THE JOURNAL OF PROSTHETIC DENTISTRY

CLINICAL REPORT

# Three-dimensional facial esthetics-driven computer-assisted osteotomy and implant placement for immediate restoration of a failing dentition with a protruded maxilla

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## ABSTRACT

The rehabilitation of facial esthetics when transitioning from a failing dentition in a patient with maxillary protrusion is challenging. This clinical report described such a patient treated with an immediate cross-arch implant-supported fixed prosthesis. The ideal virtual upper lip position was used to predict the sagittal and vertical position of the restoration. A stackable device was fabricated to guide the osteotomy and implant placement. (J Prosthet Dent 2020;■:■-■)

For patients presenting with a failing dentition, immediate cross-arch implant-supported fixed prostheses have become popular.[1] A failing dentition combined with maxillary protrusion is a common clinical problem, often associated with excessive gingival display and a disharmonious lip-tooth relationship.[2] The treatment plan for patients with a failing dentition and maxillary protrusion often involves an osteotomy. However, insufficient or excessive reduction of bone can result in prosthetic and surgical problems.[3-5]

Computer-assisted design has simplified the prosthetic procedure and improved the predictability and esthetics of the smile line in the vertical position.[6-10] However, the change in facial profile in the sagittal position after the osteotomy and arrangement of the artificial teeth is still difficult to predict. A systematic review reported on the proportion of soft-to-hard tissue movement in maxillary orthognathic surgery.[11] This proportion can provide a reference for tooth arrangement with computer-assisted 3D facial analysis. Commercially available software programs providing facial analysis and image management have been widely applied in orthodontic treatment and orthognathic surgery.[12] However, these software programs are incompatible with dental laboratory or dental implant simulation software programs, which are essential for tooth arrangement and implant planning. Thus, engineering software programs for 3D systems, such as Geomagic Studio, play a key role in connecting different dental software programs.[13,14]

The present clinical report describes a digital workflow for 3D facial esthetics-driven computer-assisted osteotomy and implant placement. Through computer-assisted facial profile and smile design, a treatment plan combining esthetics, restoration, and remaining bone considerations was completed. A stackable device was used to transfer the virtual design to the surgical procedure for implant placement guidance and for the osteotomy.

Support provided by the Oral Reconstruction Foundation (Reference ORF 41801); and the Peking University School and Hospital of Stomatology (grant PKUSSNCT-19B11).

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**Figure 1.** Pretreatment facial views: left lateral, left 45-degree-angled, frontal, right 45-degree-angled, right lateral. A, Static images. B, Maximum smile images.

## CLINICAL REPORT

A 46-year-old woman was referred to Peking University School of Stomatology, Department of Oral Implantology, with nonrestorable maxillary anterior teeth and bilateral posterior missing teeth. She was seeking to correct her maxillary protrusion. She had been provided with a cross-arch implant-supported fixed restoration in the mandible in the department 6 months previously.

The facial examination showed protruded maxillary anterior teeth producing a lip-tooth relationship that lacked harmony, excessive tooth visibility in the rest position, and 4 to 5 mm of gingival display during her maximum smile (Fig. 1). An intraoral examination identified severe periodontitis with anterior teeth splaying and Miller grade II-III mobility of the remaining teeth (Fig. 2). A stable occlusal relationship and adequate restorative space were determined.

Impressions of the arches, extraoral and intraoral photographs, 3D facial images (FaceScan; ISRA Vision), a cone beam computed tomography (CBCT) scan (0.20 mm, NewTom VGi; Quantitative Radiology) with an occlusal device and facebow,[15] and a cephalometric radiograph (CS 8000C; Carestream) were made before mandibular surgery. The cephalometric analysis showed that the sella-nasion-point A (SNA) angle was 87.1 degrees, the sella-nasion-point B (SNB) angle was 81.5 degrees, and the nasolabial angle (NLA) was 100.2 degrees. The CBCT scan showed a composite defect and adequate bone volume, as per the Bedrossian pretreatment screening method.[16] Three-dimensional facial images included an image with an occlusal device and facebow (first image)[15] and different lip position images (rest position, slight smile, and maximum smile). Different treatment options were presented, and she elected to receive an immediate cross-arch implant-supported fixed prosthesis. Because of the composite defect, visible residual ridge, and adequate bone volume, an osteotomy was determined to be necessary.[16]

