

Victor Clavijo, DDS, MSc, PhD



Anterior Ceramic Restorations

Details That Make the Difference





Anterior Ceramic Restorations

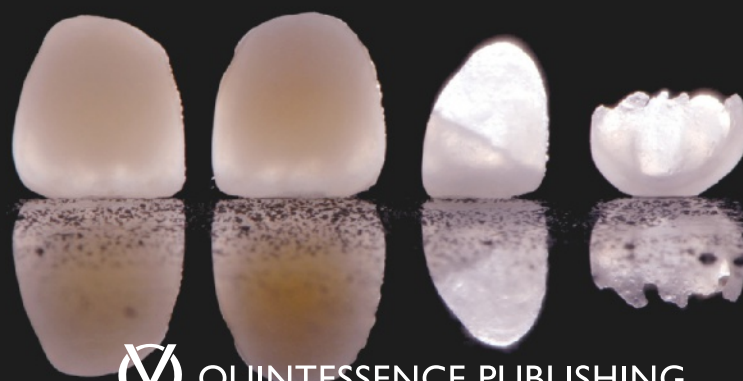
Details That Make the Difference

Victor Clavijo, DDS, MSc, PhD

Private Practice
Indaiatuba, Brazil

Visiting Professor

Advanced Program in Operative and Adhesive Dentistry
Herman Ostrow School of Dentistry
University of Southern California
Los Angeles, California



 QUINTESSENCE PUBLISHING

Berlin | Chicago | Tokyo

Barcelona | London | Milan | Mexico City | Paris | Prague | Seoul | Warsaw

Beijing | Istanbul | Sao Paulo | Zagreb



One book, one tree: In support of reforestation worldwide and to address the climate crisis, for every book sold Quintessence Publishing will plant a tree (<https://onetreepanted.org/>).



Title of original issue:

Restaurações Cerâmicas Anteriores: Detalhes que Fazem a Diferença
Copyright © 2022 Editora Napoleão, Nova Odessa, Brazil

A CIP record for this book is available from the British Library.
ISBN 978-1-78698-135-6

 **QUINTESSENCE PUBLISHING**
DEUTSCHLAND

Quintessenz Verlags-GmbH
Ifenpfad 2-4
12107 Berlin
Germany
www.quintessence-publishing.com

Quintessence Publishing Co Ltd
Grafton Road, New Malden
Surrey KT3 3AB
United Kingdom
www.quintessence-publishing.com

Copyright © 2024
Quintessenz Verlags-GmbH

All rights reserved. This book or any part thereof may not be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, or otherwise, without prior written permission of the publisher.

Editor: Bryn Grisham, Quintessence Publishing Co , Inc. Batavia, IL, USA
Production: Angelina Schmelter, Quintessence Publishing Co , Inc. Batavia, IL, USA
Design: Sue Zubek, Quintessence Publishing Co , Inc. Batavia, IL, USA

Printed in Croatia

Dedication

To Mariane, my love, who gave up many dreams for the sake of my career, who accompanied the birth of this project, and who always motivated me to not give up (which happened many times). Therefore, this book exists today because you gave me the strength and motivation to continue and the security to know that you would always be taking care of our treasures (Pedro and Giulia) while I was away for this unpredictable life of a teacher, lecturer, and dentist.

Thank you for teaching me the meaning of happiness!



Contents



Foreword by Luiz Narciso Baratieri *viii*
Foreword by Sillas Duarte Jr *ix*
Preface *x*
Contributors *xii*

- 1** Digital Photography in Dentistry *1*
- 2** Esthetic Planning and Digital Tools *24*
- 3** Diagnostic Wax-up and Mock-up Techniques *56*
- 4** Injectable Resin Technique for Provisional Restorations *84*
- 5** Intraradicular Restorations *106*
- 6** Tooth Preparations for Anterior Ceramic Restorations *154*





- 7** Techniques for Impressions and Provisional Restorations **206**
- 8** Ceramic Systems **230**
- 9** Adhesive Cementation **288**
- 10** Ceramic Fragment Restorations **352**
- 11** Modification of Peri-Implant Contours **378**
- 12** Introduction to Digital Dentistry **428**

3

Diagnostic Wax-up and Mock-up Techniques





One of the simplest and oldest techniques for visualizing the final result of esthetic planning is through a proper diagnostic wax-up, guided by photographs and a detailed esthetic analysis as described in the previous chapters. In 1966, Benjamin V. Braly stated that through an initial wax-up, the clinician could visualize the needed changes to tooth positions through orthodontic analysis, simulate changes in tooth shape to achieve an ideal occlusion, and plan the shape of future dental preparations.¹ Therefore, this laboratory procedure should be included in the treatment plan as well as treatment cost estimates.

After making the diagnostic wax-up, the mock-up or restorative try-in should be created. In 1999, Pascal Magne described clinical and laboratory procedures for evaluating esthetic changes in the smile through a silicone index of the additive diagnostic wax-up, which was filled with acrylic resin and placed on the teeth, originating the renowned mock-up technique. The purpose of this technique is to evaluate the diagnostic wax-up and its changes through a real-life try-in on the patient's teeth, where the correlation of the new design with the patient's current occlusion is observed, as well as its interaction with phonetics and the patient's face.²

The combination of these two procedures (diagnostic wax-up and mock-up) makes esthetic planning more predictable and also allows patient interaction to offer their opinions about their new smile.³ However, it is not possible to perform a mock-up in the mouth if the position of the teeth in the arch or the maxillomandibular relationship prevents the silicone index from adapting correctly and creating a faithful visualization of the final result. In these cases, it is usually necessary to make changes on the plaster cast, reducing or moving the teeth to obtain the proper positioning and tooth shape. However, there are clinical situations where the wax-up and mock-up are performed with the sole function of arousing the patient's desire to undergo treatment. In these cases, the diagnostic wax-up is done without taking into consideration the position and function of the teeth to produce a "motivational mock-up," which predicts the final result but without precision. This type of wax-up usually presents larger volumes as a result of the altered positions of the teeth and is used in interdisciplinary treatments with the use of, for example, orthodontic, surgical, or periodontal procedures in addition to restorative work.

The goal of this chapter is to provide protocols to guide diagnostic wax-up and mock-up techniques in day-to-day practice.



Classification of Diagnostic Wax-ups

Functional and motivational additive diagnostic wax-ups

In the functional additive wax-up (Fig 3-1), it is possible to achieve the desired final shape simply by adding wax and without removing any tooth or gingival structure from the plaster cast. This is possible in cases requiring, for example, diastema closure, restoration of conical teeth, treatment of fractures and incisal edge wear, reestablishment of canine guidance, increase or reestablishment of vertical dimension, or improvement of gingival esthetics.³⁻⁶ However, in motivational additive wax-ups, the addition of wax is performed without taking into consideration gingival levels, dental volumes, and occlusal function; its only objective is to demonstrate to the patient how the smile can be esthetically modified, with the explanation that to obtain the ideal final result, preliminary steps will be necessary.⁷

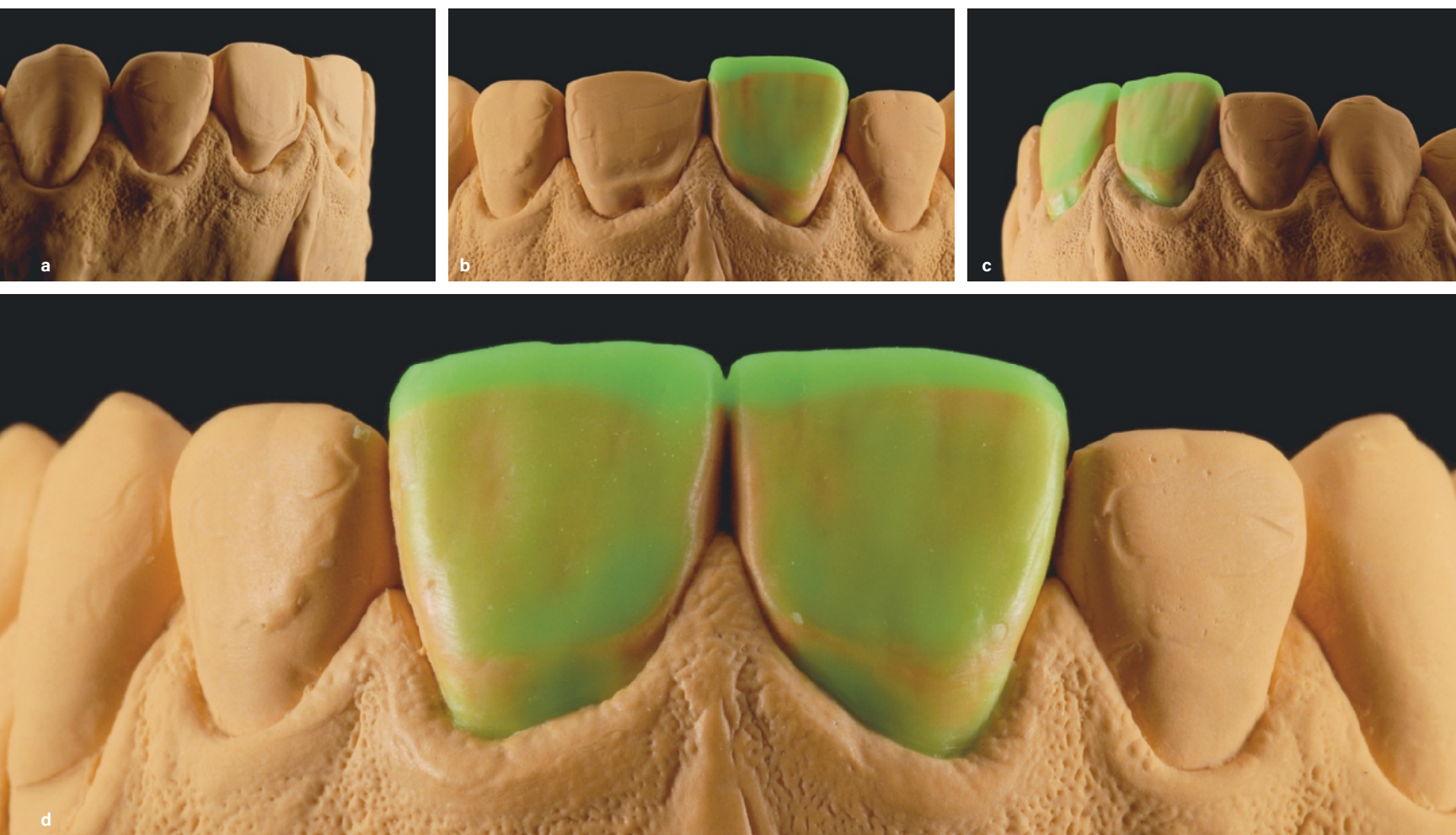


Fig 3-1 (a to d) Additive wax-up. Note the color difference between the wax and the cast; this makes it easier to visualize changes and areas with greater wax volume.

Subtractive diagnostic wax-ups

This type of wax-up (Fig 3-2) is performed when there is a need to remove structure from the plaster cast to obtain the ideal dental shape. This occurs in clinical situations such as crowding, proclined teeth, extruded teeth, and excessively bulky restorations.⁷



Fig 3-2 (a to d) Subtractive wax-up. Grinding is performed with tungsten burs and discs in the tooth and/or gingival regions to achieve optimal volume and shape.



