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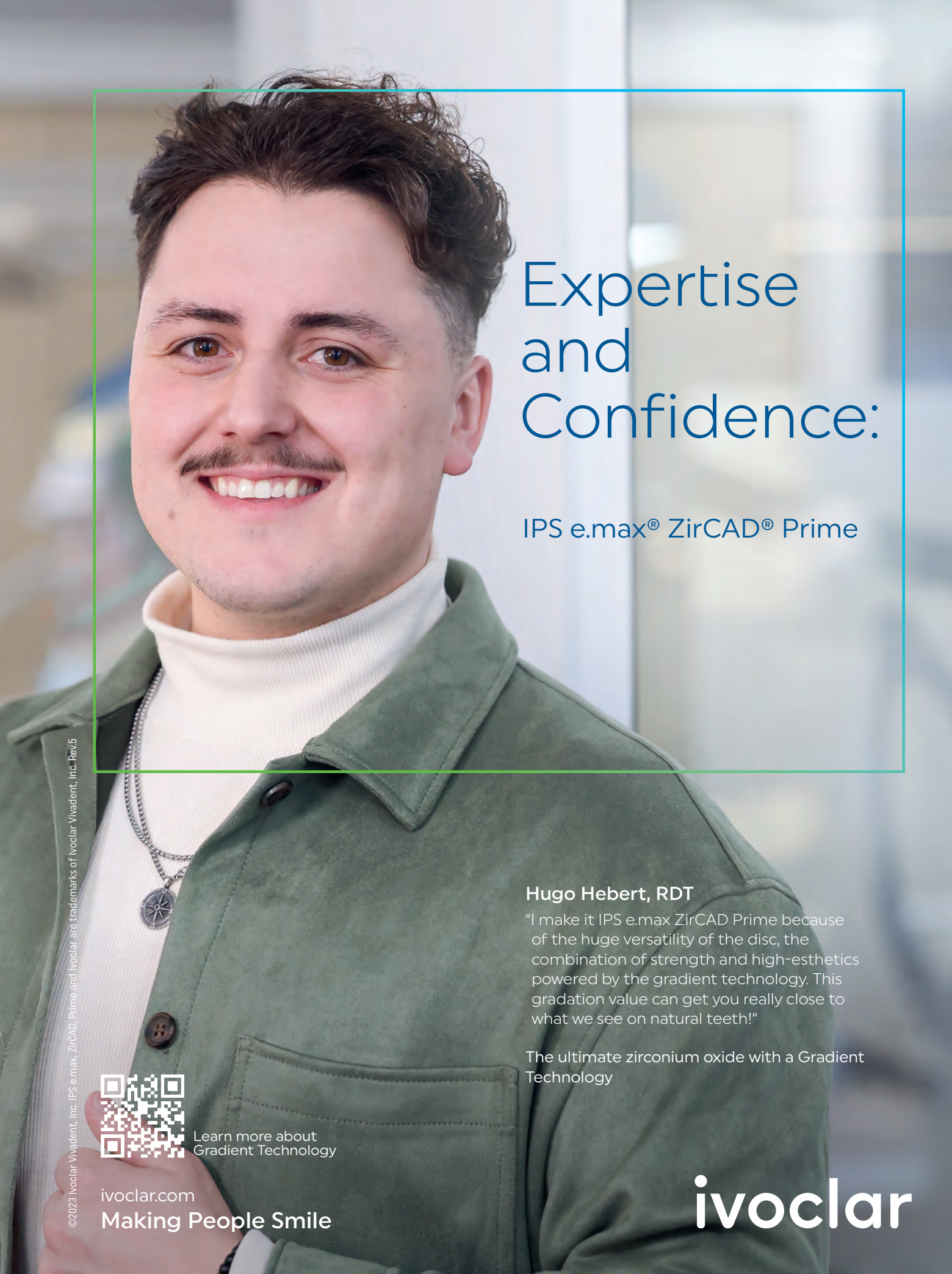
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Vincent Fehmer, MDT

Editor-in-Chief

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Editorial:
Nurturing Excellence in Dental Technology

Dear Reader,

As we dive into the 46th volume of *Quintessence of Dental Technology* (QDT), I find myself humbled by the unwavering trust and support from you and from our restorative teams providing nothing but outstanding clinical excellence and documentation. You are the driving force behind our commitment to push boundaries in the field of dental technology. Thank you for inspiring us to keep going!

In this volume, we again have the privilege of featuring contributions from some of the best restorative teams in our domain. This issue is particularly special, as we showcase complex cases and focus on how digital technologies can help to simplify treatment. The contributing authors are committed to breaking down these complex cases into step-by-step documentation so readers can understand the intricate procedures. Moreover, we emphasize the pivotal role of proper diagnosis and documentation—the cornerstone of successful dental treatment. The ability to create a comprehensive picture of a patient's oral health is an art that, when perfected, leads to informed decisions and patient satisfaction.

In our relentless pursuit of excellence, we have witnessed the transformative power of modern technology. It is not merely a tool to be more efficient and avoid technical complications; it is the key to delivering predictable and accurate treatment outcomes. However, in today's world, we must also strive to ensure that these outcomes are affordable for the general population.

As we venture together into this 46th volume of QDT, I am excited to share with you the latest advancements and insights in the world of dental technology. Together, we will continue to nurture excellence, foster innovation, and make a positive impact on the lives of our patients.

Thank you for your continued trust in QDT. Stay curious, and always be inspired.

Sincerely,

Vincent Fehmer





Image courtesy of Luis Quintero, DDS, runner-up in our QDT 2024 cover contest.



