appointment, the crowns were bonded to tooth structure with a neutral shade cement (Variolink Esthetic LC, Ivoclar Vivadent), which involved etching the intaglio surface with a 5% hydrofluoric acid gel (IPS Ceramic Etching Gel) for 20 seconds, rinsing with distilled water, and drying with oil-free air. This was followed by the application of ceramic primer (Monobond Plus, Ivoclar Vivadent) for 60 seconds, then gently drying the excess with oil-free air. The tooth structure was etched with a 37% phosphoric acid for 15 seconds (Scotchbond, 3M), rinsed with water, and dried with oil-free air. A single-component bonding agent (Adper Single Bond Plus Adhesive, 3M) was applied on the etched surface, dispersed to a thin layer with gentle air-drying, and not allowed to light-polymerize until the final cement material was applied. The cement was dispensed in the crowns one at a time, the crowns were seated and held in place with stable pressure, then excess cement was removed after light-curing for 3 seconds. To prevent oxygen inhibition, the restoration margins were covered with glycerin gel/air block immediately after the removal of excess cement. Complete light-curing was achieved for 20 seconds on the labial and lingual surfaces for each of the two teeth. Occlusion was checked after cementation, and final photographs were taken (Figs 16-18).



Figure 16: Preoperative and postoperative smile.



Figure 17: Preoperative and postoperative bite.



Figure 18: Preoperative and postoperative facial view.

Discussion

Esthetic restoration of the central incisors is one of the greatest challenges in dentistry, as they are the most prominent teeth, and any minor fault in their appearance can be easily noticed. While it is perhaps a greater challenge to restore a single central incisor, the challenge of restoring both central incisors to the harmony of the existing anterior dentition should never be underestimated. In this case, the patient's current PFM crowns, which lacked proper morphological form and harmony and exhibited unnatural opaqueness, were replaced with highly anatomical, esthetic lithium disilicate crowns, with which the patient was extremely pleased.

Tools

Diagnostic wax-up and mock-up: Several tools were essential to reach this successful result. The diagnostic/esthetic wax-up was crucial given the patient's history of having three sets of

crowns fabricated in the past, all of which he found unsatisfactory. In this case, the wax-up allowed him to envision the outcome and express his desires about it. Furthermore, the esthetic wax-up allowed the fabrication of an indirect mock-up; this procedure reproduces the wax-up onto the natural teeth for immediate clinical evaluation and tests the final design details of the diagnostic wax-up clinically. It is an extremely valuable tool to fine-tune the desired configuration and contour of the planned restorations. If necessary, further modifications can be done via adjustments or using direct composite, which allows for a more accurate visualization of the outcome.⁶ A waiting period with the provisional restorations makes it possible to assess the anticipated result, but this is not indicated in clinical cases with conservative or noninvasive approaches. Patient compliance increases with the provisional testing period as patients feel they are better informed and can follow the treatment plan more easily.⁷



Wax-Up & Mock-Up Tips

Beginner

- Use an ultra-fine black sharpie to mark the desired position of the line angles and shade the developmental depressions on the wax-up to guide you during carving.
- Level the central incisors by pressing the upper cast against the bench top when the wax is warm.
- Carve the developmental depressions with a large discoid cleoid carver using the discoid end.

Intermediate

- Move the line angles toward the midline to enhance the narrow appearance of the teeth and vice versa.
- Round the point angles to enhance the narrow appearance of the teeth and vice versa.
- Create narrower developmental depressions to enhance the narrow appearance of the teeth and wide developmental depressions to enhance the teeth's wide appearance.

Advanced

- During the mock-up stage, take photos and show them to the patient to help identify areas of concern and ensure patient satisfaction.

Digital dentistry: Digital dentistry was another important tool for the success of this treatment. Although we were not able to scan the impressions due to the nature of the subgingival margins, the diagnostic wax-up was scanned with a laboratory-based scanner and served as a design template for the final restorations. Thus, the esthetic plan was used as a tool to relay the patient's preferences to the laboratory technician. This helps to ensure that the CAD/CAM-fabricated final restorations follow the initial esthetic plan to achieve a predictable clinical result.

Digital photographs: Another essential tool was the use of high-quality digital photographs taken with a 105-mm macro lens. The photographs were used for smile analysis as well as a laboratory communication tool. Standardized film-based clinical photographs provide the practitioner with a documentation tool to compare photographic records before and after treatment, and digital photography has also been proposed as an effective tool for diagnosis, treatment planning, and communication. Ideal communication of the entire restorative team can enable a more predictable clinical outcome.¹⁵ The analysis of the patient's photographs in combination with the casts facilitated the realization of the misplaced line and point angles; rectifying these issues in the created crowns achieved the ideal form of the central incisors and resulted in great harmony with the existing dentition.

Lithium disilicate ceramic material: Lastly, the use of all-ceramic material as an alternative to the preexisting PFM crowns was the key to achieving ideal shade, translucency, and natural appearance. Lithium disilicate glass ceramic has a needle-like crystal structure that offers excellent durability and strength as well as exceptional optical properties. Chairside customization through enhancing the shade match by adding maverick colors and incisal characteristics can help to create predictable esthetic results and is far more natural looking when compared with PFM restorations.⁸

Summary

With patients' increasing awareness of smile esthetics and their ensuing high expectations, obtaining ideal results should be every clinician's goal. Patients who present with unesthetic restorations involving the central incisors should be carefully evaluated, especially those with a history of restoration remakes. An esthetic wax-up and mock-up are essential in these cases to enable communication among the dentist, patient, and laboratory technician and achieve a predictable satisfactory result. Modern tools such as high-quality digital photographs and digital scanners can supplement this communication and allow for the exact duplication of the esthetic plan as outlined by the wax-up.

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