Digital wax-ups

The digital wax-up (Fig 3-3) is performed by uploading scans of the patient's face, mouth, and teeth into software with a database of tooth shapes, allowing the shape of the teeth to be changed digitally and the creation of a wax-up on a photopolymer resin model.⁸⁻¹⁰

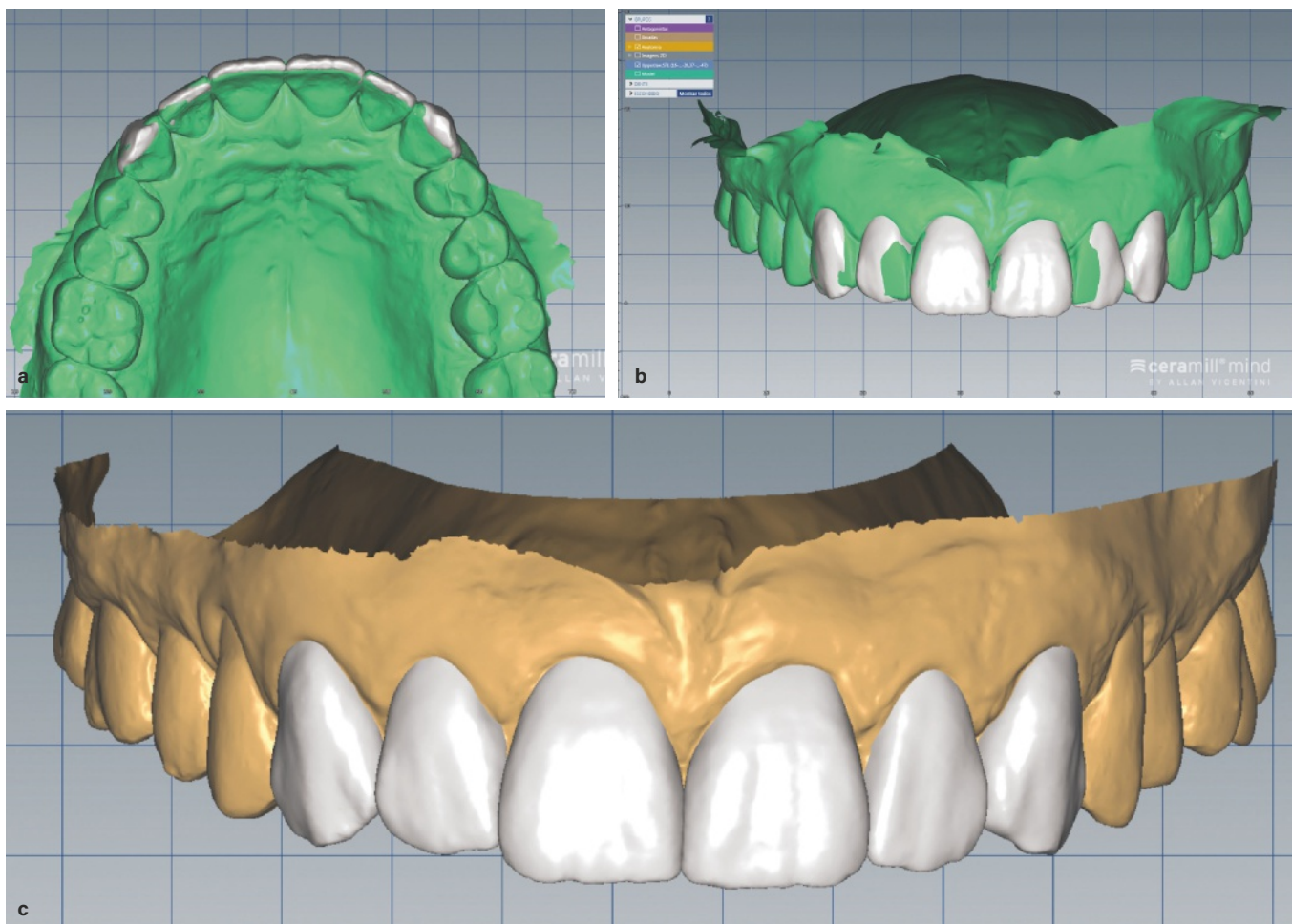


Fig 3-3 (a to c) Digital wax-up. Note the color difference between the initial digital model and the digital wax-up. It is possible to perform both additive and subtractive digital wax-ups.

copyright by
not for publication
Quintessenz

Mock-up Techniques

- Additive mock-up without adhesion
- Additive mock-up with adhesion
- Subtractive mock-up with adhesion
- Motivational mock-up
- Direct freehand mock-up
- Dentogingival mock-up
- Mock-up for clinical crown lengthening for esthetic purposes
- Mock-up using the SKYN concept
- Mock-up with flowable resin technique and transparent index
- Additive mock-up without adhesion using a digital workflow

Restorative Materials Used in Creating Mock-ups

- Bis-acryl resin (Fig 3-4a): Excellent material for mock-up techniques due to its easy handling, quick polymerization, and excellent surface gloss
- Acrylic resin (Fig 3-4b): Excellent material for mock-up techniques but requires more clinical time
- Flowable resin (Fig 3-4c): Material widely used for a long-term mock-up performed using a transparent silicone index
- Composite resin (Fig 3-4d): Material widely used for a direct mock-up in the patient's mouth without a prior diagnostic wax-up
- Photopolymer resin (Fig 3-4e): Material used to obtain prototypes of the diagnostic wax-up via 3D printing

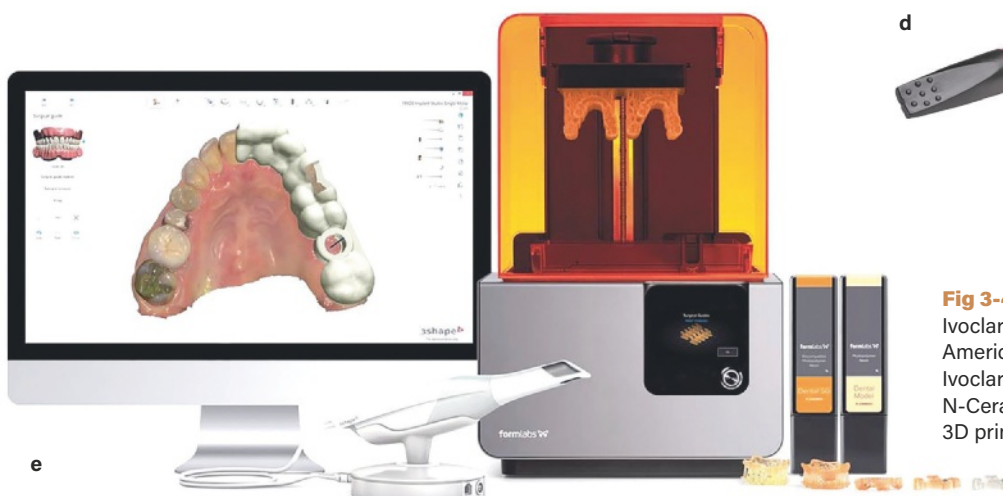


Fig 3-4 (a) Bisacrylic resin (Systemp c&b II, Ivoclar Vivadent). (b) Acrylic resin (Alike, GC America). (c) Flowable resin (Tetric N-Flow, Ivoclar Vivadent). (d) Composite resin (Tetric N-Ceram, Ivoclar Vivadent). (e) Scanning and 3D printing system using photopolymer resins.



Fig 3-5 Polyvinyl siloxane (PVS) impressions (Virtual, Ivoclar Vivadent).

Table 3-1 Materials used in creating molds for the diagnostic wax-up

	Alginate	Condensation silicone	Addition silicone	Digital
Dimensional stability	Average	Average	Excellent	Excellent
Deformation after setting	Average	High	Low	None
Time from impression taking to pouring	Immediate	Up to 20 minutes	Up to 7 days	NA
Reproduction of details	Average	Good	Excellent	Good
Cost	Low	Average	High	High

NA, not applicable.

Basic Steps in Creating a Mock-up

Obtaining impressions

The use of addition silicones or condensation silicones is recommended for creating the initial impressions. Alginates can also be used, but they have some disadvantages (Table 3-1). For these impressions, full trays should be used (Fig 3-5), and an impression of the antagonist arch should always be taken as well. Obtaining bite registration and facebow records should be considered.^{5,8} When the purpose of the impression is to perform a wax-up and mock-up of isolated areas (such as the anterior teeth), copying regions such as

the palate, the depth of the vestibule, retromolar trigone, or tuberosity is not important in the impression or plaster cast. However, when the mock-up is intended for restorations in which all teeth and occlusal surfaces are waxed up, the palate, vestibule, tuberosity, and retromolar trigone are fundamental in supporting and stabilizing the silicone index for execution of the mock-up; in the absence of these anatomical regions, the index may be destabilized, leading to distortions in the mock-up.

Impression Details

Mock-up of the anterior teeth only: It is not necessary to precisely replicate the regions of the palate, tuberosity, retromolar trigone, and depth of the vestibule; the silicone index will be supported on the occlusal surfaces of the posterior teeth.

Mock-up of all teeth (full rehabilitation): An accurate impression of the regions of the palate, tuberosity, retromolar trigone, and depth of the vestibule will be fundamental, as the silicone index will be supported on these structures during stabilization of the impression.

Always remember that the silicone index must be stabilized by three points (Fig 3-6).

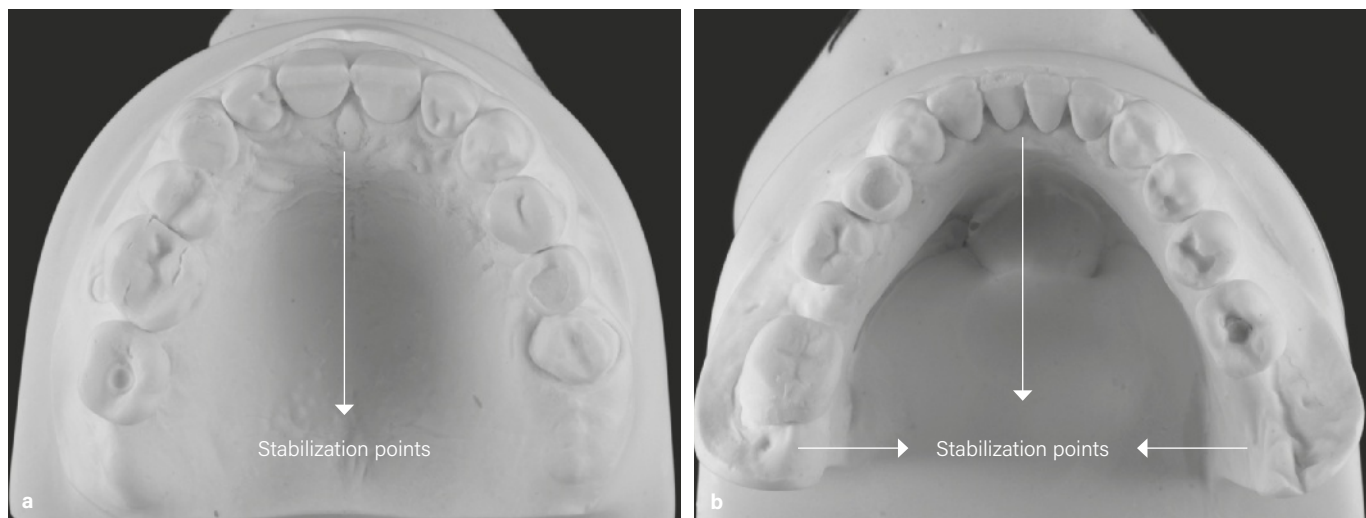


Fig 3-6 Stabilization points for full impressions in the maxillary (a) and mandibular (b) arches.

Communicating with the dental technician

The information obtained in the conversation with the patient (chief complaint) should be combined with the clinical examination results, photographs, and treatment goals to draw up a list of modifications to be carried out on the wax-up by means of digital planning and esthetic analysis, as described in the previous chapters. All of this information must be passed on to the dental technician, who should make precision casts with plaster or photopolymer resins in adequate proportions, work with a semi-adjustable articulator (based on the facebow record or Camper plane) in a conventional or digital manner, analyze the facial photos to check the inclination of the horizontal plane in relation to the interpupillary line⁷ (Fig 3-7; for more details, see chapter 2), and evaluate the dental exposure with the lips at rest and during maximum smile.

The clinician, together with the technician, should decide whether to perform the wax-up using the additive, subtractive, or motivational technique. At this stage, it is preferable that the technician creates the wax-up using a different color than the plaster cast so that it is easier to visualize the prospective restorative materials and margins, as well as the regions where the changes will occur.

When receiving the diagnostic wax-up from the laboratory (Fig 3-8), one should always know which technique was performed (additive or subtractive), as this is fundamental in the choice of which technique should be performed for the intraoral try-in. When the subtractive technique is used, one must know where tooth and/or gingival structure was removed by means of photographs; markings on the initial cast; or acrylic, metal, or plastic reduction guides.

copyright by
not for publication
Quintessence



Fig 3-7 (a) Facial photograph with interpupillary and intercommissural lines. (b) Photograph of the plaster cast with the correct inclination in relation to the interpupillary and intercommissural lines.