Full-Arch Implant-Supported Zirconia Bridge:

Digital Tools for Planning, Guided Surgery, and Prosthetics

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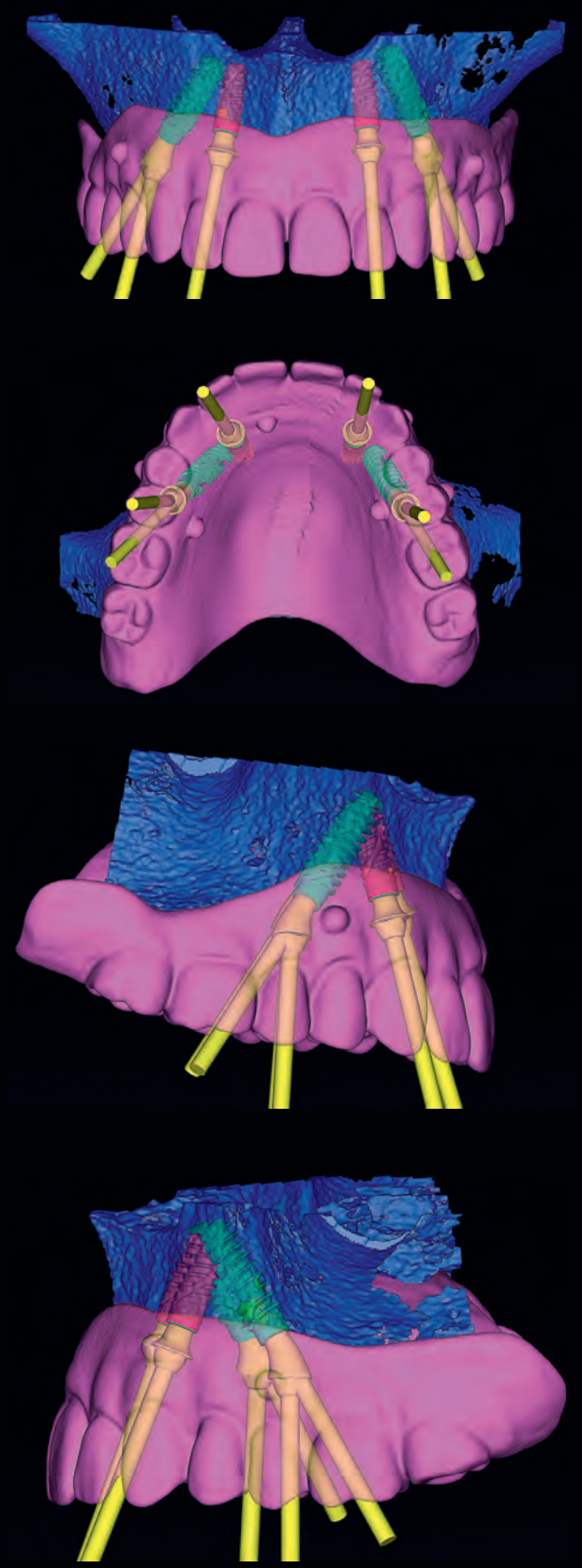
Restoring the teeth of patients who have lost their natural teeth or whose existing teeth are severely damaged is a complex and lengthy process. Thankfully, modern technologies and tools have made it easier to speed up specific processes and reduce the number of visits required. However, it is important to find a balance between minimizing patient visits and allowing enough time for proper healing and stabilization of soft and hard tissue. In this article, we outline the stages and tools used in our clinic to ensure the highest standard of dental care for our patients.

Prosthetically driven planning refers to an approach wherein the desired final prosthesis should be the inspiration source for surgical planning and implant placement rather than vice versa (Figs 1 to 4). Implant treatment can be especially useful in treating edentulous patients not only to replace missing teeth but also to restore function, esthetics, and speech.

Here are the steps involved in providing prosthetically driven planning of immediately loaded implants with screw-retained full-mouth bridges to edentulous patients or those with terminal dentition who require immediate implant loading.

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FIGS 1–4
Prosthetically driven implant planning based on preferable tooth position.



FIGS 5/6
Establishing correct vertical dimension and verification of lip support with wax rims.

1. Clinical Assessment

Before initiating any process, a thorough clinical assessment must be undertaken of the patient's oral health, dental needs, and esthetic expectations. Clinicians and patients may hold different views regarding what constitutes esthetic success; an understanding must be reached between them both.



2. Determination of Prototype Prosthesis

The initial step in creating the ideal prototype prosthesis is identifying its size, shape, color, and positioning of teeth. Wax occlusal rims help to establish the correct bite position, the vertical dimension, and the position of teeth (Figs 5 and 6) while giving an idea of patient lip support and smile line, which can be verified by additional cephalometric radiograph examination. Cephalometric analyses help to fully understand a patient's facial profile and maxillomandibular relationship (Fig 7).

To ensure accurate function, it is important to plan for canine and anterior guidance as well as dynamic occlusion during speech and chewing movements. The Zebris JMA system (Jaw Measurement Analysis) is a perfect tool for this purpose. It records the mobility of the mandible and all degrees of movement. By analyzing the data, any issues with jaw movement that may affect the patient's dental rehabilitation can be identified (Fig 8).

Dental photography and software like SmileFy or Smilecloud can be invaluable tools in achieving and verifying the position of teeth (Figs 9 and 10).



FIG 7
2D cephalometric examination and analysis helps in understanding the facial profile and maxillomandibular relationship.

