Received: 18 June 2022 | Accepted: 6 September 2022

DOI: 10.1111/jopr.13605

ORIGINAL ARTICLE

A complete digital approach for facially generated full arch diagnostic wax up, guided surgery, and implant-supported interim prosthesis by integrating 3D facial scanning, intraoral scan and CBCT

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Abstract

Continuous innovation in digital dental technology offers new prospects for creating a complete virtual environment. The technique described adds a facial approach to the conventional digital workflow by incorporating 3D face scans to cone beam computed tomography and intraoral scans. Using this workflow, clinicians can obtain a complete virtual patient for facially generated diagnostic wax up and plan and implement a predictable implant placement and interim prosthesis. This technique provides a full digital workflow for restoratively-driven computer-aided implant planning, guided surgery, and 3D printing of an interim complete-arch fixed implant-supported prosthesis.

KEYWORDS
3D facial scan, facially generated, diagnostic wax up

Immediate implant-supported prosthesis have been proven to improve the quality of life in edentulous patients or patients with terminal dentition.[1,2] Adequate restorative and surgical planning are required to avoid biologic or prosthetic complications.[3–5] Therefore, designing a proper facially generated diagnostic wax up is considered a crucial step in dictating the functional and esthetic requirements of the future prosthesis.[6] Integrating prosthetic guided implant planning with stackable guides provides a direct link between surgical placement and the prosthetic outcome.[7–9] Successful prosthodontic complete arch rehabilitation requires coordination between facial anatomy, lips, and teeth, which may impose a clinical challenge.[10] The standard digital approach integrates the data from cone beam computed tomography (CBCT), intraoral scanners (IOS), and facial 2D images to enable design of wax ups for virtual implant planning.[11] Data from CBCT and standard tessellation language (STL) files provide a 3D analysis for the patient's bone and soft tissue. However, only 2D facial data is provided by this technique and no actual representation of patient's facial and extraoral soft tissue is recorded which highly impact the esthetics.[12,13] The evolution of 3D face scanning provided a breakthrough in prosthetic dentistry.[6,14] 3D facial analysis can help in comprehensive wax up design for provisional prosthesis;[15–17] the main concept is the integration between the designed wax up and the 3D virtual patient's face to adjust teeth shape, size, and alignment for a prosthetic-driven implant planning experience.[18–21]

Even though CBCT, IOS, and face scanners are currently accessible, the challenge is to accurately correlate and combine all these data in one planning software to obtain a complete virtual patient.[22–24] Therefore, there is still scarcity in literature on the advantages of integrating facial scanning, IOS, and CBCT in guided complete-arch rehabilitation.

The purpose of this technique is to describe a fully guided digital workflow with a 3D face scanning approach for wax up designing, surgical implant planning, and fabrication of an interim complete-arch implant supported prosthesis following guided alveolar ridge reduction with fewer appointments, increased function and efficiency, as well as predictable and optimized esthetics.

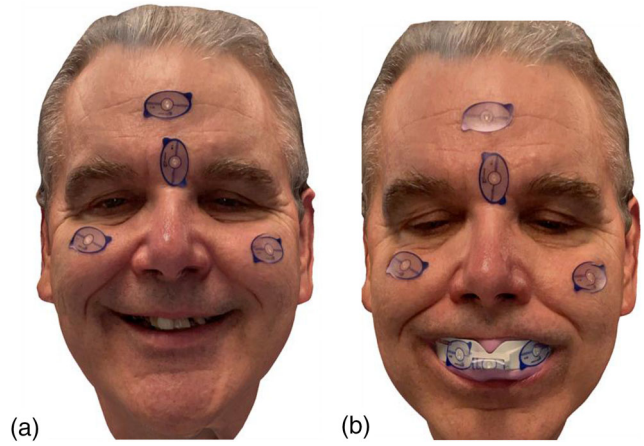

FIGURE 1 (a) Frontal view screenshot of patient's facial scan with markers. (b) Frontal view screen shot of patient's facial scan with markers and inter arch tray with markers.

A middle-aged male presented with maxillary terminal dentition. After a complete exam and treatment plan discussion, a maxillary implant-supported fixed complete denture was accepted as the final treatment.

TECHNIQUE

1. Place four Radio opaque markers (Suremark, Co.) on patient's face. Take the first facial scan (FS1) using a facial scanner (Dental Pro, Bellus3D, CO) while the patient is smiling. Select a proper size triple tray (Miratray, pearson Dental), adjust the tray if needed, and keep the impression material to the minimum required to avoid any overextension that can cause forced soft tissue displacement. Remove the handle and place 3 markers (Suremark, Co.) on the front of the triple tray. Fill the tray with heavy body venylpolysiloxane (VPS) material (Extryde XP, Kerr, CO.) and insert it in patient's mouth. Instruct the patient to close in maximum intercuspation position (habitual occlusion) and take the second facial scan (FS2) (Fig 1A and B) with the head in the same position. Import both facial scans to a dental software design program (DentalCAD3 Galway, exocad) as STL_1 and STL_2 files, respectively. Take a CBCT while the markers are still in place. Through the face scans and CBCT scan, make sure the patient is in a natural head position where reference lines (Frankfurt plane and occlusal plane) are confirmed to be parallel to the floor. Instruct the patient to stay still.
2. Take the maxillary and mandibular intraoral scans with jaw relation record (STL_3) using an intraoral scanner (CEREC Prime Scan, Dentsply Sirona) following manufacturer scanning instructions. Scan the triple tray on both sides and external borders with markers in place using the Bio copy tool in Prime scan (STL_4) (Fig 2). Export all scans to the design software.
3. Use the design module of CAD software (DentalCAD3 Galway, exocad), to superimpose the facial scans (STL_1 and STL_2) by using markers as reference points. Integrate the intraoral scans to facial scans by using the inter arch impression STL_4 (Scan of triple tray or Bio copy) as a merging tool. Complete the facially generated diagnostic wax up (STL_5) (Fig 3).
4. Export the completed maxillary diagnostic wax up (STL_5), pre op intraoral scans (STL_3) and import to implant planning software using STL markers to merge STL files correctly. Merge the STL files with CBCT and plan guided surgery using adopted workflow (Figs 4 and 5A, B).