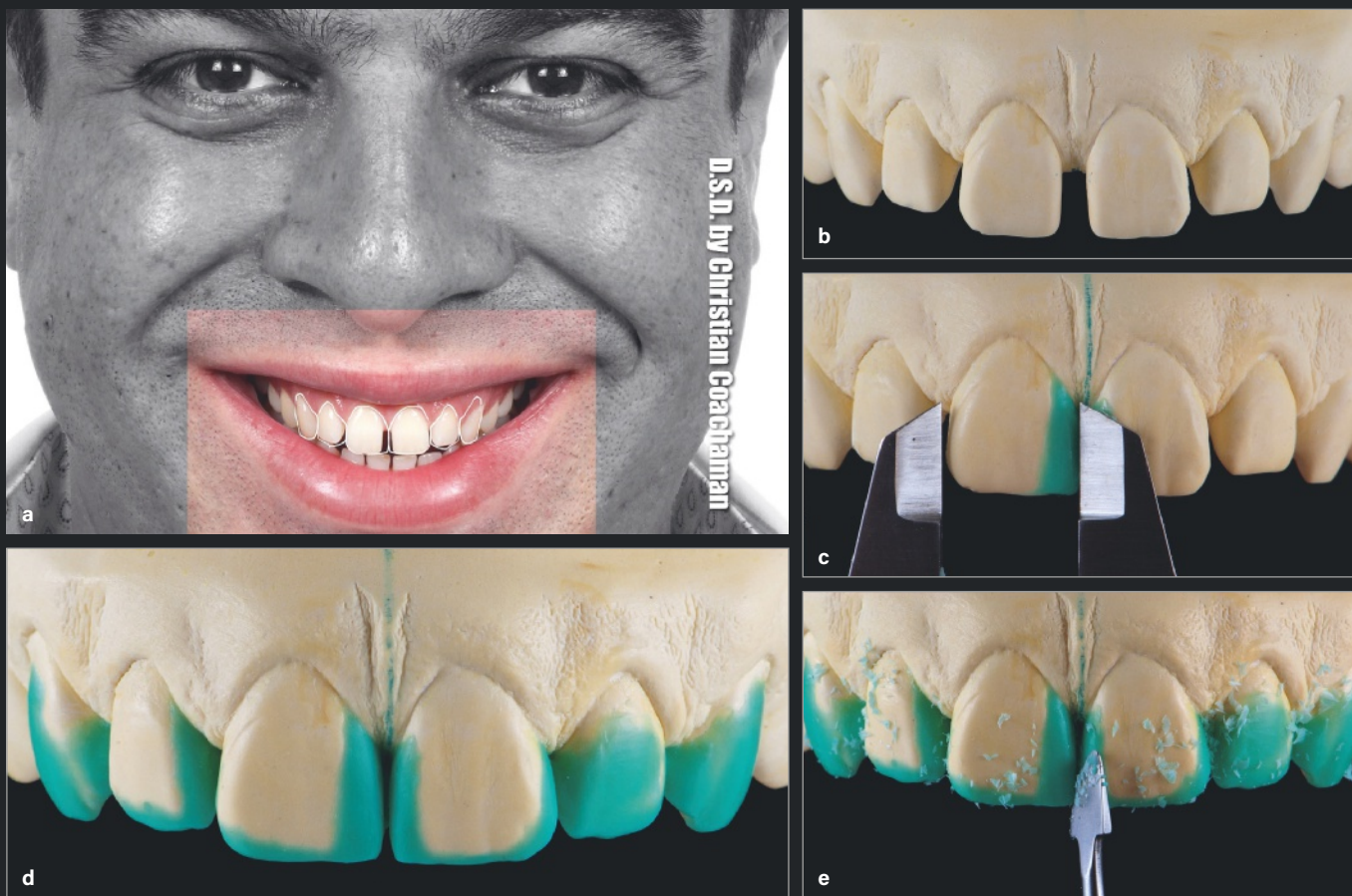


Fig 3-8 (a to e) Diagnostic wax-up guided by Digital Smile Design (DSD).

Fabricating the silicone index

To continue the procedure, the silicone index becomes essential to transfer the information from the diagnostic wax-up to the patient's mouth. The index must be made in two steps: first with heavy-body silicone and then with flowable silicone, thus copying the surfaces (vestibular, occlusal, and palatal) of the teeth that were waxed up and the adjacent teeth that were not. As mentioned before, for a full rehabilitation mock-up, the palate and supporting anatomical structures should be copied to give stability to the index when it is inserted in the mouth. After the material has set (on average 10 minutes: 5 minutes for heavy-body silicone and 5 minutes for flowable silicone), precise cuts should be made with scalpel blades or knives to mark the midline and the contour of the gingival margin and papillae, providing space for the material to overflow and aiding in insertion of the index in the mouth (Fig 3-9).

After the index has been fabricated, it should be tested in the mouth using clinical mirrors to check for gaps between the teeth or gingival margin and the silicone index. If there are gaps, distortions may have occurred, or there may still be retentive areas in the silicone, usually located at contact points or between the gingival embrasures. In the latter case, removal of the retentive areas with scalpel blades or scissors is recommended.

The mock-up technique must be performed only after the correct fit of the silicone index is confirmed, all interferences have been removed, and the polymeric material has been chosen, which can be bis-acryl resin, acrylic resin, composite resin, or flowable resin. Then, the color of the polymeric material must be chosen using an appropriate shade guide. For each mock-up technique, a clinical sequence is recommended, as explained in the following sections.

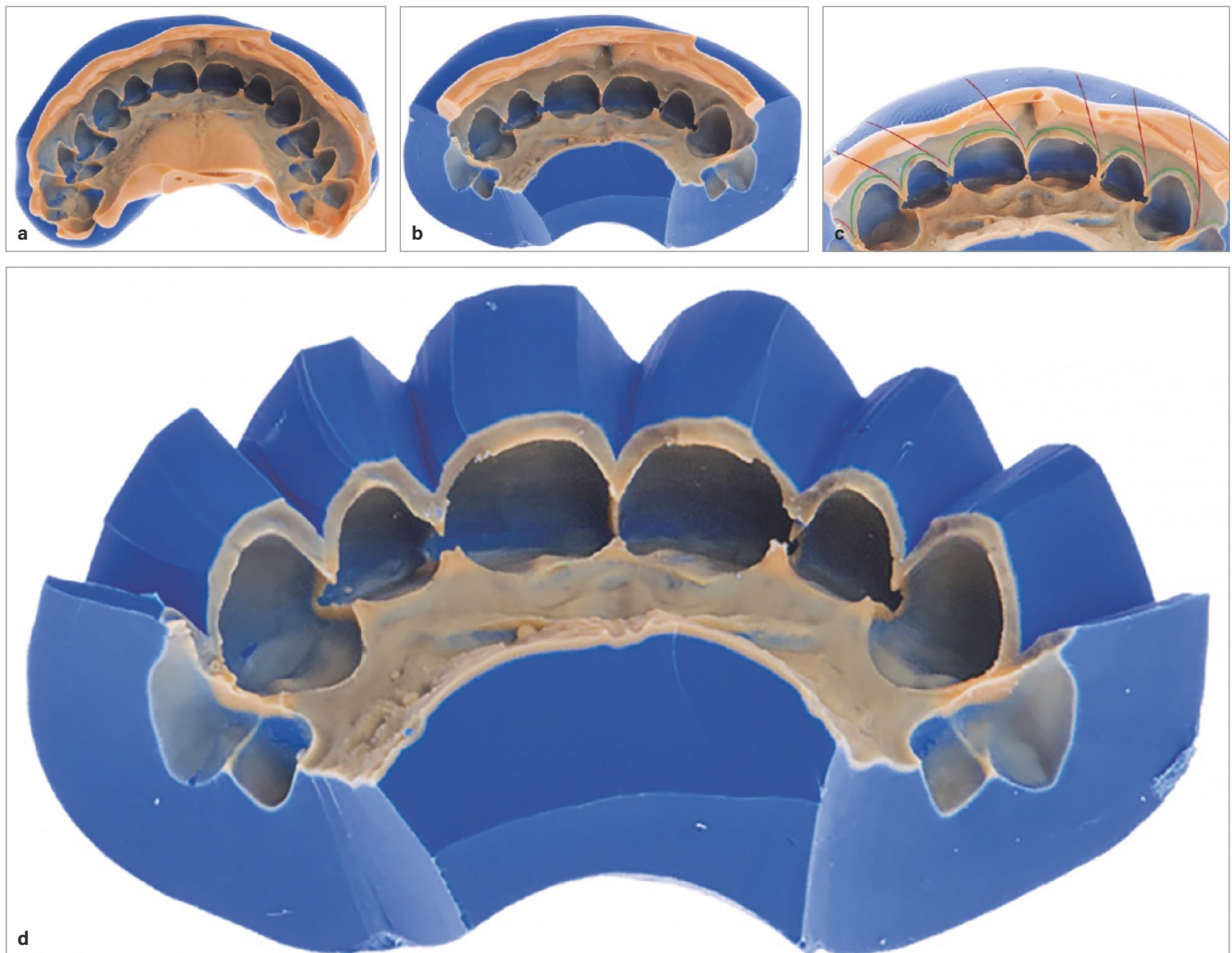


Fig 3-9 (a) Index created from the diagnostic wax-up. (b) Cut made sagittally through the tooth after the most distal tooth included in the wax-up. (c) Illustration of how to cut out the region of gingival margin and papilla. (d) Appearance of an index made from a wax-up of the four incisors after trimming.



Clinical and laboratory protocols

Initial planning

Initial planning should be done before involving the technician and should include the chief complaint, photographs, impressions, casts, and the written and digital checklists.⁷

Equipment, instruments, and materials required

- Digital camera and accessories (lens, flash, memory card, lip retractor, black contrast backgrounds, and mirrors)
- Plastic or metal impression trays
- Impression materials
- Impression tray adhesive
- Facebow
- Materials for occlusal records
- Computer with software for digital planning

Clinical sequence

- Perform the photographic protocol.
- Make a precise impression for the diagnostic wax-up, copying the sulcus, palate, and other areas as needed for the stability of the silicone index.
- Make excellent replica casts to have a record of the initial reference.
- Mount the casts in a semi-adjustable articulator.
- Write down and organize all of the data, then transmit to the dental technician.

Diagnostic wax-up

Equipment, instruments, and materials required

- Vacuum forming machine
- Precision scales and distilled water
- Plaster cutter
- Electric wax knife and colored waxes
- Wax-up instruments
- Photographs and digital planning references

Clinical sequence

- Make precision casts.
- Assemble in articulator.
- View the digital planning references.
- Draw the horizontal plane on the plaster cast.
- Perform a diagnostic wax-up.



Making the silicone indices

Equipment, instruments, and materials required

- Cast with diagnostic wax-up
- Addition or condensation silicone (heavy-body and flowable)
- Knife or scalpel blades

Laboratory and clinical sequence

- Determine the extent of the index (support areas and teeth involved).
- Manipulate the heavy-body silicone, placing it over the teeth and anatomical areas, creating a reference line at the midline of the teeth that is at least 1 cm thick buccally.
- Wait 5 minutes and remove the index.
- Insert the flowable silicone inside the index and return it into position on the arch.
- Wait another 5 minutes, then remove the index and trim it to contour the gingival margins and papillae.

Technique for additive mock-up without adhesion, motivational mock-up, or mock-up for clinical crown lengthening

This additive functional mock-up strategy without adhesion applies to cases in which the patient has teeth with little volume that are widely spaced, for example, cases requiring diastema closure, restoration of conical teeth, treatment of fractures and incisal edge wear, reestablishment of canine guidance, increase or reestablishment of vertical dimension, or improvement of gingival esthetics^{7,8,11} (Figs 3-10 to 3-12).

Equipment, instruments, and materials required

- | | |
|---|-----------------------------------|
| • Diagnostic wax-up | • Grinding wheels for adjustments |
| • Alcohol | • Shade guide |
| • Silicone index | • Dental adhesive |
| • Dappen dish | • Photopolymerizer |
| • Bis-acryl resin | • No. 12 scalpel blade |
| • Goat hair polishing disk | • Microbrush |
| • Flowable composite resin in the same color as the bis-acryl resin | • Cotton balls |
| | • Rubber dam or Teflon tape |

copyright by
not for publication
Quintessenz



Fig 3-10 Mock-up sequence. (a) Diagnostic wax-up. (b) Silicone index. (c) Initial intraoral photograph. (d) Removal of the index after chemical curing of the bis-acryl resin. (e) Appearance of the bis-acryl resin after removal of the index. (f) Removal of the excess with a scalpel blade. (g) Removal of the unpolymerized layer of resin with cotton ball moistened with alcohol. (h) Polishing of the bis-acryl resin with brushes. (i) Final intraoral photo. (j) Facial photograph before mock-up. (k) Facial photograph after mock-up.