Facial profile and smile design procedures were performed. The digital imaging and communications in medicine (DICOM) file of the CBCT scan was converted into a standard tessellation language (STL) file (File A) by using an STL software program (Materialise Magics; Materialise). The first 3D image with File A was registered with a surface registration technique with a reverse engineering software program (Geomagic Studio 2012; 3D Systems).[10,15] The 3D lip position images were registered with surface registration, and definitive digital images were obtained.[17] The flowchart (Fig. 3) shows the analyzing and reconstruction of an ideal profile as per the normal range of NLA (approximately 80 to 110 degrees in Chinese people with normal occlusion), and the labrale superius of the ideal profile was marked as point LS and established near the esthetic plane. As a result, NLA was designed as 107.8 degrees and LS was designed to move 1.2 mm palatally (Fig. 3B). Based on the position change of LS, the movement of the maxillary incisor in the sagittal direction was calculated as per the ratio of 0.6:1 (LS to maxillary incisor).[11] The maxillary incisors were relocated 2 mm palatally (Fig. 4A). Because horizontal space was created by the mandibular restoration, it was possible to retract the maxillary incisors. The lip position was then evaluated, and the maxillary incisors were set 2 mm below the upper lip in the rest position (Fig. 4A). The occlusal plane was set parallel to the ala-tragus line and the interpupillary line (Fig. 4B). The bone cutting line was set 4 mm above the maximum smile line (Fig. 4B), and the basal point of the prosthesis (F-point) was 1 mm apically to the maximum smile line (Fig. 4A). Based on the settled maxillary incisor point, F-point, and occlusal plane, a virtual diagnostic tooth arrangement was created in the computer-aided design and computer-aided


**Figure 2.** Pretreatment intraoral examination. A, Frontal view. B, Maxillary occlusal view. C, Mandibular occlusal view.

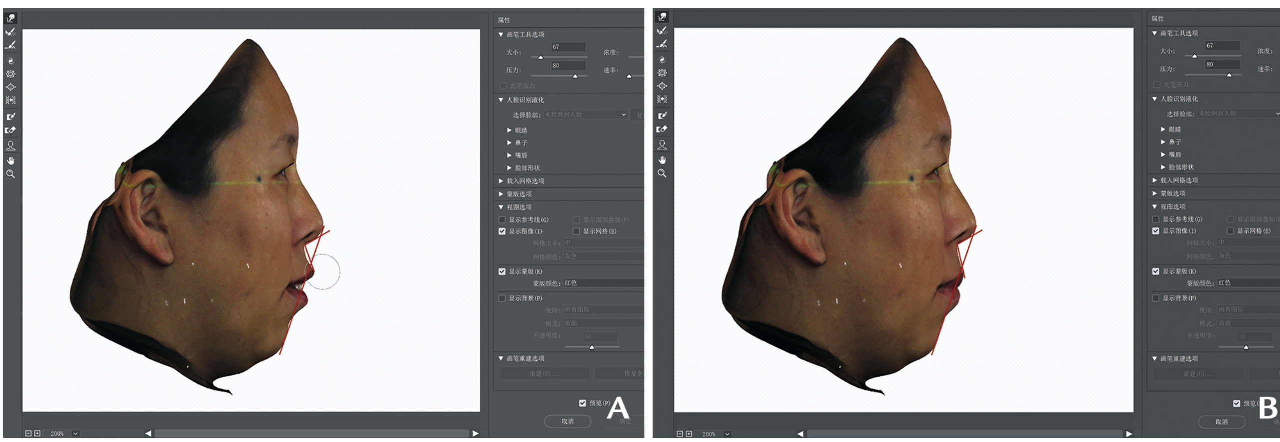


**Figure 3.** Virtual facial profile design. A, Pretreatment lateral profile: lateral profile adjusted to ideal position in Adobe Photoshop CC 2018. B, After virtual facial profile design: NLA increased to107.8 degrees, upper lip length unchanged, and LS closer to esthetic line. LS, labrale superius; NLA, nasolabial angle.