FIGURE 2 Screen shot of scanned inter arch impression with triple tray.

FIGURE 3 Lateral view screenshot of patient's facial scan with completed wax up; Facially generated wax up.

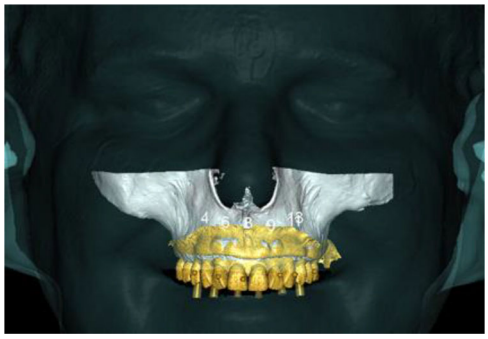

FIGURE 4 Super imposition of facially generated maxillary diagnostic wax up with CBCT for computer-assisted guided implant surgery.

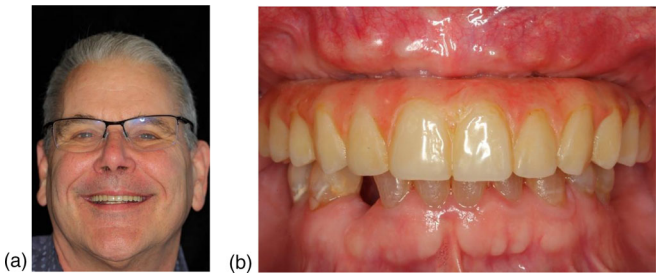

FIGURE 5 (a) Frontal view full-face image of the patient with delivered maxillary interim FCD. (b) Frontal view intraoral image of delivered maxillary FCD in maximum intercuspation (MI).

DISCUSSION

The described technique presents an alternative full digital workflow for patients requiring complete-arch rehabilitation. It supports the addition of face scans as a beneficial supplement to existing scanning technologies (CBCT and intraoral scanning) to allow dental professionals to virtually design a full arch diagnostic wax up that is in harmony with the patient's 3D facial anatomy. The presented technique also highlights the importance of prosthetically-driven virtual implant planning, guided ridge reduction, and implant placement as they offer a safe, simplified, and accurate way to avoid both surgical and prosthetic complications.

Furthermore, this technique completes the digital workflow by 3D printing the designed wax up to provide an immediate interim prosthesis that truly matches the functional and esthetic demands. This is consistent with the results of the current literature that supports the use of digital dental technology as it provides better outcomes and reproducibility of the prosthesis with fewer patient visits compared to conventional techniques. [25]

This technique addressed the superimposition limitations mentioned in previous studies, where the use of the described jig device and extraoral markers offered a more accurate and reproducible way for relating the CBCT, face, and intraoral scans using common calibrated fixed references rather than relying solely on facial landmarks that can be influenced by the presence of facial hair or the absence of prominent anatomy for registration. Also, facial skin artifacts or skin color can influence the anatomic landmarks identification. The existing pool of literature includes comparable techniques where matching was done between the face scan and pictures of the patient's face which may be subject to anatomic distortion when matching a 3D object to a 2D one. Thus, we made sure to use the extraoral face markers to match two 3D objects together.

Similar techniques relied on the teeth for directly matching the CBCT scan to the face scan. However, in 2019, Pokpong Amornvit and Sasiwimol Sanohkan[26] classified the difficulty of capturing the facial structure as easy, medium, or hard. The teeth fell in the hard category. Also, in 2020, da Silva Marques[27] measured the accuracy of facial scanners using different superimposition methods. The highest discrepancy was found when using reference landmarks in the lower third of the face. For that reason, we adopted the triple tray with markers in addition to the extraoral face markers.

In this presented technique, the extraoral face markers were placed on the middle and upper face for better scan accuracy. Four markers were placed on relatively immobile soft tissue supported by bone (zygoma and frontal bone) to keep the displacement as minimal as possible. This minimal soft tissue displacement is repeatable when the patient smiles. The patient was instructed to say 'E' rather than randomly smile to give his maximum smile and keep it as standardized as possible.

The patient was scanned in a natural head position with reference line parallel to the floor. However, further adjustments in case of any discrepancy, can be done by adjusting the scan data orientation using the planning and design software with the aid of virtual grids.

The limitations of this technique include the stability of the markers on the patient's face, and possible patient discomfort. Also, the superimposition methods are technique sensitive, and the quality of the face scanners is still to be improved. That's why this technique presents a proof of concept rather than accuracy measurement.

SUMMARY

Digital dental technologies, including facial scans, can be integrated to create a 3D representation of a patient for full arch virtual diagnostic wax up to plan an accurate, restoratively-driven, computer-aided implant guided surgery and implant-supported interim prosthesis.

CONFLICT OF INTEREST

The authors do not have any conflict of interest, financial or personal, in any of the materials described in this study.

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How to cite this article: Amin SA, Hann S, Elsheikh AK, Boltchi F, Zandinejad A. A complete digital approach for facially generated full arch diagnostic wax up, guided surgery, and implant-supported interim prosthesis by integrating 3D facial scanning, intraoral scan and CBCT. J Prosthodont. 2023;32:90–93. https://doi.org/10.1111/jopr.13605