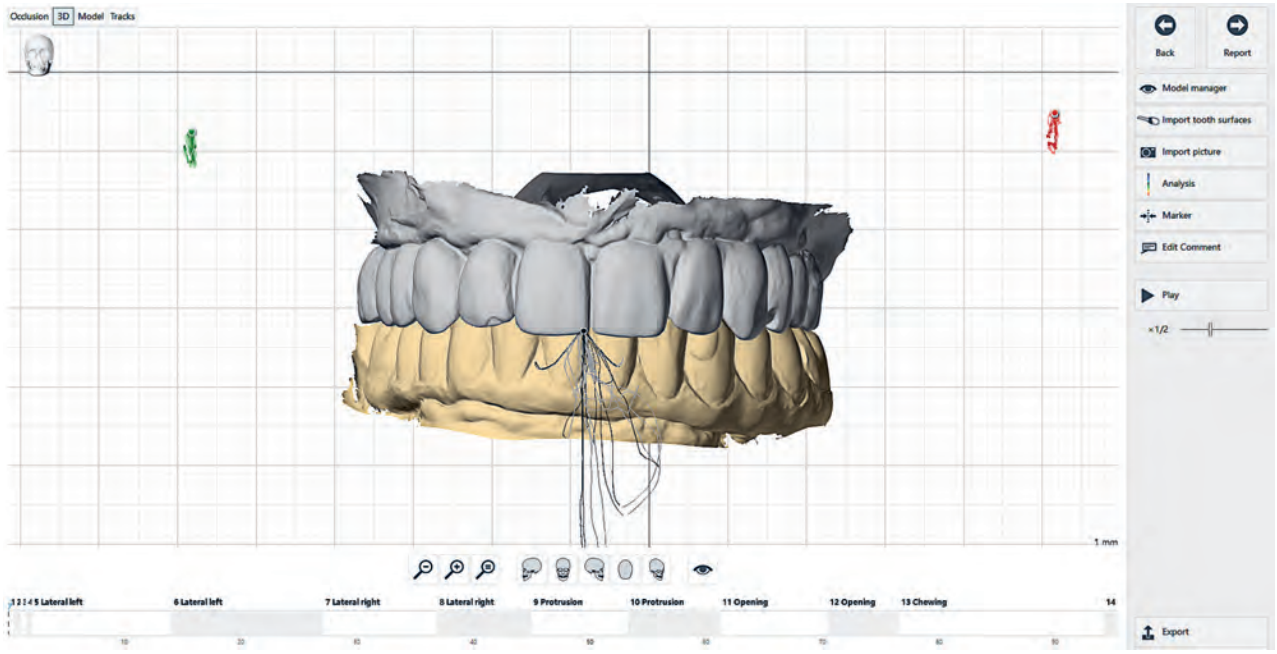
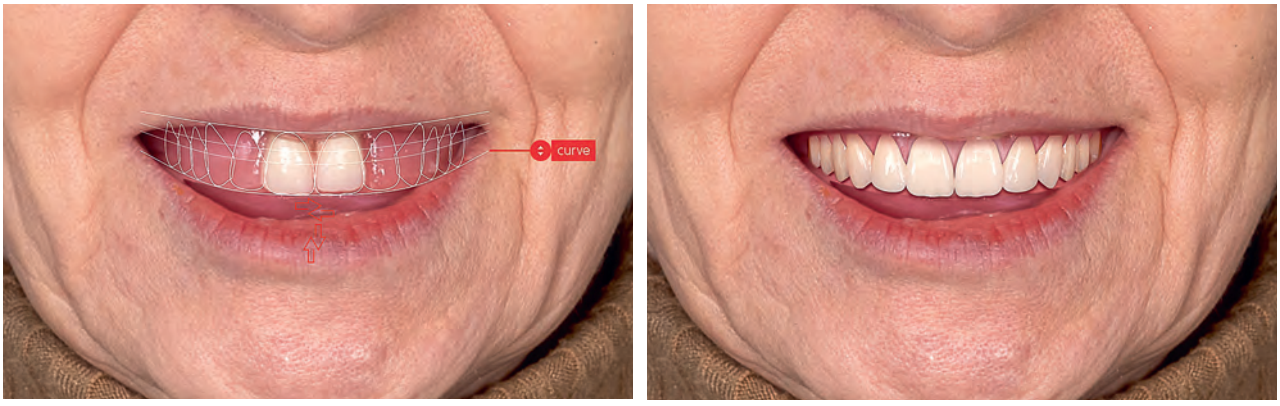
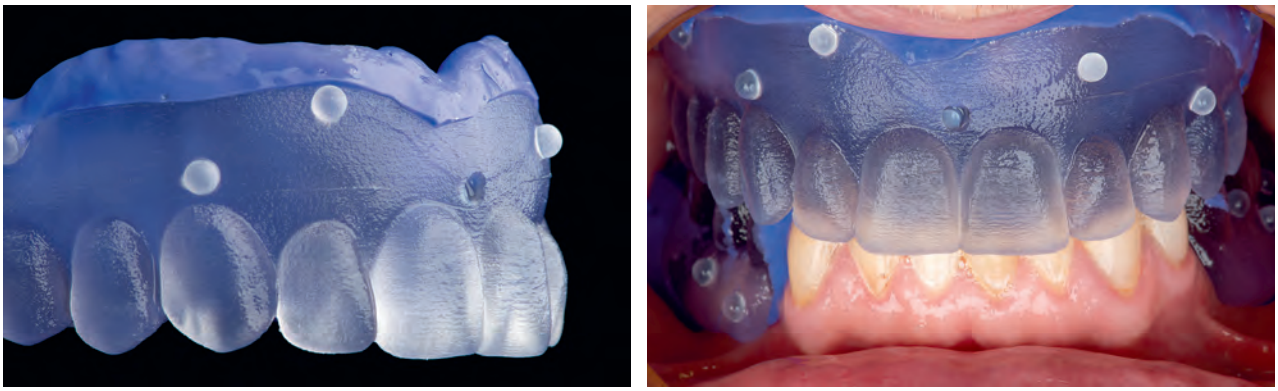


FIG 8 Record of the mobility of the mandible performed with Zebris JMA system.



FIGS 9/10 Diagnosing esthetic appearance of the restoration based on dental photographs and cloud-based software SmileFy.



FIGS 11/12 3D-printed radiographic guides prepared for the dual scan technique.

3. Radiographic Guide and CBCT

To provide an accurate visualization of prosthesis placement relative to existing bone tissue, imaging techniques such as the dual scan technique can be used. In the dual scan technique, patients are imaged while wearing a radiopaque template of their intended prosthetic design (Figs 11 and 12). The radiographic guide allows the clinician to visualize where the prosthesis will ultimately reside on existing bones, thereby enabling implant placement that optimally supports the planned prosthetic design. Implant placement decisions are therefore guided by prosthetic considerations.

4. Integrating Imaging Data with the Prosthetic Plan

When combined with advanced surgical planning software such as coDiagnostiX (Dental Wings), imaging data relating to bone quantity and quality can be combined with a second scan of a radiographic guide or digital design of the prosthesis (Fig 13). This allows clinicians to virtually place implants in optimal positions considering both prosthetic requirements as well as surgical considerations (Figs 14 and 15). This step makes it possible to segment specific tissues (like bone and soft tissues) and add objects like provisional bridge designs.