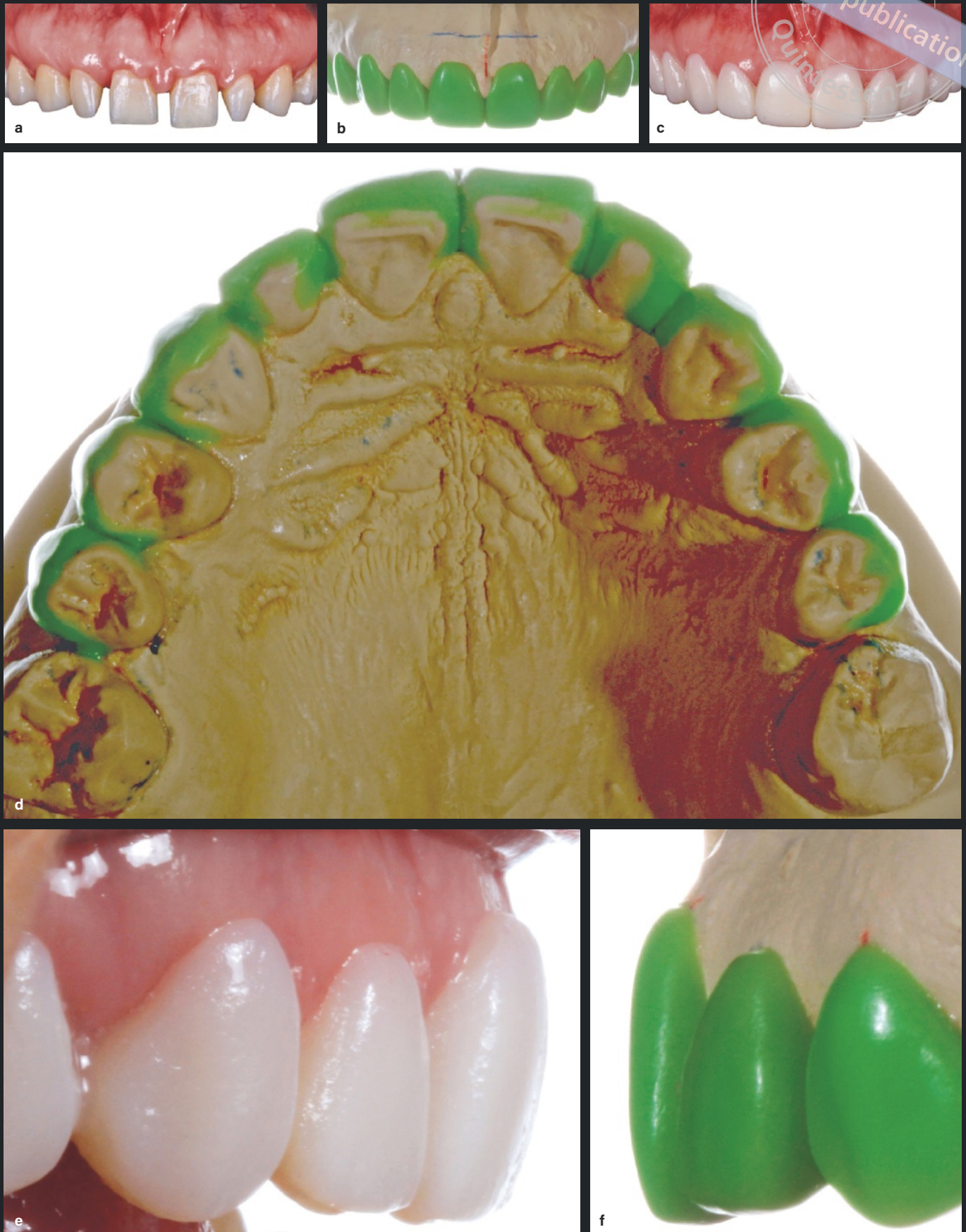


Fig 3-11 Additive wax-up for clinical crown lengthening. (a) Initial intraoral photo. (b) Frontal view of additive diagnostic wax-up simulating the new dental and gingival contours. The wax-up should be at least 1.5 mm thick on the gingival margin to avoid distortion during mock-up fabrication. (c) Frontal intraoral photograph with the mock-up. (d) Occlusal view of diagnostic wax-up. (e and f) Profile views of the mock-up and diagnostic wax-up. Observe the volume on the gingival margin, simulating the new gingival contour.

copyright by
not for publication
euntesenz

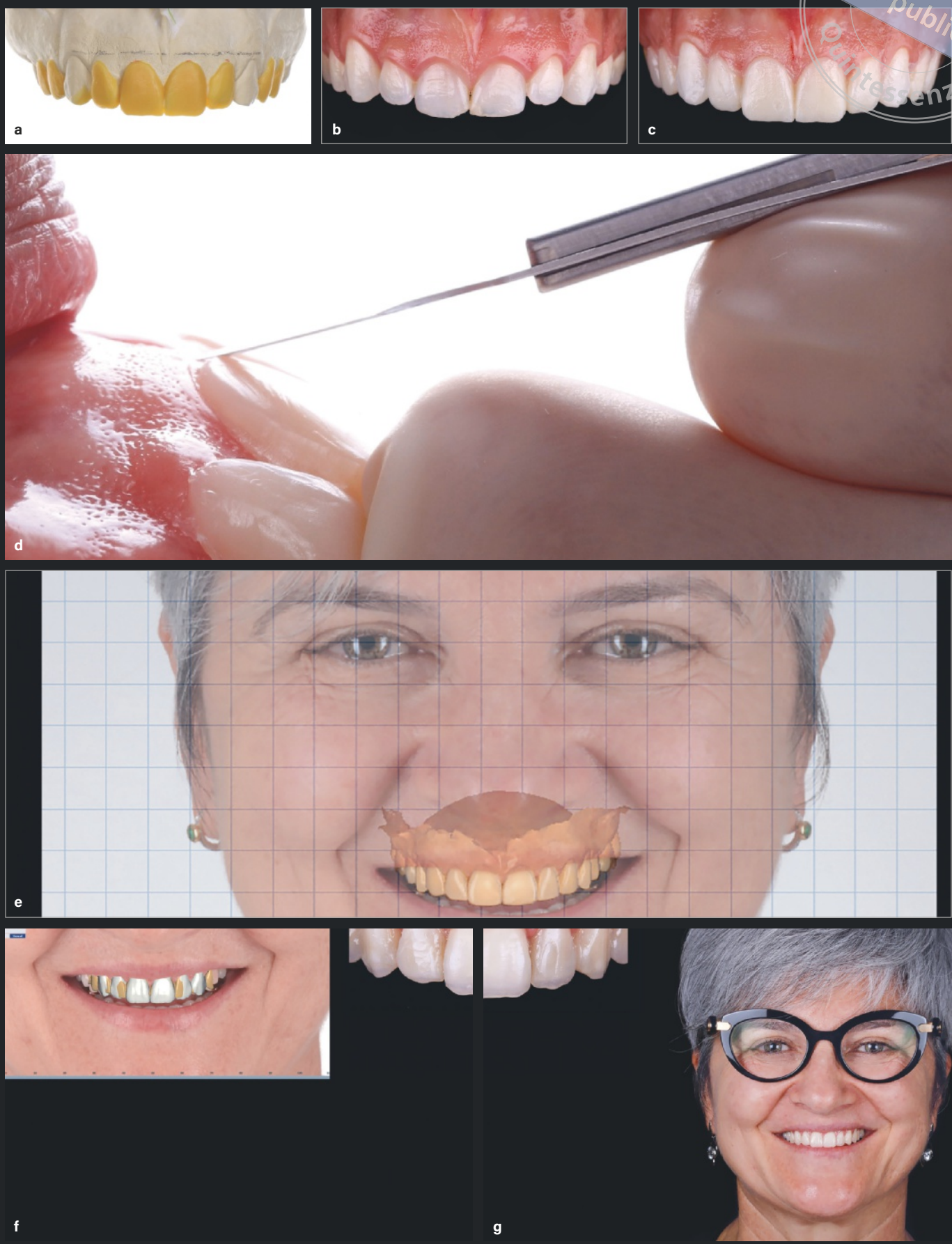


Fig 3-12 Clinical sequence of the mock-up for clinical crown lengthening. (a) Initial additive wax-up. (b) Initial intraoral photo. (c) Intraoral photo after mock-up. (d) Gingivectomy guided by the mock-up. (e) Frontal intraoral view following clinical crown lengthening guided by the mock-up. (f) Initial smile. (g) Smile after clinical crown lengthening guided by the mock-up.



Clinical sequence

- Check the silicone index for any distortions or interferences.
- Confirm the fit of the silicone index in the mouth and visualize landmarks.
- Select the color of the bis-acryl resin.
- Block retentive areas in the mouth, such as orthodontic retainers or diastemas, with rubber dam or Teflon tape.
- Dispense the first drop of bis-acryl resin on the back of the hand.
- Insert the bis-acryl resin into the silicone index by pressing the tip against the incisal edge.
- Position the index in the mouth and keep it in place for the duration of the material's polymerization time.
- After the material has set, remove any excess material on the index using a dental explorer.
- Remove the index using twisting movements at a 45-degree angle apicocoronally to avoid removing the resin from the tooth structure.
- Remove the unpolymerized surface layer of resin with a cotton ball moistened with alcohol.
- Remove excess resin from the gingival margin, papillae, and palatal and lingual regions with a no. 12 scalpel blade.
- Use a goat hair disk for polishing.
- Take photos for before and after comparisons.

Technique for additive mock-up simulating gingival tissues

This mock-up strategy applies to cases in which the patient has teeth with missing gingival tissue or edentulous areas with poor gingival architecture (Fig 3-13).

Equipment, instruments, and materials required

- | | |
|---|--|
| • Diagnostic wax-up | • Goat hair polishing disk |
| • No. 12 scalpel blade | • Gingiva-colored resins |
| • Silicone index | • Grinding wheels for adjustments |
| • Cotton balls | • Dental adhesive |
| • Bis-acryl resin | • Shade guide |
| • Alcohol | • Spatulas and brushes for composite resin |
| • Flowable composite resin in the same color as the bis-acryl resin | • Microbrush |
| • Dappen dish | • Photopolymerizer |
| | • Rubber dam or Teflon tape |

copyright by
not for publication
Quintessenz



Fig 3-13 (a) Initial smile. (b) Initial plaster cast. (c) Plaster cast with dental and gingival wax-up. (d) Silicone index in position. (e) Initial intraoral photo. (f) Mock-up with gingiva and gingival resin cartridge (*inset*). (g) Intraoral photo with mock-up. (h) Smile with mock-up.



Clinical sequence

- Check the silicone index for any distortions or interferences.
- Confirm the fit of the silicone index in the mouth and visualize landmarks.
- Select the color of the bis-acryl resin and the resin replicating the gingival tissue.
- Block retentive areas in the mouth, such as orthodontic retainers or diastemas, with rubber dam or Teflon tape.
- Dispense the first drop of bis-acryl resin on the back of the hand.
- Insert the bis-acryl resin into the silicone index by pressing the tip against the incisal edge.
- Position the index in the mouth and keep it in place for the duration of the material's polymerization time.
- After the material has set, remove any excess material on the index with a dental explorer.
- Remove the index using twisting movements at a 45-degree angle apicocoronally to avoid removing the resin from the tooth structure.
- Remove the unpolymerized surface layer of resin with a cotton ball moistened with alcohol.
- Remove excess resin from the gingival margin and papillae with a no. 12 scalpel.
- Reduce the mock-up in the area with artificial gingiva with diamond tips.
- Apply adhesive on the bis-acryl where the gingival resin will be inserted and polymerized.
- Apply the gingival resin to the mock-up and light cure.
- Use a goat hair disk for polishing.
- Take photos for before and after comparisons.

Technique for subtractive mock-up

The subtractive wax-up is indicated when there is a need to reduce the plaster cast to obtain the final anatomy; this happens in cases of, for example, dental crowding, proclined teeth, extruded teeth, and restorations with excessive volume (Figs 3-14 and 3-15). Thus, to perform the mock-up, it is necessary to create guides for reduction of dental structure on the cast prior to the tooth reduction and diagnostic wax-up.⁸

Equipment, instruments, and materials required

- Initial cast
- No. 12 scalpel blade
- Tooth reduction guide (acrylic, metal, or acetate)
- Cotton balls
- Diagnostic wax-up
- Alcohol
- Bis-acryl resin
- Dappen dish
- Flowable composite resin in the same color as the bis-acryl resin
- Goat hair polishing disk
- Grinding wheels for adjustments
- Dental adhesive
- Fine-tipped marker
- Spatulas and brushes for composite resin
- Microbrush
- Photopolymerizer
- Rubber dam or Teflon tape

copyright by
not for publication
Dentessenz



Fig 3-14 (a) Initial plaster cast with the clinical crown lengthening marked in pencil. (b) Cast with wax-up simulating the clinical crown lengthening, new tooth shapes, and the area requiring a gingival graft. (c) Subtractive wax-up of the same case for fabrication of provisional restorations. (d) Initial intraoral photo. (e) Finalized mock-up. (f) Gingivectomy guided by the mock-up. (g) Intraoral photograph after gingivectomy. (h) Dental preparations guided by the new gingival margins. (i) Intraoral photo after clinical crown lengthening guided by the additive wax-up and provisional restorations guided by the subtractive wax-up.



Fig 3-15 Volume reduction procedure prior to mock-up performed using acetate tooth reduction guides. (a) Initial occlusal photo; observe the proclination of the maxillary right lateral incisor. (b) Buccal reduction of the maxillary right lateral incisor and canine on plaster cast and creation of an acetate guide to aid intraoral reduction. (c and d) Guide in position on teeth to be reduced with fine-grained diamond tips.