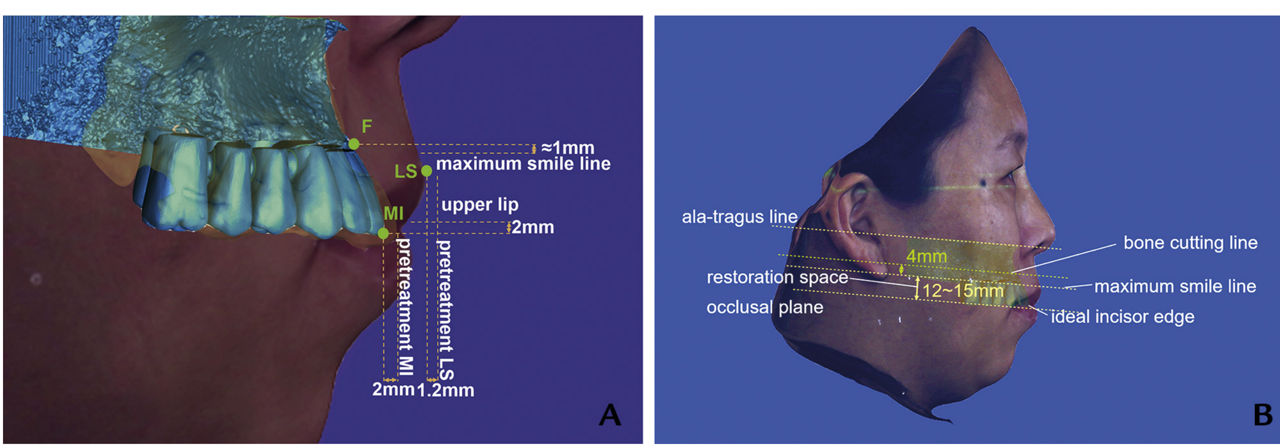


**Figure 4.** A, Diagram of corresponding points and movement distance between prosthesis and upper lip. In sagittal direction, LS moved 1.2 mm and maxillary incisor moved 2 mm palatally. In vertical direction, F was about 1 mm above upper lip during maximum smile and maxillary incisor was 2 mm below upper lip during rest position. B, Virtual diagnostic tooth arrangement in lateral view. Confirmation of occlusal plane was paralleled to ala-tragus line, ideal incisor edge determined in Figure 4A and bone cutting line 4 mm above maximum smile line. LS, labrale superius.

manufacturing (CAD-CAM) software program (exocad; exocad GmbH) (Fig. 5A, 5B).

The STL data of diagnostic teeth were then superimposed on the DICOM file of the CBCT scan in an implant planning software program (6D Dental Planning Software; Hangzhou 6D Dental Tech Co). The surgical plan was determined based on all the diagnostic data (Fig. 5C, 5D), and software programs (Materialise Magics and Geomagic Studio 2012) were used to design the anchor guide, implant placement guide, and tooth-supported framework (Fig. 6A, 6B). Finally, the designed templates were exported into STL file format and sent to a dental laboratory for fabrication of the stackable device from cobalt-chromium alloy powder with selective laser melting (Fig. 6C).