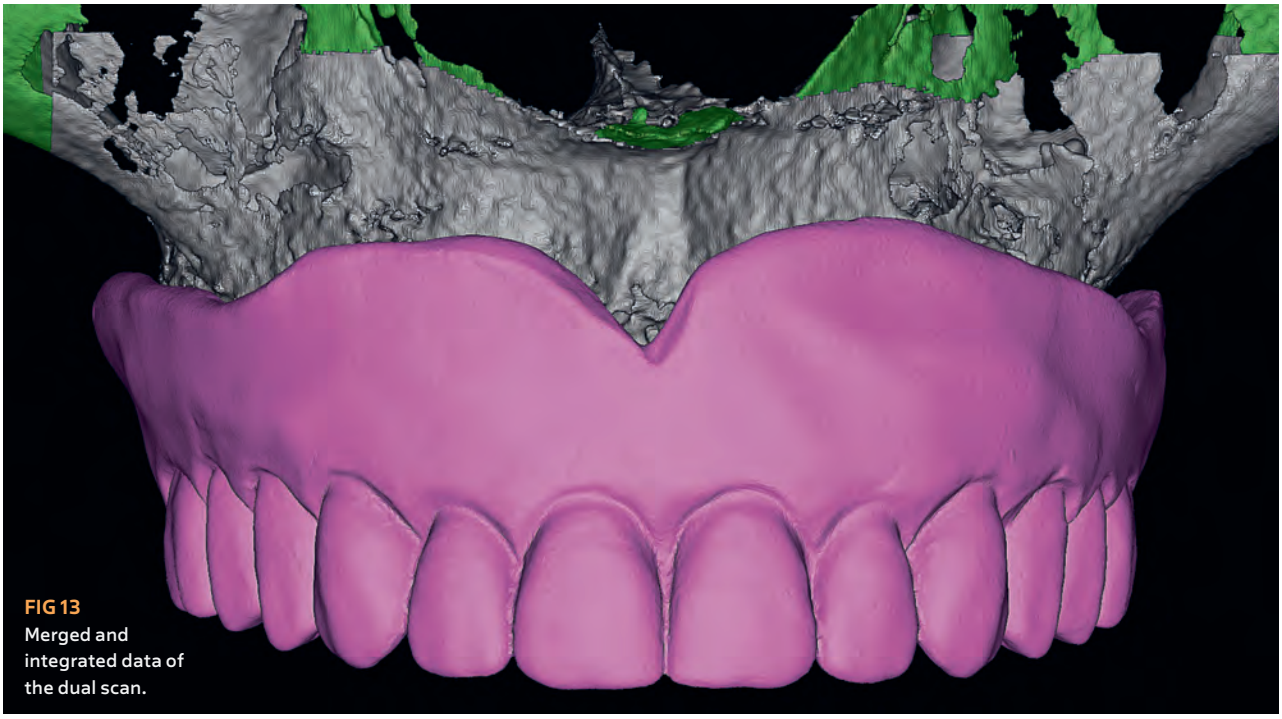
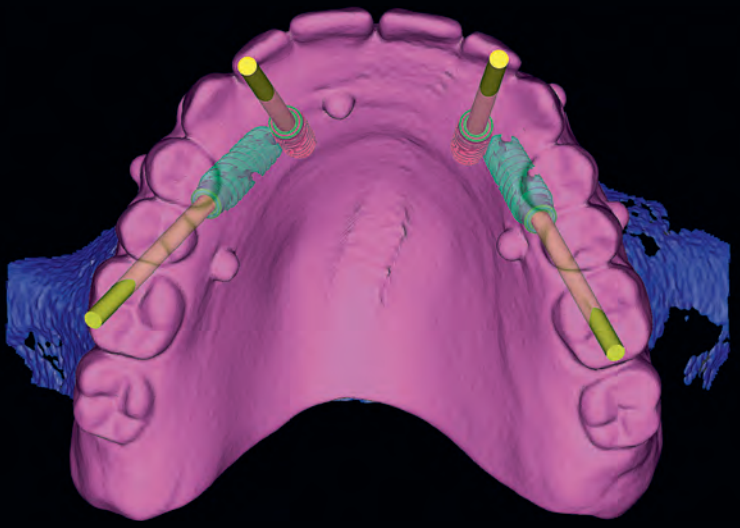
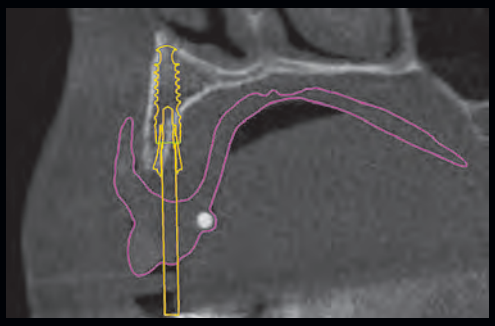


FIG 13 Merged and integrated data of the dual scan.





FIGS 14/15
Data integration in the coDiagnostiX software.

5. Digital Planning of the Surgical Guide

After finalizing the design of a prosthesis, a surgical guide is created to assist with the placement of implants and abutments during surgery, ensuring that they are positioned precisely as intended.

Digital planning uses specialized software, such as coDiagnostiX, to identify optimal implant locations and angulations as well as prosthetic abutment positions. Gingival height and angle options for prosthetic abutments may be selected from within the software's library. Measuring angles between implants and abutments provides additional insight into acceptable deviation and assists in establishing the insertion path for restorative work. Construction of a surgical guide for edentulous cases entails several steps to ensure accurate implant placement and access for drills. The specific techniques and materials used for guide fixation and drill access may differ depending on individual operator preferences, patient-specific needs, and available technology.

Bone-supported surgical guides gain their support from the alveolar ridge. These surgical guides can be used by partially or fully edentulous patients and utilize bony structures for stability and accuracy during implant placement. Bone-supported guides may require extra flap reflection to access, making fabrication more complicated (Fig 16).

Magnetic or stackable guides can be an ideal solution to address numerous limitations. Their construction consists of three layers in the majority of cases:

1. The template base can be placed directly onto bone, mucosa, and teeth using pins as anchor points to secure its positioning on bone surfaces. It serves as the basis for further layers, and its positioning determines the positioning of the other elements and magnets; depending on indication, it may act as a template for bone-reduction procedures (Fig 17).
2. An osteotomy template serves as the second layer. After its fixation, the surgeon conducts bone preparation and implant placement. Final implant depth and internal index position for abutment orientation are achieved using markers marked on the template and the implant carrier (Fig 18).
3. The provisional magnetic bridge forms the third layer (Figs 19 to 21). Its spatial position is decided at the planning stage in relation to the patient's head coordinates.



FIG 16
Bone-supported guide printed with the verification bone model.