Clinical sequence

- Try in the tooth reduction guide on the tooth structure.
- Trace around the wear guide with a fine-tipped marker.
- Reduce dental structure with a high-speed handpiece with a fine diamond tip and irrigation. Evaluate the need for anesthesia prior to the procedure.
- Check the silicone index for any distortions or interferences.
- Confirm the fit of the silicone index in the mouth and visualize landmarks.
- Select the color of the bis-acryl resin.
- Block retentive areas in the mouth, such as orthodontic retainers or diastemas, with rubber dam or Teflon tape.
- Dispense the first drop of bis-acryl resin on the back of the hand.
- Insert the bis-acryl resin into the index by pressing the tip against the incisal edge.
- Position the index in the mouth and keep it in place for the duration of the material's polymerization time.
- After the material has set, remove any excess material on the index with a dental explorer.
- Remove the index twisting at a 45-degree angle apicocoronally to avoid removing the resin from the tooth structure.
- Remove the unpolymerized surface layer of resin with a cotton ball moistened with alcohol.
- Removal excess resin from the gingival margin, papillae, and palatal and lingual regions with a no. 12 scalpel blade.
- Use a goat hair disk for polishing.
- Take photos for before and after comparisons.
- If the patient approves the mock-up, the same procedure should be performed, but with prior conditioning of the enamel and dentin following the protocol of the adhesive system selected, applying flowable resin without polymerizing, and finishing with the insertion of bis-acryl resin using the index. After removing the index, light cure for 20 seconds on each buccal, palatal, and lingual surface of the teeth where the mock-up was applied.
- If necessary, break off any interproximal contact points with serrated strips and finish the proximal surfaces with composite resin abrasive strips.
- At this stage, the finishing and polishing of the mock-up must be done carefully since it will remain in the mouth for a considerable time.



Technique for direct intraoral mock-up

Sometimes it is difficult for the dental technician to perform a diagnostic wax-up because the dentist is not able to provide the correct references to guide the anatomical transformation. When the path to be followed is uncertain, the best approach is to make a mock-up directly in the patient's mouth so they can collaborate in the decision-making process^{5,12,13} (Fig 3-16).



- Equipment, instruments, and materials required**
- Flowable composite resin
 - Dental adhesive
 - Microbrush
 - Spatulas and brushes for composite resin
 - Photopolymerizer
 - No. 12 scalpel blade
 - Grinding wheels for adjustments
 - Goat hair polishing disk
 - Fine-tipped marker
 - Dry-point compass
 - Endodontic millimeter ruler

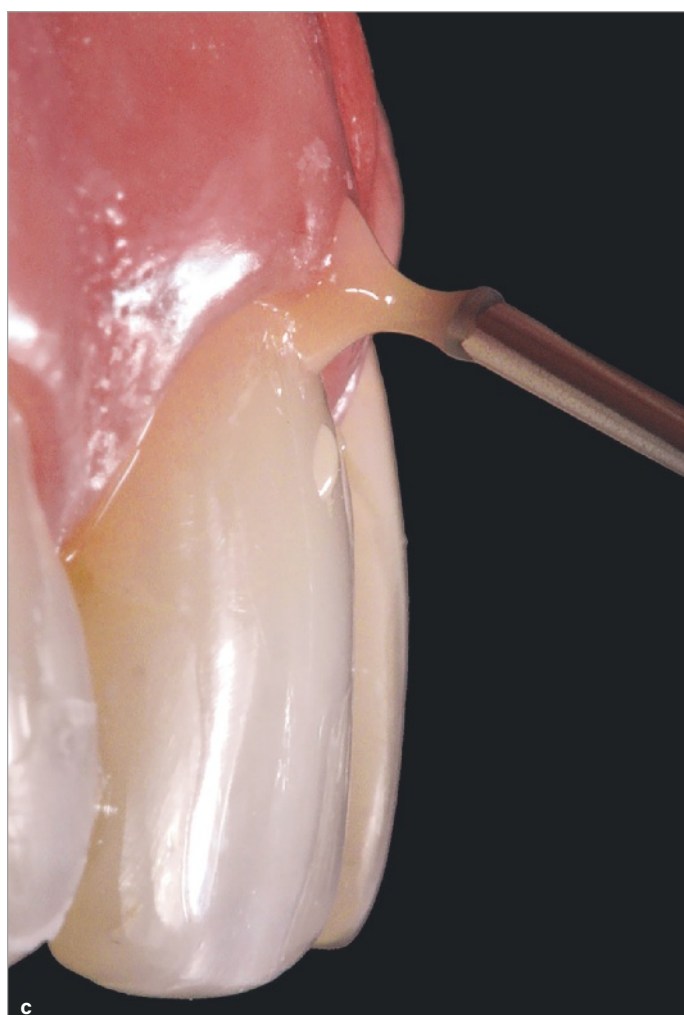


Fig 3-16 (a) Initial smile. (b) Smile with the direct mock-up simulating clinical crown lengthening and reduction of incisal edges of the anterior teeth. (c) Detail of placement of flowable resin to simulate clinical crown lengthening. (d) Marking the possible reduction at the incisal edge with a fine-tipped marker.

Clinical sequence

- Take a photograph of the lips at rest and in maximum smile to check dental exposure.
- Take a facial photograph to check for asymmetries.
- Perform an esthetic analysis and define the parameters to follow.
- Apply flowable resin over the gingival tissue to simulate clinical crown lengthening and composite or flowable resin to simulate tooth shape changes.
- With a black marker, paint the incisal edges to simulate reduction of the clinical crown.
- Photograph the smile after the direct mock-up has been performed.
- Discuss the result obtained with the patient and define the path forward.
- Take an impression of the direct intraoral mock-up to send to the dental technician as a reference.

Technique for mock-up with flowable resin and transparent index

In clinical situations in which the mock-up may remain in the mouth for a long time, even for years in some situations, flowable resin can be indicated as the material of choice, as it has mechanical and optical properties superior to bis-acryl resin. However, because it is a light-cured restorative material, the use of a conventional silicone should be avoided, as it is not possible for light to penetrate the opacity of the index. Therefore, transparent silicones are recommended for making this index to allow the passage of light to photoactivate the flowable resin.¹⁴⁻¹⁶ Following is a sequence for performing a mock-up using this technique (Fig 3-17).

Equipment, instruments, and materials required

- Cast with wax-up
- Replica of the cast with wax-up
- Laboratory silicone
- Vacuum former and 0.5-mm acetate dies
- Transparent addition silicone, gun, and mixing tips
- Shade guide
- Flowable composite resin
- 37% phosphoric acid
- Dental adhesive
- Microbrush
- Spatulas and brushes for composite resins
- Photopolymerizer
- No. 12 scalpel blade
- Grinding wheels for adjustments
- Goat hair polishing disks
- Fine-tipped marker
- Dry-point compass
- Endodontic millimeter ruler
- Teflon tape
- Transparent impression tray



Fig 3-17 Clinical sequence for performing mock-up using the flowable resin technique and clear index. (a and b) Impression of the wax-up using clear addition silicone.

copyright by
not for publication
Quintessenz



Fig 3-17 (cont) (c) Etching of the teeth. (d) Adhesive application. (e) Light curing. (f) Injection of flowable resin through holes created in the transparent matrix. (g) Appearance before removal of excess, finishing, and polishing. (h) Initial intraoral view. (i) Intraoral view after mock-up.

Clinical sequence

- Check the adaptation of the transparent index.
- Create injection holes for the flowable resin on each tooth in the largest regions of the diagnostic wax-up. Note that the holes may vary from tooth to tooth.
- Selecting one tooth at a time, protect the neighboring teeth with Teflon tape.
- Check again the adaptation of the transparent index.
- Apply the adhesive system on the selected tooth according to the manufacturer's instructions.
- Place the index, inject flowable resin through the hole in the index on that tooth, and light cure.
- Remove the index and perform preliminary finishing.
- Repeat the same protocol for the other teeth.
- Carry out final finishing, occlusal adjustment, and final polishing.
- Take photos for before and after comparisons.

Technique for additive mock-up without adhesion using a digital workflow

With the introduction of digital scanning in dentistry, the evolution of software, and the possibility of printing photopolymer resin models, it is now possible to obtain a digital replica of the patient's mouth without conventional

impression taking. A digital wax-up can also be performed using specific software, and after the new tooth shape is defined, the file can be printed on a 3D printer to obtain a physical model. The next steps for the mock-up technique follow the conventional clinical sequences as already described for the additive mock-up without adhesion⁷ (Fig 3-18). However, there is also the possibility of a printed or milled mock-up using suitable equipment.

Equipment, instruments, and materials required

- Scan of the mouth obtained with a dental scanner
- Appropriate software for making the mock-up
- 3D printer for dentistry
- Silicone for making the index
- Bis-acryl resin
- Flowable composite resin in the same color as the bis-acryl resin
- Dental adhesive
- Spatulas and brushes for composite resin
- Photopolymerizer
- No. 12 scalpel blade
- Cotton balls
- Alcohol
- Goat hair polishing disk
- Grinding wheels for adjustments



Fig 3-18 Wax-up carried out using a digital workflow. (a) Initial appearance.

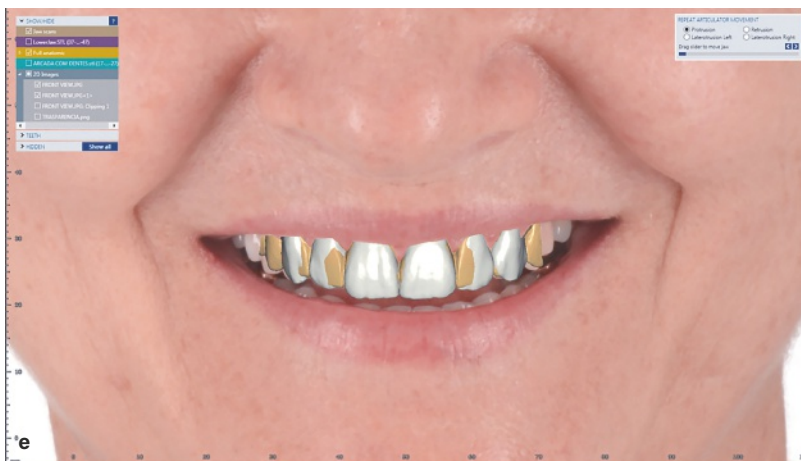
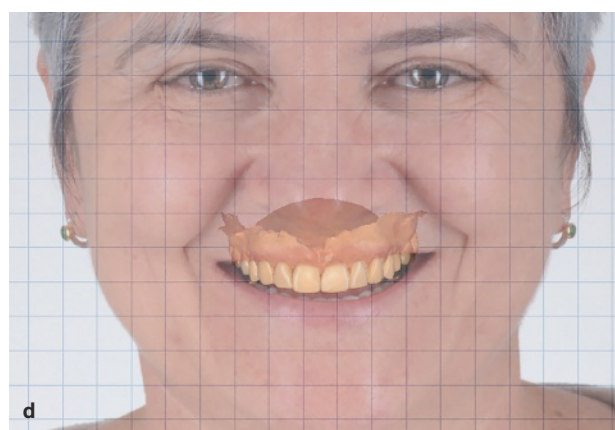
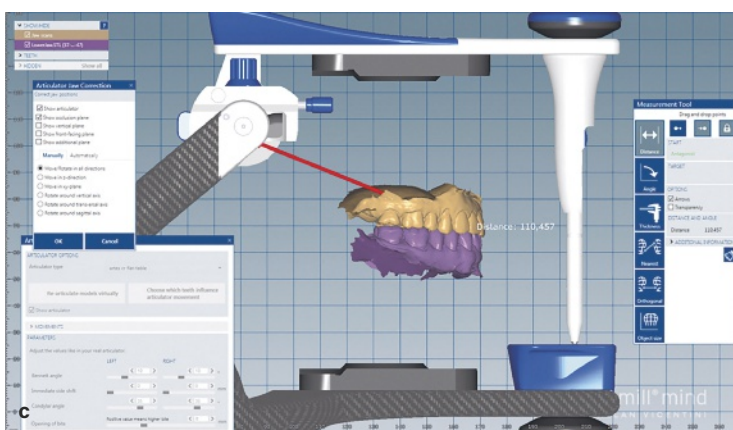


Fig 3-18 (cont) (b to e) Digital wax-up performed using a facial photo and the digital scan file (STL) to generate a new digital file to be printed by a 3D printer. (f and g) Intraoral and facial views of the mock-up.

Clinical sequence

- Check the silicone index for any distortions or interferences.
- Confirm the fit of the silicone index in the mouth and visualize landmarks.
- Select the color of the bis-acryl resin.
- Dispense the first drop of bis-acryl resin on the back of the hand.
- Insert the bis-acryl resin into the index by pressing the tip against the incisal edge.
- Position the index in the mouth and keep it in place for the duration of the material's polymerization time.
- After the material has set, remove any excess material on the index with a dental explorer.
- Remove the index with twisting movements at a 45-degree angle apicocoronally to avoid removing the resin from the tooth structure.
- Removal the unpolymerized surface layer of resin with a cotton ball moistened with alcohol.
- Removal excess resin from the gingival margin and papillae with a no. 12 scalpel blade.
- Use a goat hair disk for polishing.
- Take photos for before and after comparisons.

Technique for mock-up using the SKYN concept

In 2013, Paulo Kano et al¹⁷ published a technique to improve the predictability of CAD/CAM restorations. In

this technique, prior to scanning the dental preparations, a mock-up is performed using flowable resin veneers obtained from natural tooth models. A silicone index is fabricated on the vestibular side of a natural teeth model, then a thin film of flowable composite resin is applied to the index, followed by light curing. The resin veneers are then removed from the index and positioned on the dental preparations or natural teeth. They should be fitted and relined with composite or flowable resin until the teeth are in harmony, thus making a mock-up directly in the mouth without the need for a diagnostic wax-up by the dental technician¹⁸ (Fig 3-19).