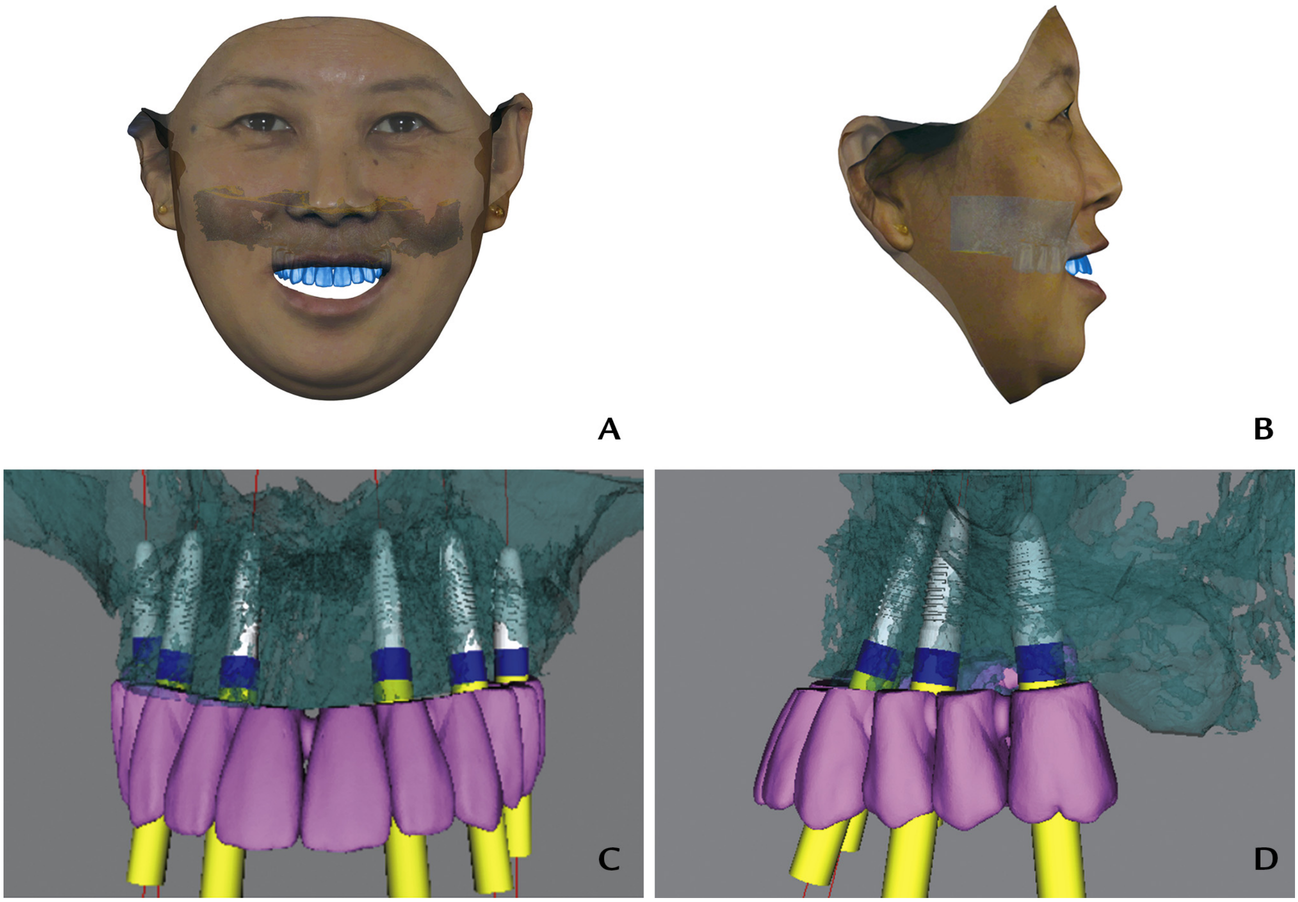


Figure 5. Facial esthetic driven implantation surgical plan. A, Frontal view of virtual tooth arrangement during maximum smile. B, Lateral view of virtual tooth arrangement during maximum smile. C, Frontal view of virtual implant plan. D, Lateral view of virtual implant plan.