FIG 17
First layer of magnetic template base for the maxillary treatment supported on the palate and fixed with vestibular and palatal pins.

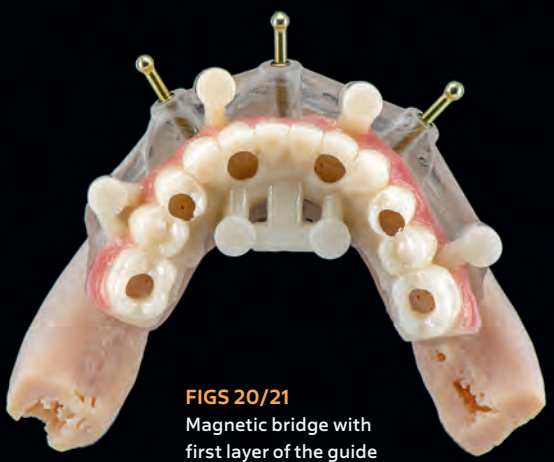


FIG 18
Second layer for osteotomy and implant insertion fixed in position with magnets.



FIG 19
The third layer is a PMMA magnetic bridge.





FIGS 20/21
Magnetic bridge with first layer of the guide fixed on the bone of the mandible.

6. Fabricating the Surgical Guide and Provisional Restoration

Once the surgical guide design has been finalized, it is saved and exported in STL format (Fig 22). Based on this data and the technology used for printing, the file is prepared by the dedicated nesting software for the 3D printing process.

The surgical guide is typically printed using a 3D printer compatible with dental applications, such as SLA (stereolithography), DLP (digital light processing), or PolyJet printers. A biocompatible resin explicitly designed for surgical guides is used during printing; layer by layer, it is cured to create an accurate surgical guide. Support structures may be needed during this process to support overhangs and complicated geometries and will later be removed.

After printing, surgical guides may undergo post-processing steps to eliminate excess resin and achieve their desired surface finish. Post-processing may involve rinsing with a cleaning solution or using a post-curing device to ensure complete polymerization of the resin (Figs 23 and 24). Before surgery, the guide must undergo a disinfection/sterilization process following medical hygiene standards.

The provisional bridge Is made of PMMA (polymethyl methacrylate), and after milling, it is cut and finished. In the final stage, magnets are glued in the orientation following the base (first layer) of the template (Fig 25).

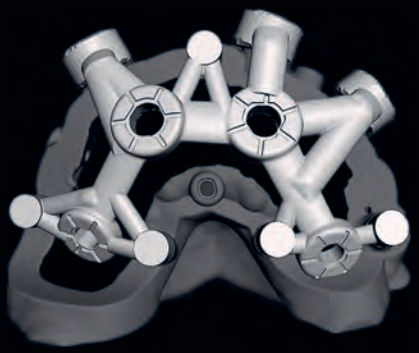


FIG 22 Designed surgical guides are saved in STL format for production.



FIGS 23/24 Surgical guides after removal of support material and cleaning.



FIG 25 PMMA bridge after finishing with magnets glued into the housings.

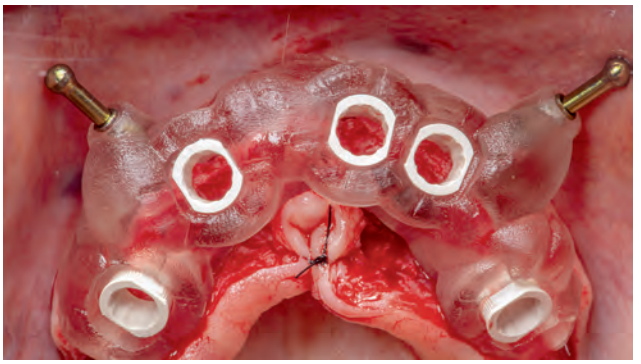


FIG 26 Bone-supported guide in an edentulous case fixed on the bone after flap reflection.

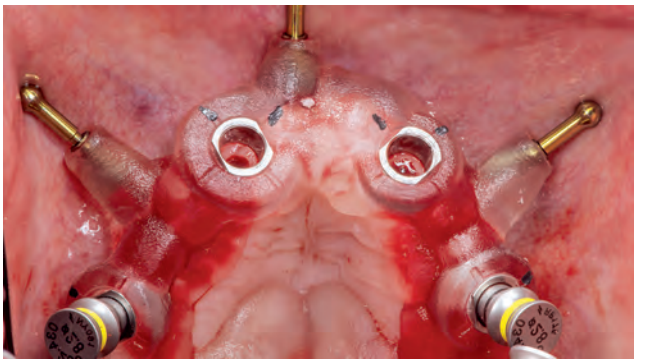


FIG 27 Soft tissue–supported guide in an edentulous case fixed on the bone with pins.

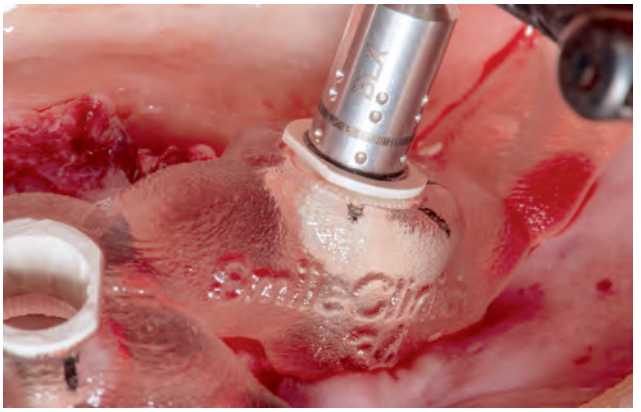


FIG 28 Implant index reference marked on the guide in black and implant driver alignment with corresponding reference markers.

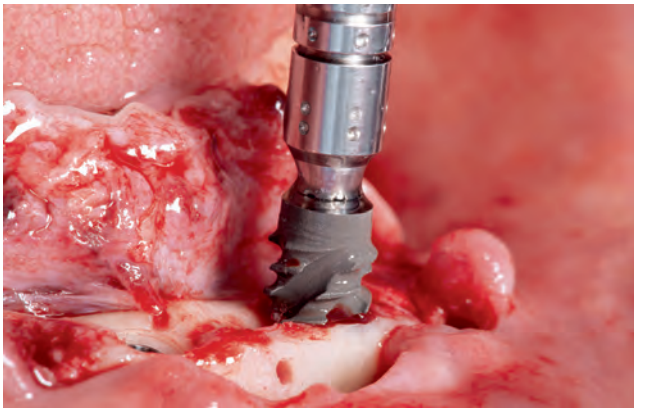


FIG 29 Implant mounted on the implant driver without the guide.