Equipment, instruments, and materials required

- Scan of the mouth obtained with a dental scanner
- Computer and appropriate software for digital mock-up design
- 3D printer for dentistry
- Models of natural teeth
- Silicone for fabricating an index
- Flowable composite resin
- Dental adhesive
- Spatulas and brushes for composite resin
- Photopolymerizer
- No. 12 scalpel blade
- Disks and abrasive rubber wheels for adjustments
- Goat hair polishing disks

copyright by
not for publication
Quintessence



Fig 3-19 (a) Initial intraoral photograph. (b and c) Flowable resin veneers simulating the texture of natural teeth are placed on the patient's teeth. (d and e) Insertion of composite resin for adaptation of the veneers to the teeth. (f) Intraoral photograph of mock-up using the SKYN technique after polishing with goat hair disks.



Clinical sequence

- Select a natural tooth model with the desired height-to-width ratio; this ratio can be obtained using digital planning as described in chapter 2.
- Fabricate a silicone index on the buccal surface of the natural tooth model.
- Apply a thin layer of flowable resin on the index surface and light cure.
- Check the fit and position of the flowable resin veneers on the tooth structure.
- Adapt and position the veneers with flowable composite resin.
- Carry out finishing and polishing with abrasive rubber wheels.
- Take photos for before and after comparisons.

Decisions to Be Made

- Through esthetic and functional analysis, decide which type of diagnostic wax-up to use.
- Define the extensions and supports of the silicone index that you will use.
- Define the mock-up technique you will use and the amount of time it will remain in the mouth.
- Define the polymeric material that you will use for the mock-up.
- Always remember to take photos of the mock-up to compare with the initial photos.
- Good luck! For further reading, see the references below.

References

1. Braly BV. A preliminary wax up as a diagnostic aid in occlusal rehabilitation. *J Prosthet Dent* 1966;16:728–730.
2. Magne P, Douglas WH. Additive contour of porcelain veneers: A key element in enamel preservation, adhesion, and esthetics for aging dentition. *J Adhes Dent* 1999;1:81–92.
3. Kahng LS. Patient-dentist-technician communication within the dental team: Using a colored treatment plan wax-up. *J Esthet Restor Dent* 2006;18(4):185–195.
4. Morgan DW, Camella MC, Staffanou RS. A diagnostic wax-up technique. *J Prosthet Dent* 1975;33:169–177.
5. Higashi C, Gomes JC, Kina S, Andrade OS, Hirata R. Planejamento estético em dentes anteriores. *Odontol Estética* 2006;(February 2016):146.
6. Reshad M, Cascione D, Magne P. Diagnostic mock-ups as an objective tool for predictable outcomes with porcelain laminate veneers in esthetically demanding patients: A clinical report. *J Prosthet Dent* 2008;99:333–339.
7. Coachman C, Calamita MA, Sesma N. Dynamic documentation of the smile and the 2D/3D Digital Smile Design process. *Int J Periodontics Restorative Dent* 2017;37:183–193.
8. Clavijo V, Sartori N, Phark J, Duarte S. Novel guidelines for bonded ceramic veneers: Part 1. Is tooth preparation truly necessary? *Quintessence Dent Technol* 2016;39:7–25.
9. Abduo J, Bennamoun M, Tennant M, McGeachie J. Precision of digital prosthodontic planning for oral rehabilitation. *Curr J Appl Sci Technol* 2014;4(27):3915–3929.
10. Abduo J. Morphological symmetry of maxillary anterior teeth before and after prosthodontic planning: Comparison between conventional and digital diagnostic wax-ups. *Med Princ Pract* 2016;25:276–81.
11. Gurra J, Bruguera A. Wax-up and mock-up. A guide for anterior periodontal and restorative treatments. *Int J Esthet Dent* 2014;9:146–162.
12. Gürel G. Porcelain laminate veneers: Minimal tooth preparation by design. *Dent Clin North Am* 2007;51:419–431.
13. Clavijo V, Kabbach W. Enceramento Diagnostico e sua aplicabilidade clínica. *Clínica Int J Braz Dent* 2012;8:16–22.
14. Terry D, Powers J. Using injectable resin composite: Part one. *Int Dent Afr Ed* 2014;5(1):52–62.
15. Dias E, Conejo J, Flores J, Blatz MB. Full-mouth rehabilitation with the flowable injection technique. *Quintessence Dent Technol* 2018;41:204–218.
16. Blasi A, Alnassar T, Chiche G. Injectable technique for direct provisional restoration. *J Esthet Restor Dent* 2018;30(2):85–88.
17. Kano P, Xavier C, Ferencs J, Van Dooren E, Silva NFR. Anatomical shell technique: An approach to improve the esthetic predictability of CAD/CAM restorations. *Quintessence Dent Technol* 2013;36:38–58.
18. Cofar F, Gaillard C, Popp I, Hue C. SKYN concept: A digital workflow for full-mouth rehabilitation. *Quintessence Dent Technol* 2016;39:47–56.

10



Ceramic Fragment Restorations





The cementation of a fragment-type ceramic restoration can be compared to post-trauma tooth fragment bonding techniques. These techniques have been discussed since 1964, when Chosack and Eigdelman¹ described bonding the fragment of a fractured central incisor. Since then, different techniques for fragment bonding after dental fracture have been reported. In 1990, Baratieri et al² indicated bonding of a tooth fragment as the treatment of choice, reporting satisfactory esthetic results, maintenance of the anterior guidance in enamel, and emotional and social benefit to the patient. The use of partial ceramic restorations cemented on enamel emerged following the same philosophy of bonding a fragment to the tooth remnant after trauma.

Kyrillos and Moreira³ highlighted the importance of multidisciplinary planning to longevity of partial ceramic fragment restorations. Clavijo et al⁴ described the clinical steps of ceramic fragment restoration at the incisal edge with minimal tooth reduction. Following the philosophy of minimal tooth reduction, the same article reported on placement of multiple ceramic fragments on the mesial and distal surfaces for diastema closure without tooth preparation. In 2011, the same authors described ceramic fragment restorations without tooth reduction.⁵ In the same period, Gresnigt and Özcan⁶ reported on partial restorations associated with veneers with full coverage of the buccal surface. The authors emphasized that the adhesive, finishing, and polishing steps are essential for restoration performance.

Horvath and Schulz⁷ described a minimally invasive modality for indirect restoration in which a thin partial ceramic restoration was used as a class 4 restoration in a maxillary incisor. The dental preparation was limited to the removal of the old resin restoration, and thus the ceramic margin remained in the middle third. The authors justified using ceramics for greater color stability, less plaque accumulation, as well as higher mechanical strength.



Signore et al⁸ described closing a diastema between central incisors using fragments without any tooth preparation, if the shape of both incisors allowed the insertion of the ceramic fragments. The authors emphasized that cases in which there is no indication for tooth preparation are few and should be considered with caution.

Andrade et al⁹ reported an average of 5 years of follow-up for six minimally invasive ceramic restorative cases. After cementation, finishing, and polishing, they presented the standard ceramic-cement-enamel interface as an area of continuous adhesion and concluded that the longevity of these interfaces could be effectively evaluated by studying micrographs.

Vadini et al¹⁰ reported that, to provide a better long-term prognosis, it is essential to use cementing agents with loads greater than 70% due to the visible interface (70 to 130 μm^{11}) between the fragment and the dental structure, in addition to performing all finishing and polishing steps at this interface after cementation.

Sinhori et al¹² demonstrated the efficacy and favorable prognosis of fabricating ceramic fragments through CAD/CAM technology using blocks with color gradients.

Gresnigt et al¹³ compared the fracture strength of ceramic fragments, ceramic veneers, and direct composite restorations and concluded that the ceramic fragment can behave acceptably, both esthetically and functionally, as a restorative technique.

Indications for Ceramic Fragment Restorations

Ceramic fragments are ceramic restorations that partially cover one or more tooth surfaces (Fig 10-1). Ceramic fragment restorations are ideal as a minimally invasive procedure, avoiding unnecessary reduction of the healthy tooth structure. However, these restorations require a high degree of precision in terms of their indications and their fabrication.

There are four determining factors for this technique:

1. The color of the tooth to be restored must be the intended color, as the fragments cannot block darkened tooth structure, given their minimal thickness.
2. Fragments should only be fabricated in cases where the restoration or augmentation of dental structures is required.
3. The insertion axis of the fragments must be evaluated to verify if there is a need for removal or reduction of small retentive areas.
4. Their fabrication must be undertaken by a lab that has mastery of the technique.

These restorations are indicated in situations in which the tooth position allows the addition of material because, even if minimal reduction is required, it must start and end in enamel. Thus, the maximum amount of viable enamel is maintained so that there is no significant deformation of the dental structure when submitted to masticatory stress.^{14,15} Likewise, adhesion is optimized, as the fragile ceramic fragments have no mechanical retention and no ductility, and therefore depend on the adhesive and mechanical properties of healthy tooth enamel for longevity. Thus, they are indicated in situations such as incisal edge augmentation, buccal volume augmentation, closure or reduction of diastemas, incisal fractures, restoration of canine guidance, noncarious cervical lesions, and even partial occlusal restorations to restore occlusion after an erosive or abrasive process with loss of tooth structure. Table 10-1 shows the main clinical indications, the teeth usually involved, and the advantages of ceramic fragments as the treatment option for the corresponding indication.



a

Fig 10-1 (a and b)
Examples of ceramic
fragment restorations.

Table 10-1 Indications, tooth locations, and clinical advantages of ceramic fragments

Indications	Teeth involved	Clinical advantages of ceramic fragment
Recovery of previous guidance	Maxillary and mandibular incisors	Increased material stability due to mechanical wear resistance capability
Recovery of canine guidance	Canines	Longevity
Restoration of occlusal enamel due to mechanical wear or erosion	Premolars and molars	Long-term stability of occlusion in the restoration
Class V cervical lesions	Premolars and molars, eventually canines	Easy adherence to the gingiva due to the greater smoothness of the piece
Diastema closure	Anterior and posterior teeth	Avoids the tooth reduction required for conventional veneers that cover the entire buccal surface and have cervical margins
Class 4 restoration	Central and lateral incisors	Color stability, easy adjustments, less time in the office
Ceramic restoration repair	Any tooth with a restoration that has small fractures and well-adapted edges	Prevents removal of well-adapted restorations, avoiding dental reduction to allow greater biologic preservation



b

Contraindications for Ceramic Fragment Restorations

When there is no possibility of insertion or an inability to achieve the desired shape just by adding restorative material, fragments are contraindicated. In these two clinical situations, greater reduction of the dental structure becomes necessary to redesign the smile. Additionally, in cases where there are severe occlusal dysfunctions causing the loss of healthy dental structure, dental fragments should not be used to reconstruct the lost anatomy. Table 10-2 shows the main clinical situations in which the prognosis for the use of ceramic fragments is not favorable.

Table 10-2 Unfavorable predictors for use of ceramic fragments

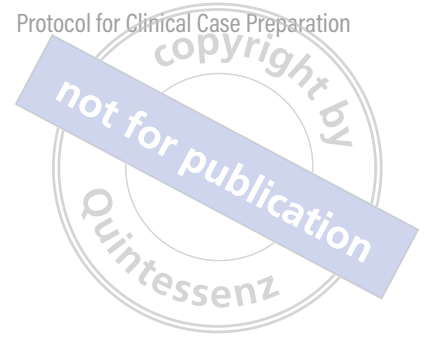
Clinical situation	Absolute contraindication	Relative contraindication
Darkened substrate	x	
Absence of insertion axis		x
Adhesion area partly on dentin		x
Untreated occlusal dysfunctions	x	

Clinical Complexities

Because it is a very sensitive technique, failures can occur during the process. Table 10-3 describes the most common clinical complexities during the fabrication of ceramic fragment restorations. One way to minimize possible errors is to establish clinical protocols and follow them without compromise.

Table 10-3 Clinical complexities in the fabrication of ceramic fragments

Clinical difficulty	Rationale
Delimiting small areas of reduction	Selective grinding must be performed so that the restoration can be passively inserted.
Absence of contact point	Because it is passively inserted, it is important to verify the contact point prior to cementing.
Fracture prior to cementing	The greatest possible care must be taken when making any required adjustments and exerting pressure on the restoration during try-in and cementation.
Incorrect positioning during cementation	As there is no delimited margin, insertion in the wrong position is very common.
Precision in removing the overcontour after cementation	As there is no defined margin, the laboratory must send the restoration with overcontouring, which will be removed after cementation.
Inadequate polishing	Invariably, there is cement exposure and glaze removal during the process.
Late fracture	The mechanical performance of fragments depends on the performance of the adhesive process.