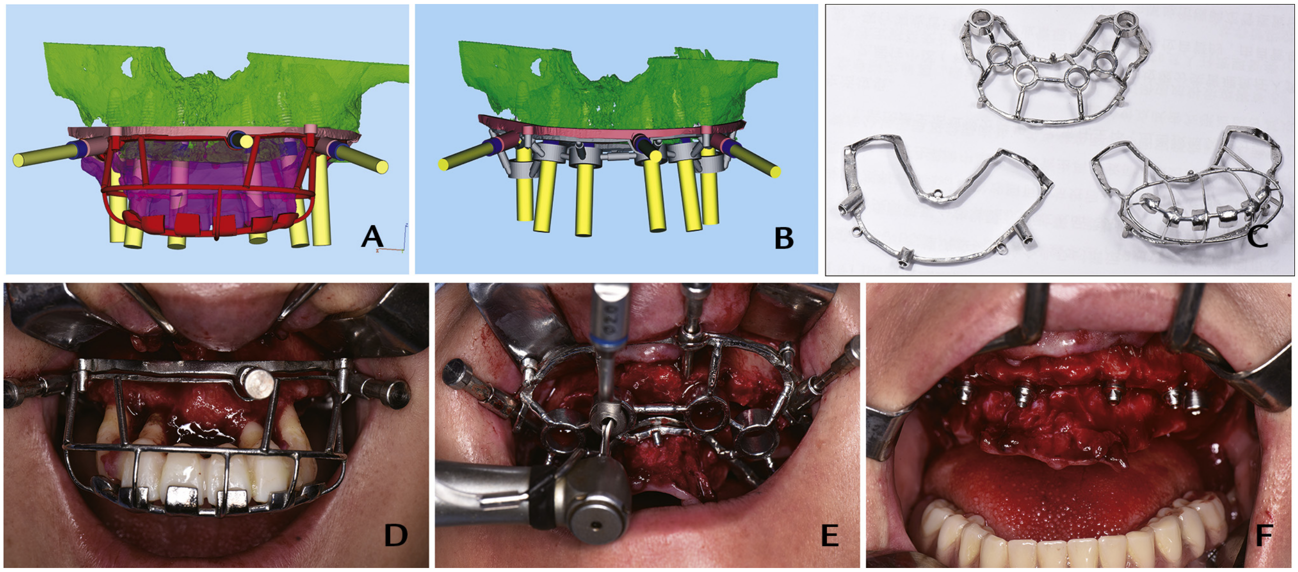


Figure 6. Surgical templates and surgical procedures. A, Virtual anchor guide and tooth-supported framework. B, Virtual anchor guide and implant placement guide. C, Selective laser melted stackable device: anchor guide, tooth-supported framework, and implant placement guide. D, Surgical procedures: stackable device (tooth-supported framework and anchor guide) fitted over alveolar ridge and remaining teeth. E, Implant placement with guidance from stackable device (implant placement template and anchor guide). F, Implant placement in prosthetically guided position.