7. Surgery and Provisional Restoration

During surgery, a surgical guide is used to place implants as planned precisely. Once local anesthesia has been administered, soft tissue incisions are made to access underlying bone structures. A flap is created to provide access to the implant site. (Depending on individual circumstances, some procedures can be completed without having to expose the bone, but these instances are rare.) Situations in which individuals have worn complete dentures for many years often result in significant bone loss, necessitating complex surgical procedures to place implants and regenerate soft and hard tissues to create a strong base for prosthetic work (Figs 26 and 27).

Immediate loading of implants in edentulous patients involves several considerations. One of the key goals should be achieving adequate primary stability during implant placement in an environment with sufficient bone volume and quality. *Primary stability* refers to the initial mechanical stability of implants in bone tissue and depends on both macro and micro design considerations. Primary stability is essential because it enables immediate functional loading without jeopardizing osseointegration processes.

With stackable guides, implants are placed in their desired locations with careful consideration given to index orientation (Figs 28 and 29). Once the implants are in position, multiunit abutments (MUAs) chosen in planning are mounted onto each implant

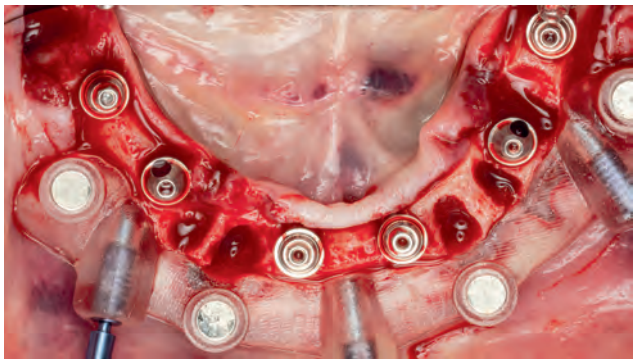


FIG 30 MUAs mounted on the implants with visible magnetic platform mounted on the mandibular bone.

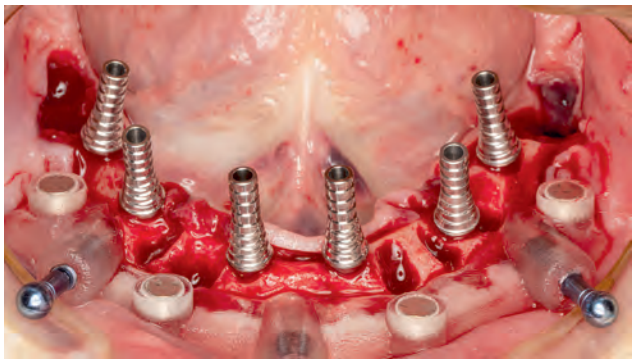


FIG 31 Titanium sleeves mounted on the MUAs.

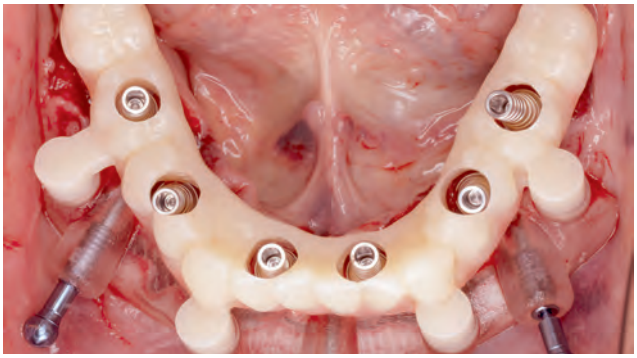


FIG 32 Titanium sleeves mounted on the MUAs with magnetic bridge on top.



FIG 33 Fixation of the sleeves with flowable composite.



FIG 34 PMMA bridge after trimming the connectors and finishing.



FIG 35 PMMA bridge after finishing and being fixed with screws.

according to the initial plan and index position (Fig 30). A PMMA magnetic bridge is then mounted to the template base and connected via titanium sleeves using flowable composite (Figs 31 to 33). Finally, the magnetic connectors are cut off, and the gingival side of the bridge is finished as desired (Fig 34).

Once sutured, the provisional prosthesis is screw retained (Fig 35), and occlusal adjustments are made. When loading implants immediately, the utmost care must be taken to ensure optimal results from occlusal contacts in a provisional restoration. For maximum effectiveness, aim for a balanced occlusion; that is, forces during biting and chewing should be evenly distributed among all the implants and supporting structures to limit excessive forces on individual implants and reduce complications.