Protocol for Clinical Case Preparation

Case selection

Check the main complaint, tooth shade, and the possibility of additive treatment. At this stage, it is fundamental that the clinician takes intraoral and extraoral photographs, as well as the initial impressions with addition silicones to obtain study casts for the diagnostic wax-up.

Wax-up and mock-up

Once photographs and initial casts have been obtained, the dental technician must perform the diagnostic wax-up. For better visualization of small shape alterations, colored wax should be used on the cast. Testing the diagnostic wax-up in the mouth is fundamental in esthetic treatments.^{15,16} The mock-up has two indispensable purposes: to show a preview of the final restoration for the patient's approval and to guide the small adjustments to be performed.¹⁷

Color selection

After the definition of the intended tooth shape in the mock-up, careful prophylaxis and the removal of dental calculus, especially in the proximal and palatal areas, must be performed. If possible, this procedure should be done in a visit prior to the impression taking, as bleeding gingiva can jeopardize impression taking.

With ceramic fragment restorations, the shade of the tooth is crucial for good esthetics after cementation. The first procedure in the impression-taking appointment is to take the tooth shade before dehydration occurs.

Selective reduction

When sharp, retentive angles are present, minimal grinding is necessary, limited to the most superficial enamel.^{18,19} Visual inspection, followed by pencil marking of the retentive areas on the tooth structure, serve as a guide for reduction to establish the insertion axis of the ceramic restorations. In some cases, the dental technician can make a small grinding guide on the initial plaster cast that will be inserted on the dental enamel to remove the retentive areas.²⁰⁻²² The grinding should be performed with a fine-grained diamond tip followed by polishing with abrasive disks.

Impressions

To fabricate indirect restorations, addition silicone is the preferred impression material due to its tear resistance, low viscosity, dimensional stability, high elastic recovery capacity, and the possibility of the two-step impression technique. Obtaining a good plaster cast of the antagonist arch helps in the accuracy of occlusal adjustment. For this reason, addition silicone should be used for impression taking of both arches.^{23,24}



Ideally, the two-step impression technique should be used to obtain an accurate copy of the tooth structure and gingival margin. However, caution is required with retraction of the gingiva for the impression. As a rule, use of retraction cord is only suitable for ceramics with a buccal cervical margin. For ceramic fragments, the alteration of the cervical margin can lead to overcontouring and an artificial final appearance, even alteration of the natural emergence profile. Therefore, it is ideal to take impressions for fragments without retraction, keeping the gingival margin in its natural position. However, the use of retraction cords on the proximal surfaces is essential in cases of diastema or when a new emergence profile is to be created along the entire cervical extension.

Choice of ceramic material

Fragment restorations can be fabricated from various materials within disilicate or feldspathic ceramics.

Disilicate ceramics are indicated for occlusal and palatal restorations that can be produced by means of injection or CAD/CAM. Injected or milled ceramics used for thin restorations are generally monochromatic and have many glass particles in their composition, which makes them more translucent. Consequently, they have a low value (degree of luminosity), which can lead to a grayish aspect when very translucent. Lithium disilicate is recommended for fragments made to recover the canine guidance or restore the occlusal surface, due to its greater strength.²⁵ However, it is worth emphasizing the need for polishing if the ceramic is reduced intraorally; the high hardness of lithium disilicate combined with the high roughness of the restoration after occlusal adjustment may lead to excessive wear of the opposing teeth.²⁶

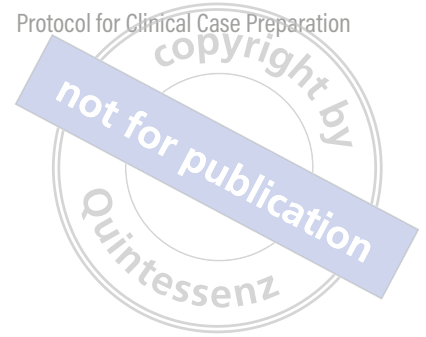
Feldspathic ceramics are fabricated manually by adding powder or liquid and sintered on a refractory cast. When compared to disilicates, the refractory ceramics present with more feldspar and quartz in their composition. Additionally, they can be stratified from the first layer and can receive a thin layer of opaque ceramic, providing opaque or translucent areas even in thin restorations.

Try-in of restorations

The appointment must begin with prophylaxis of the dental structure with a rubber cup or Robson brush and pumice, with special care in proximal areas where the greatest accumulation of bacterial plaque occurs. If there is calculus in the proximal region, a metallic abrasive strip must be used to remove the calculus with smooth movements, avoiding laceration of the gingiva.

The try-in of ceramic fragments is a meticulous procedure, demanding delicacy and exacting care.²⁷ The following guidelines should be followed:

- **Observe the insertion axis:** It is valuable to practice the precise insertion movement and correct positioning of the fragment on the plaster cast. When feeling ready, the clinician repeats the movement, bringing the fragment to the natural tooth without exerting pressure on the restoration. Should any interference prevent the restoration from being correctly positioned, the perceived retentive area is removed on the tooth, never in the internal region of the ceramic, thus avoiding fractures and cracks.



- **Evaluate the contact point:** Contact point adjustment is extremely important and delicate. Therefore, it must be precise and can be done with the support of the piece in the hand or on the plaster cast.²⁸ It is necessary to be confident in the small adjustments that will be performed.

There are resin cements with value and saturation options. These cement systems have try-in “cements,” which are glycerin gels with coloration corresponding to the optical effects of the resin cement. These try-in pastes can be used to correct small variations in value. This step must be taken with great care, because the fragments are extremely thin, and the wrong cement color can be disastrous. Therefore, preference should be given to translucent cement colors. On whitened teeth, however, high-value try-in pastes can be used, because whitened teeth have a higher value (luminosity).

Cementation

Choice of cementing agent

Resin cementing agents that are exclusively light cured are optimal for the cementation of fragment restorations. Their relevant characteristics are better color stability, longer working time, and lower viscosity. Their lower viscosity facilitates insertion of ultra-thin restorations and prevents fracture during the adhesive process. It is also possible to opt for light-curing cements based on a value scale, not on chroma, unlike traditional light-curing cements. In addition, exclusively light-activated cements use alternative photoinitiators such as Lucirin (BASF), bisacylphosphine oxide (BAPO), and phenylpropanedione (PPD), which make these cements more translucent and less yellowish. However, they must be polymerized by third-generation polywave LEDs, with a light spectrum of 380 to 515 nm.

Cautions for the cementation of ceramic fragments

Ceramic fragment restorations can be cemented out of their correct position; because they do not require conventional tooth preparation, they have more than one insertion axis. To avoid cementing fragments in the wrong orientation, it is necessary to pay maximum attention to their positioning and to carefully remove the excess cement before polymerization. The clinician should position themselves at different angles (12, 3, 6, and 9 o'clock) to inspect the fragment after insertion and prior to light curing.

Preparing the ceramic fragment

Hydrofluoric acid etching of the ceramic fragments must be carried out with caution due to their fragility. The etching must only be done after try-in.

Step-by-step fragment preparation:

1. **Application of 10% hydrofluoric acid on the internal surface of the fragment.** After the conditioning time, the acid is removed under running water with great care not to fracture the restoration. The conditioning time for each ceramic is different due to variations in silica; always check the conditioning time according to the manufacturer. The purpose of hydrofluoric acid etching is to expose the silica on the surface of the ceramic piece, which will be reactive to the silane, as well as to create microporosities.



After washing and drying, a white, opaque surface will be obtained. At this point, residues must be removed with correct cleaning of the restoration, according to the ceramic material used.^{29,30}

2. **Restoration cleaning.** Options include:

- Water spray to remove conditioning residues.
- Placement in an ultrasonic tank for 5 minutes with isopropyl alcohol.
- Brushed with 35% phosphoric acid actively for 30 seconds.

3. **Silanizing.** Silane is applied to the etched and dried surface for at least 60 seconds. The protocol for acid and silane application varies by material. Therefore, before using a cementation system, it is necessary to find out the recommended protocol. The use of a pure adhesive after silanization is an optional step.

Preparing the tooth structure

1. Begin with prophylaxis using pumice stone and Robson brush, rubber dam isolation, and blasting with aluminum oxide.
2. Conditioning the enamel substrate should be done with 37% phosphoric acid for 30 seconds, followed by washing with water spray and air drying.
3. The adhesive is applied to the properly conditioned tooth surface. Excess should be removed with the aid of suction and air spray is applied for solvent evaporation.
4. After the restoration has been set on the tooth, excess cement must be removed using brushes, dental floss, and a serrated metal strip. The initial light curing must then be carried out for 3 seconds. Removal of excess with a brush prior to photoactivation assists in the formation of a continuous bonding line for less bacterial colonization³¹ and no gap formation from cement removal with an explorer after initial polymerization.³²
5. Remove excess, place glycerin for oxygen inhibition, and complete polymerization for 40 seconds on each surface.
6. Remove excess cement with floss and a scalpel blade.

Finishing and polishing

Ceramic-tooth margins after cementation

As mentioned previously, any overcontouring of partial ceramic restorations must be addressed after cementation. Failure to remove overcontoured ceramic may lead to esthetic compromise, food impaction, increased plaque accumulation, difficulty in cleaning, and subsequent gingival inflammation. Poor polishing can lead to staining of the adhesive margin and bacterial adhesion. Therefore, overcontouring should be removed by means of finishing techniques and detailed polishing around the restoration-tooth margin.

Dedicating a subsequent appointment to the finishing and polishing step is recommended. Reducing the restoration removes part of the enamel and the glaze applied to it. This process is irreversible and must be performed accurately and meticulously. Adhesive margins can be classified into the following:

- Vertical margin (Fig 10-2): This is when the largest area of restoration-tooth margin is parallel to the long axis of the tooth (eg, for diastema closure).
- Horizontal margin (Fig 10-3): This is when the largest area of restoration-tooth margin is perpendicular to the long axis of the tooth (eg, incisal edge correction).
- Combination margins: This is when the ceramic fragment has margins that are both perpendicular and parallel to the long tooth axis (eg, diastema closure associated with a Class IV lesion).



Fig 10-2 (a) Lateral incisor that will receive a ceramic restoration to close a distal diastema. (b) Ceramic fragment. (c) Try-in of the ceramic fragment. (d) Cemented ceramic fragment. Note that most of the ceramic-tooth margin is a vertical line.

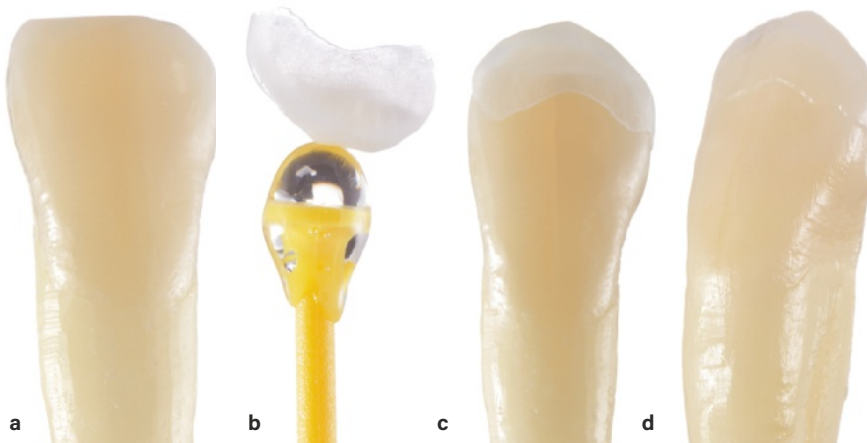


Fig 10-3 (a) Maxillary canine with cusp tip wear. (b) Ceramic fragment to reestablish the cusp tip. (c) Try-in of the ceramic fragment. (d) Cemented ceramic fragment. Note that most of the ceramic-tooth margin is a horizontal line.

Finishing sequences at different margins

It is necessary to use extra-fine diamond tips for finishing carried out with movements perpendicular to the ceramic margin. This will prevent formation of unwanted depressions and concavities. Precise movements under magnification are essential. The finishing must be oriented according to margin classification:

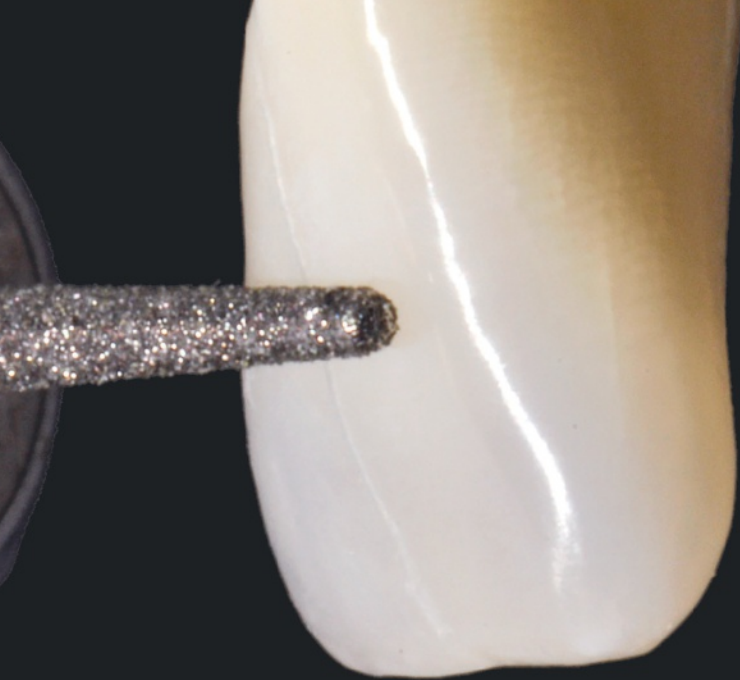


Fig 10-4 Always finish and remove steps between the ceramic fragment and the tooth with fine-grained diamond tips in a perpendicular direction to the margin.