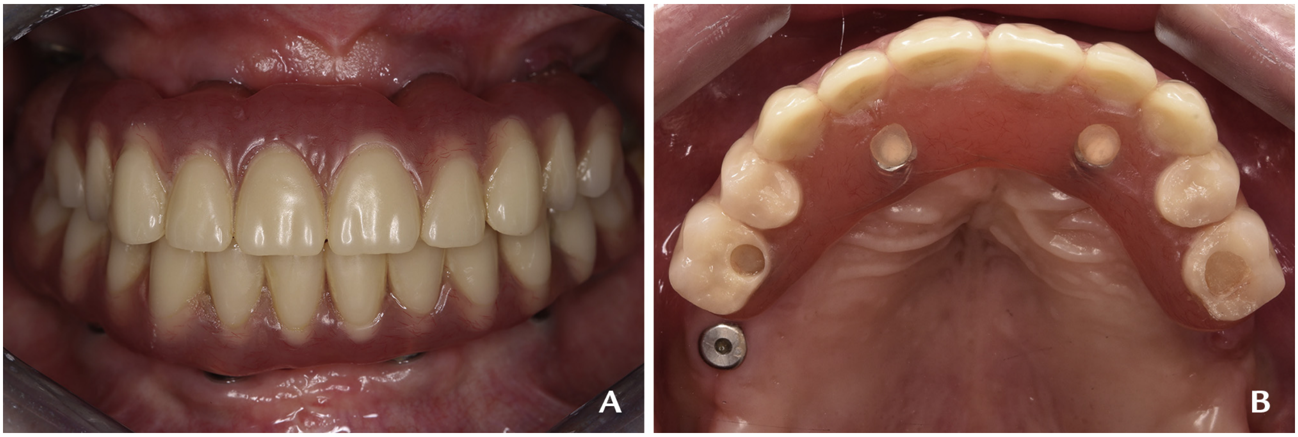


**Figure 7.** Posttreatment photographs. A, Frontal view. B, Maxillary occlusal view.


**Figure 8.** Post-treatment facial views: left lateral, left 45-degree-angled, frontal, right 45-degree-angled, right lateral. A, Static images. B, Smile images.

The surgery was performed under local anesthesia. The stackable device was positioned over the remaining teeth (Fig. 6D). The alveolar crests were trimmed as per the index of the anchor guide. Six implants (Camlog Promote; Camlog Biotechnologies GmbH) were inserted after the implant placement template (Fig. 6E, 6F). A 3D-printed model from the STL data of virtual tooth arrangement was used for assisting the diagnostic waxing and fabricating the interim restoration. Clinical examination confirmed that she had the same occlusal vertical dimension as before the treatment. After the maxillary restoration, a cephalometric analysis showed a palatal shift of maxillary incisors of 2 mm. The post-treatment NLA (109 degrees) and movement of LS (1.0 mm) were aligned with the designed facial profile, determining the predictability of the workflow. Reexamination showed that the facial profile was satisfactory and the prosthesis-tissue junction was not visible during a maximum smile (Figs. 7, 8).

## DISCUSSION

The purpose of this clinical report was to describe a novel digital workflow for the design of a facial profile, to improve facial esthetics, and to increase the precision of both osteotomy and implant placement for a patient with a failing dentition and maxillary protrusion. Based on the facial profile prediction, the maxillary incisor position, smile line, and occlusal plane information were obtained, which were later used for the design of the realignment of artificial teeth. The prosthetically driven implant placement and osteotomy plan was then based on the realignment design.

Predicting facial profile change for patients with a failing dentition and maxillary protrusion is challenging. Software programs have been marketed that offer predictions of facial soft tissue movement for patients under orthodontics or orthognathic surgeries.[18,19] However, the software predictions are often rudimentary, and the software program requires a lengthy learning curve.[18,19] For the present patient, the ratio of soft-hard tissue movement in the sagittal direction in orthognathic treatment was calculated, providing a more direct and feasible method of predicting facial change.[11]

The execution of the design was via stackable surgical devices with a tooth-supported component, which fit the reproducible landmarks of teeth for support and retention.[20,21] This method has been determined to be accurate in laboratory, cadaver, and clinical studies.[22] With the indication for osteotomy, the present procedure improved the outcome.

## SUMMARY

The present clinical report demonstrates a novel 3D facial esthetics-driven digital workflow that predictably treated a patient with maxillary protrusion with an immediate implant-supported fixed prosthesis. By using the facial profile design to guide the tooth arrangement, smile design to guide the osteotomy, and stackable device to convert the virtual plan into surgery, the treatment outcome was satisfactory.

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**Acknowledgments**
The authors thank Ms Rongrong Liu for her assistance in preparing this manuscript.

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https://doi.org/10.1016/j.prosdent.2020.08.045