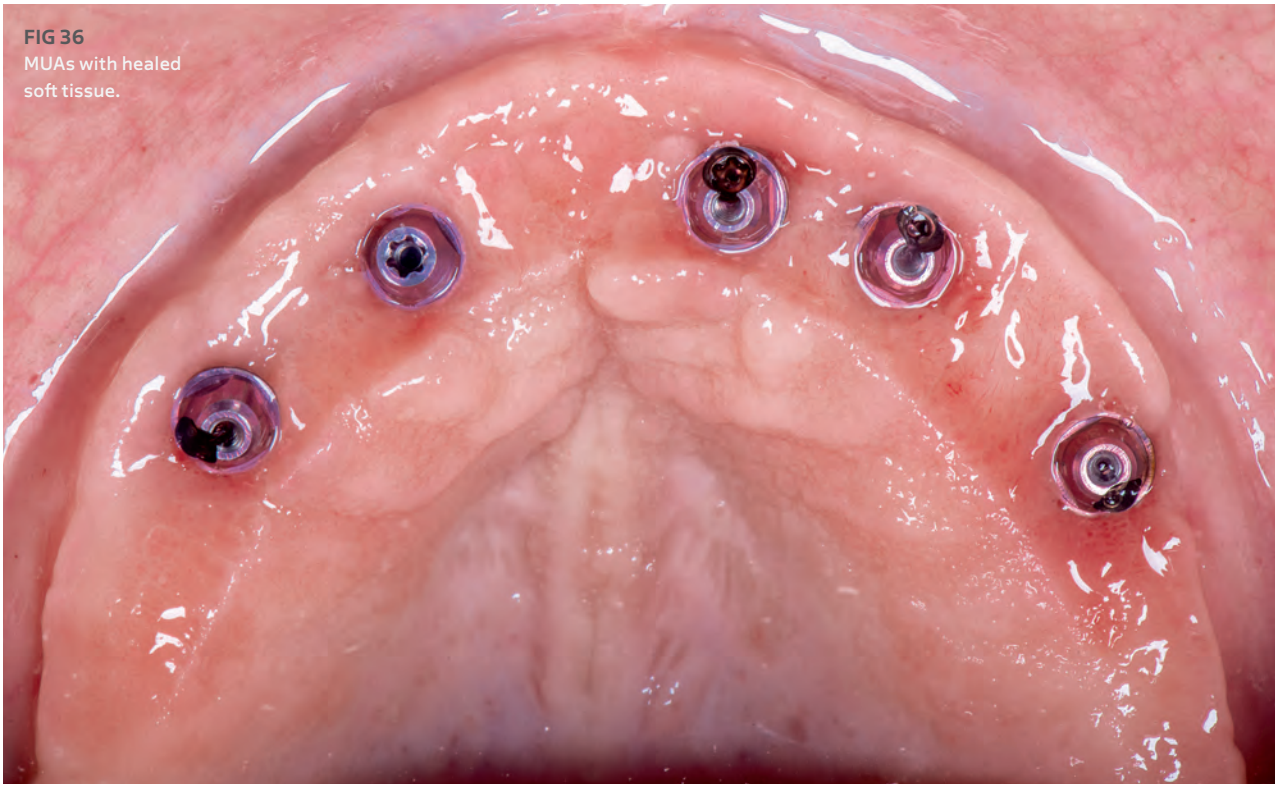


FIG 36
MUAs with healed soft tissue.

8. Healing Period

After the implant surgery, a healing period is necessary for osseointegration to occur. This process typically takes several months (usually 3 to 6 months) to ensure a strong and durable foundation for the final restoration. Once the bone and soft tissue healing process is complete, it is necessary to assess the position and volume of the soft tissues around the prosthetic abutments. Due to soft tissue remodeling and maturation, individual MUAs may need to be replaced before taking impressions for the final prosthetic work (Fig 36).

9. Final Restoration Production and Delivery

Several steps are still required before delivery of the final restoration:

- Implant impression
- Prosthetic design and verification
- Prosthesis manufacturing
- Delivery of the restoration

Implant impression

This step begins with the precise transfer of prosthetic abutments and soft tissue. Intraoral scanning and photogrammetry are two modern digital technologies utilized in prosthetic dentistry to create accurate impressions and measurements for dental restorations; their precision and reliability, compared with traditional impression methods, are essential factors when determining the overall fit and success of prosthetic restoration.

Photogrammetry can only transfer position information regarding implants/abutments; an intraoral scan must also be utilized to provide soft tissue information (Figs 37 and 38). The PIC camera (Precise Implants Capture, Pic Dental) is an imaging system specifically designed to capture high-resolution images for dental photogrammetry applications, offering precise digital impressions of implant positions. The camera takes multiple images from different angles to capture comprehensive coverage before processing these with photogrammetry software to reconstruct an in-depth 3D model with high accuracy (up to 4 micron).



FIG 37
PIC markers mounted on MUAs to transfer MUA position.



FIG 38
Scanbody fixed on MUAs to transfer soft tissue position with intraoral scanner.



FIG 39 Printed prototype of the restoration in the mouth for evaluation of esthetics and function.

Prosthetic design and verification

Based on the impressions taken, a blueprint is designed. A prototype of the future restoration may be milled or printed to check its shape, function, and esthetics. At this stage, the clinician must evaluate all aspects of the prototype, including its passivity, esthetics, function, phonetics, and soft tissue adaptation (Fig 39). Canine and anterior guidance, as well as dynamic occlusion during speech and chewing movements, must also be checked to assess function accurately; the Zebris JMA system serves this purpose perfectly.

It is important to conduct thorough testing to ensure the bridge fits properly and satisfies the patient's expectations in terms of both appearance and function. Any needed modifications are made based on the outcomes of these trials.



FIG 40
Titanium bars milled.

Prosthesis manufacturing

Once the prototype is approved, the dental lab team uses it to create a zirconia bridge for the patient's full arch. This may take multiple iterations, because each bridge must precisely meet individual oral structures and functional needs. The white and pink esthetics will replace the lost volume of soft tissue, so capturing the gingival shade for color reference is very helpful.

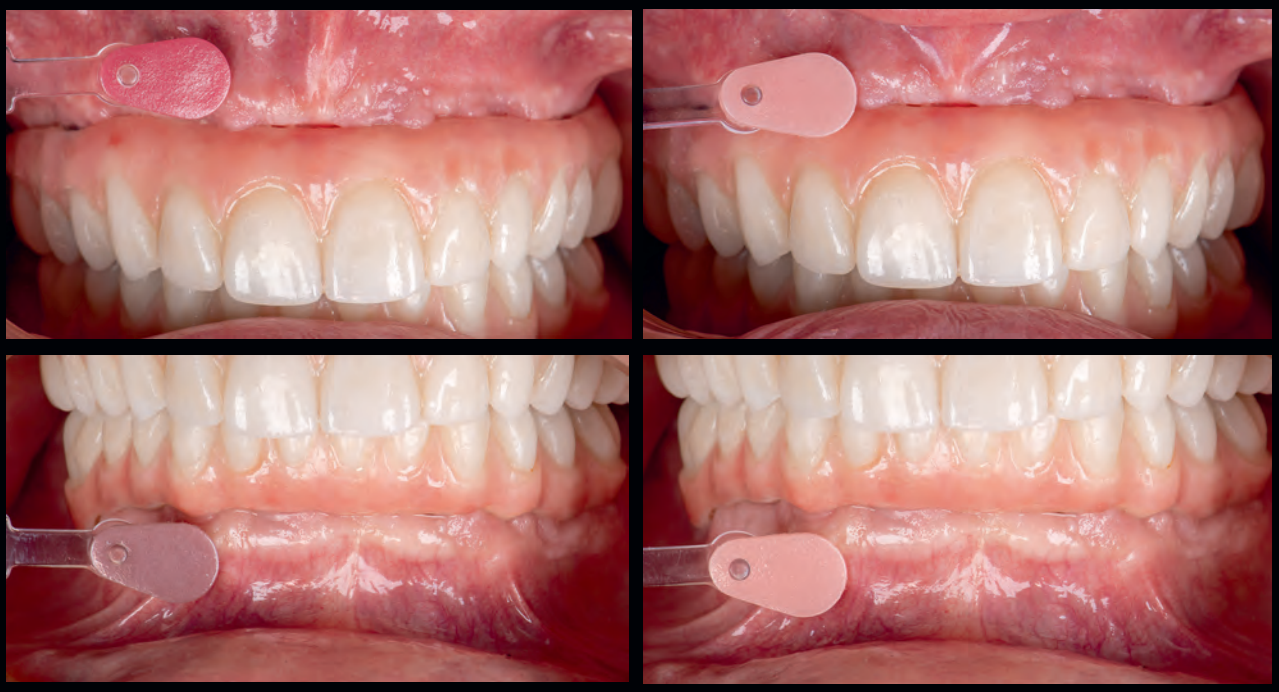
Fabricating a full-mouth screw-retained zirconia bridge with titanium bar reinforcement typically involves these steps:

1. Titanium bar design: Using a CAD/CAM system, dental technicians create an individual titanium bar framework according to the prototype volume and soft tissue transition desired. When creating a zirconia bridge, choosing the appropriate metal for the framework is crucial to ensure the bar does not break. The framework serves as a reinforcement and support for the bridge.
2. Milling the titanium bar: Once a titanium bar design has been finished, a five-axis milling machine is used to mill it with extreme precision and accuracy, guaranteeing accuracy during the fabrication of its shape (Fig 40).
3. Zirconia bridge fabrication: To create a zirconia bridge, the titanium bar is first scanned and used to design the bridge. Depending on the CAD operator's expertise, the project may be completed directly with the CAD software. Once finalized, the milling process begins to ensure a proper fit. It is crucial to select the appropriate material based not only on esthetics but also on mechanical properties that align with the prosthesis design. After milling, the zirconia frame is carefully removed from the blank and finished prior to the sintering process.



FIG 41
Example of zirconia milled frame.

4. Sintering: The sintering process is crucial for determining the physical properties of zirconia. To achieve optimal results, it is important to carefully follow the manufacturer's recommendations for the specific type of material being used. When creating a framework, it is essential to ensure that the connectors and stabilizers are positioned and sized correctly to prevent cracks from forming (Fig 41). Even if these cracks are not visible to the naked eye, they can cause irreversible damage to the structure after a few firing cycles in the ceramic oven. The temperature and timing of the heating and cooling phases are critical factors in achieving the desired strength and properties of the final product.
5. White and pink esthetics: A zirconia bridge features white and pink esthetics in terms of teeth and soft tissue replacement. Zirconia is an increasingly popular material for dental restoration due to its strength, durability, and natural appearance. *White esthetics* refers to the color of the teeth in a zirconia bridge restoration, specifically their shade, to ensure they blend in naturally with surrounding natural teeth. *Pink esthetics* refers to the color of the gingival replacement tissue of a bridge that mimics natural gingival tissue for an authentic and lifelike effect. Pink esthetics are particularly useful when the bridge is visible in a smile line because it helps to create a smooth transition between artificial and natural gingival structure. Reaching optimal white and pink esthetics requires the combined skill set of a dentist, CAD/CAM specialist, and ceramist. Working together, they customize the shape, size, color, and translucency of artificial teeth until the final restoration closely resembles that of the patient's natural teeth and gingiva (Figs 42 to 47).
6. Integrating the titanium bar: Once the vestibular ceramic layering and finishing have taken place, a milled titanium bar is integrated into the zirconia bridge using dual-curing luting composite bonding techniques to adhere it. Final delivery to the dental office occurs after final polishing and inspection by the dental lab team (Figs 48 and 49).



FIGS 42–45 Transfer of the soft tissue color shade for pink ceramic work.



FIG 46
Vestibular layering of ceramic with respect to the morphology, texture, and color.



FIG 47
Final result after polishing.



FIG 48
Zirconia framework and titanium bar before the integration process; verification on the model.



FIG 49
Zirconia bridge bonded with the titanium framework and finished.

Delivery of the restoration

Appointments to deliver the final screw-retained zirconia bridge may involve several steps:

- Patient prep and anesthesia as necessary.
- Bridge fit: Once the zirconia bridge is placed in the patient's mouth, it is examined for proper fit and alignment with the implants and surrounding teeth. All components are checked to ensure they fit correctly.
- Screw retention: Once the fit has been verified, the zirconia bridge is attached to its abutments using specially designed occlusal screws with recommended torque settings. Occlusal screw channels are sealed using Teflon tape before being closed using flowable composite.
- Check of the occlusion.
- Final inspection: Once the bridge has been set in place and its bite adjusted correctly, a final examination occurs to ensure its optimal esthetics and function (Figs 50 and 51).
- Follow-up appointments: Following bridge placement, regular dental checkups should also be scheduled to assess healing processes and the long-term health of both the tissues surrounding it and the bridge itself.



FIG 50
Radiographic verification of the delivered restoration.

While the steps outlined previously provide an overall process, it is important to remember that every patient is unique, and the specific procedures may differ based on individual needs and dental health conditions.

For the best care, it is recommended to have follow-up appointments every 6 months. During these appointments, the restorations will be unscrewed and removed for examination and cleaning while the clinician checks the health of the soft tissues. All worn screws will be replaced. Once cleaned, the restorations will be securely screwed back on with the proper torque values. The screw channels will then be sealed with Teflon tape and closed with composite.



FIG 51
Delivery of the final restoration.

Conclusion

Prosthetically driven planning focuses on the desired final prosthesis as the inspiration for surgical planning and implant placement. The steps involved include clinical assessment, determining the prototype prosthesis, using dental photography and software like SmileFy or Smilecloud, using a radiographic guide and CBCT, and integrating imaging data with the prosthetic plan. By balancing patient visits and allowing ample time for proper healing and stabilization, exceptional dental care can be provided to patients with edentulous or terminal dentition.

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