- Vertical margin (Figs 10-4 and 10-5): Tilt the head of the contra-angle handpiece by about 90 degrees to be perpendicular with the step.
- Horizontal margin (Figs 10-6 and 10-7): Similarly, the diamond tip should be used perpendicular to the step. However, when finishing this type of margin, it can be difficult to insert the high-speed contra-angle handpiece due to the position of neighboring teeth; in this case, it will be necessary to perform parallel to the step, which makes the process riskier. Greater attention must be paid to the movement of the diamond tip, which must be in the direction of the ceramic-tooth margin. The grinding can be performed with air spray without irrigation to allow visualization of the margin and avoid possible concavities.

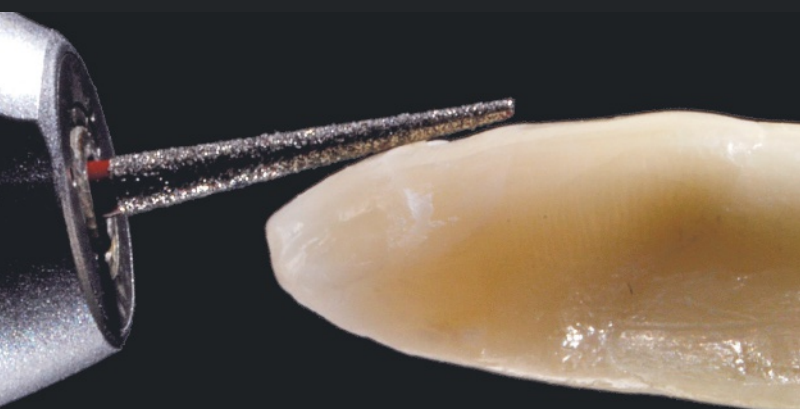


Fig 10-6 Always finish and remove steps between the ceramic fragment and the tooth with fine-grained diamond tips in a perpendicular direction to the margin.



Fig 10-5 Avoid positioning the diamond tip parallel to the margin. This can easily create concavities in the margin area.

- Combination margins: It is recommended to divide finishing into segments and apply the vertical and horizontal margin technique according to the orientation of each segment of the step. Ceramic fragments with both horizontal and vertical margins are common in canines because they have greater volume in the middle third.

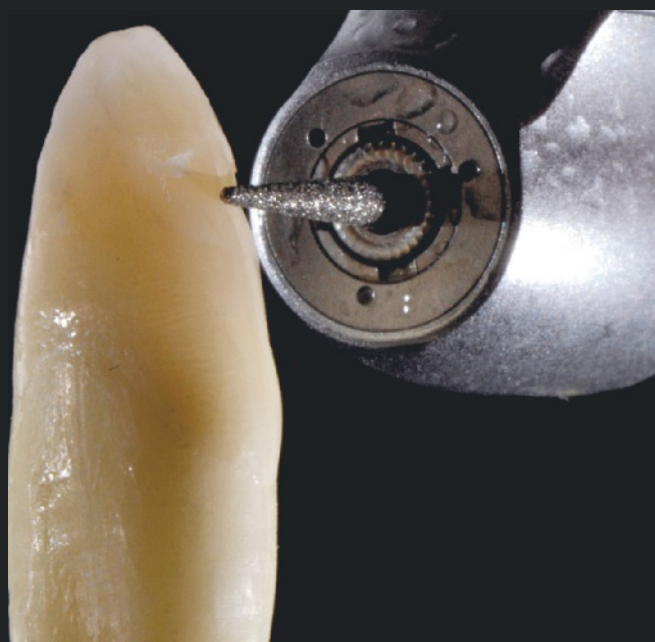


Fig 10-7 In some situations, it will not be possible to perform polishing in a perpendicular orientation, due to the location of the margin; therefore, finishing must be done with the point in a parallel direction to the margin. In this situation, great care must be taken not to create concavities at the margin. Always work in the direction of the ceramic-tooth margin.

copyright by
not for publication
Quintessenz

The diamond tips that are used should be new, fine grain, and from a reputable manufacturer. The finishing of the interface is considered complete when the ceramic fragment and the tooth structure are in continuity, without a step, and properly polished. A significant step can be felt directly with the explorer. Under magnification, small steps can be observed at the line of continuity between the ceramic, the bonding material, and the dental enamel. Figure 10-8 shows the enamel surface after the removal of a ceramic step. After finishing the tooth-restoration complex there are grooves and partial removal of the ceramic glaze.



Fig 10-8 Ceramic fragment after cementation on a maxillary left central incisor. (a) Note the step formed at the ceramic-tooth margin. (b) Planing the step at the ceramic-enamel margin with a diamond tip perpendicular to the interface. Note that a rough, scratched margin is created as a consequence, and a line of resin cement is exposed. (c) Ceramic fragment after finishing and polishing. Note the ceramic-resin cement-enamel interface. (d) Ceramic fragment at 8-year follow-up.

Final polishing

The goal of polishing is to reduce surface roughness (Fig 10-9a) until it becomes shiny. The increased smoothness leads to a brighter and more esthetic tooth surface. Furthermore, it tends to decrease the adhesion of bacterial plaque, increasing the longevity of the restoration.

Although essential, polishing with rubber polishers (Figs 10-9b to 10-9d) will not restore the initial smoothness of the fragment obtained by glazing the ceramic, which unfortunately has to be removed during the finishing process.³³ Inadequate polishing may lead to staining at the margin (Fig 10-9e).

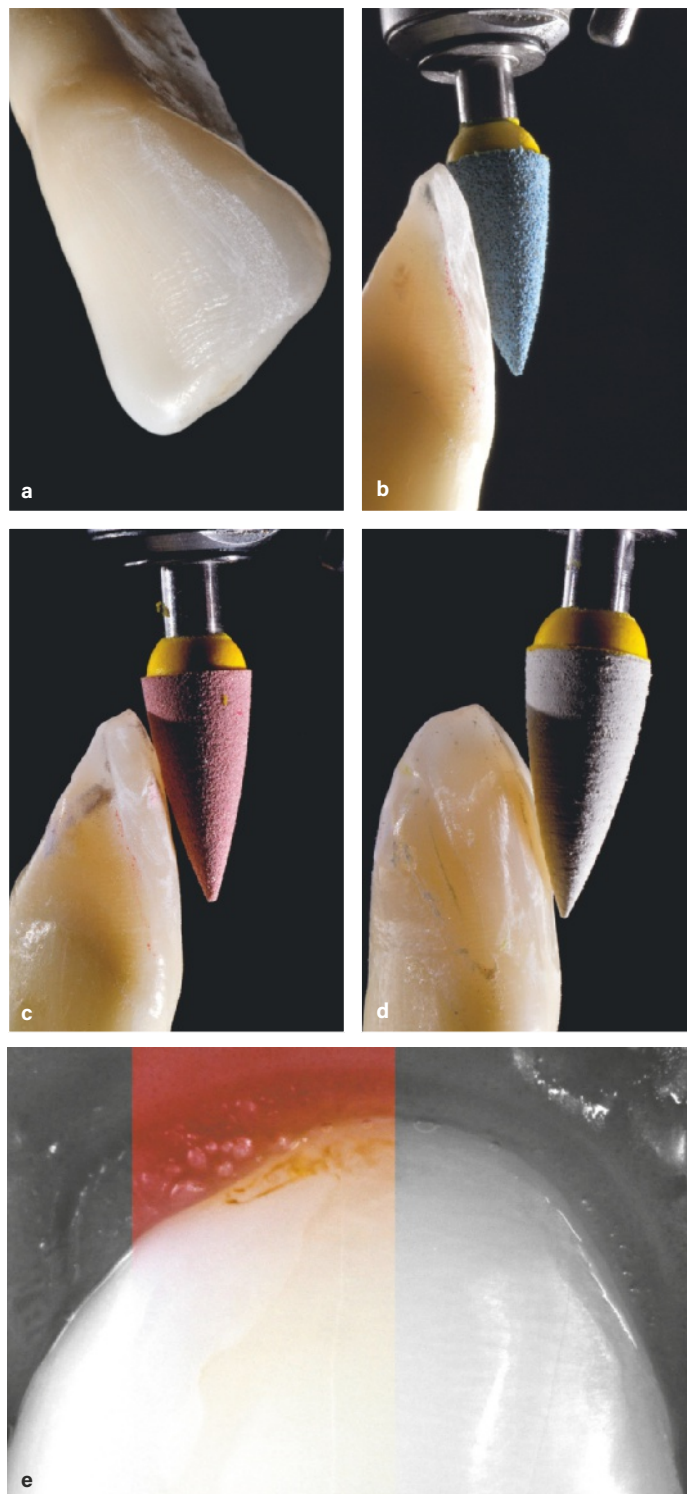
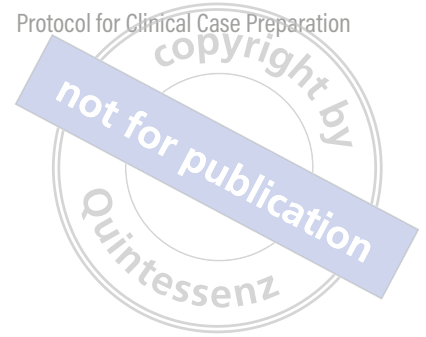


Fig 10-9 (a) Note that after finishing the ceramic interface, there will be irregularities and grooves on both the enamel and the ceramic, and a small band of resin cement can also be seen between the ceramic and the tooth, creating a new resin cement-tooth interface. (b) Coarse-grained diamond ceramic rubber polisher removing the grooves created during finishing. At this stage, the polishing direction is not critical. The main concern is to prevent overheating of the tooth. (c) Medium-grained diamond rubber polisher for ceramics. (d) Fine-grained diamond rubber polisher for ceramic. This polisher will provide the final brightness. It is difficult to equalize the luster of the glaze and the ceramic; it is important to create not only excellent smoothness, but also optical characteristics that make the restoration look natural. (e) Margin of the ceramic fragment restoration after 4 years of follow-up. Note that there are areas without staining and areas with pigmentation near the gingiva, which suggests that it was a difficult area to polish.



The quality of rubber polishers and the length of time they have been used are relevant. With continuous use, the diamonds loosen from the surface, decreasing the polishing capacity and generating a surface with less smoothness and shine. Each polishing system has its own order in which polishers of various grains should be used, which must be followed according to the manufacturer's instructions.

Materials required for finishing

1. Colored pencils or graphite (fine tip) for marking edges and reflection angles
2. Truncated cone-shaped fine-grained diamond tips with rounded ends (2200F, 2135F, and 2135FF)
3. Contra-angle multiplier handpiece
4. Flame-shaped bur (FF) for palatal surface
5. MiniFlex diamond blades (Rigaku) for finishing incisal edges
6. Rubber polishing kit for finishing and polishing ceramics
7. Dry-point compass
8. Contra-angle handpiece
9. Straight handpiece

Checklist for finishing and polishing

1. For multiple teeth, do the finishing and polishing in a separate session.
2. Use magnification whenever possible. Opt for magnifiers with 3.5× magnification on average.
3. Check the necessary adjustments from 3, 6, 9, and 12 o'clock positions
4. To adjust the incisal edge, always apply the rubber polisher on the palatal side at a 45-degree angle, avoiding reduction of the edge on the vestibular surface.
5. Make sure that the occlusal contacts are balanced and that there is no premature contact.
6. Make all the movements with the drill in one direction only. Avoid back-and-forth movements with the drill rotating.
7. Make the reflective areas identical to those of the contralateral teeth. To accomplish this, check the size of the reflective areas and the amount of light reflection with calipers.



Contents

- 1 Digital Photography in Dentistry
- 2 Esthetic Planning and Digital Tools
- 3 Diagnostic Wax-up and Mock-up Techniques
- 4 Injectable Resin Technique for Provisional Restorations
- 5 Intraradicular Restorations
- 6 Tooth Preparations for Anterior Ceramic Restorations
- 7 Techniques for Impressions and Provisional Restorations
- 8 Ceramic Systems
- 9 Adhesive Cementation
- 10 Ceramic Fragment Restorations
- 11 Modification of Peri-Implant Contours
- 12 Introduction to Digital Dentistry

ISBN 978-1-78698-135-6



9 781786 981356

www.quintessence-publishing.com