DENTAL TECHNIQUE

Virtual facebow technique using standardized background images

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ABSTRACT

The procedure described provides a novel and accessible virtual facebow transfer based on standardized photographs loaded in the virtual articulator module of a computer-assisted design and computer-assisted manufacturing (CAD-CAM) software program for dental applications. The practical application of the technique in a digital workflow is the correct alignment of the digital maxillary cast to the virtual articulator with respect to the patient's planes and the skin markings of the condylar axis. (J Prosthet Dent 2019;121:724-8)

Conventional workflows in prosthetic dentistry are being replaced by digital-assisted technologies which have improved the speed, accuracy, and reliability of the definitive prosthesis. For computer-assisted design and computer-assisted manufacturing (CAD-CAM) dental applications, the virtual articulator simulates mandibular motions and occlusal contacts.[1,2] To program a virtual articulator, most current CAD-CAM systems rely on physically mounting casts in a traditional mechanical articulator.[3]

The correct location of the maxillary cast on the articulator with respect to the patient's anatomic planes and the mandibular rotational axis is essential for extensive treatments such as complex fixed dental prostheses or complete dentures,[4-7] orthognathic surgery planning,[8,9] or orthodontics.[10] Head posture has been used for facebow registration by means of a spirit level.[8,11] Transfer to the articulator in this way avoids individual and ethnic variations[12] and is reproductible.[13,14]

Different methods of transferring digitized casts onto the virtual articulator have been proposed, including a 3-dimensional (3D) optical scanner,[15,16] digital axiography,[17] a series of photographs converted into a 3D face scan,[18] stereophotogrammetry,[19] cone beam computed tomography (CBCT),[20-22] cephalometric images,[23] and scanning the position of a pointer in 6 positions with reference to the head.[24] However, none of these have been widely adopted.

This article describes a step-by-step technique using standardized extraoral photographs for the transfer of the digitized maxillary cast in exocad (exocad GmbH). The application exocad is one of the most widely used dental CAD-CAM applications including a virtual articulator module used by this technique.

TECHNIQUE

1. Prepare the camera and the patient. The camera is mounted on a tripod, and the camera lens must be kept horizontal to the midsagittal plane of the maxilla and focused on the maxillary interincisive point (Fig. 1). The patient's head must be in a natural position. The patient sits on a chair with minimal or no back support, with the soles of both feet on the ground and eyes looking forward to infinity. The patient should provide an exaggerated smile revealing as much as possible of the maxillary arch with slight interarch separation. The maxillary teeth will be used as reference for indexing with the digital casts (Fig. 2). Alternatively, a reference line can be traced on the background behind the

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Figure 1. Standardized conditions for making photographs.

Figure 2. Frontal face photograph with teeth separated slightly.

patient to represent the geometric horizontal plane, which may be used as a reference for the smile line and/or the bipupillary line assessment.

2. Crop the portrait image in an image-editing program (Paint for Windows; Microsoft Corp). The crop should include the maxillary teeth, and the dimensions of the cropped image must occupy a significant part of the computer display for maximum visibility of the position match between the background picture and the digital cast.

3. Check the computer display resolution and resize the cropping area of the portrait image in Paint for Windows or other image-editing software. Make the crop to occupy half to two-third of the display size (Fig. 3).

4. Save the cropped picture in portable network graphics (PNG) format under the name of BackgroundImage.png and copy the file into the DentalCaddApp/icons/directory of the CAD application. The original purpose of this file is to display the user's or original equipment manufacturer's personal logo, starting at the bottom-right corner of the screen, according to the size of the image. In exocad's newer versions, from 5541, the image must be BackgroundImage.xaml, in the same directory.

5. Open the DentalCAD application after selecting the teeth corresponding with the planned restoration. The previously cropped image appears in the background and occupies most of the computer screen for easier indexing (Fig. 4A). Import the virtual casts obtained from a TRIOS 3 intraoral scan at the same time as the standardized photographs are made as standard tessellation language (STL) files.

6. Launch the articulation module of the application by choosing from the application menu "virtual articulator," uncheck "show articulator" option,
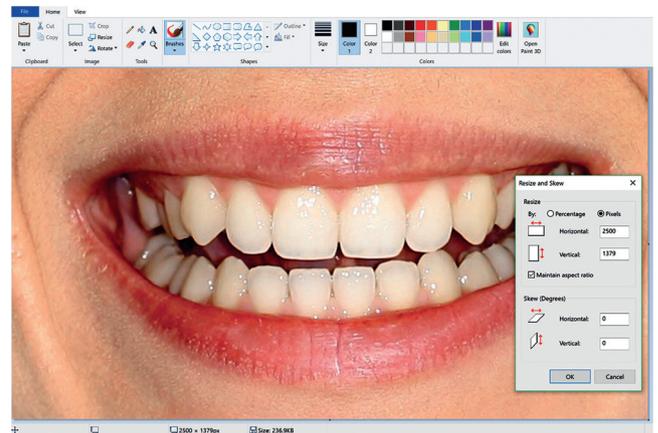

Figure 3. Cropping and resizing.

and hide the mandibular cast from the "show-hide" panel to gain visibility only for the background picture and the maxillary cast. Then choose "rearticulate models virtually." Make all the modifications of the maxilla position by selecting the frontal view arrow from the 6 standard views of the right menu bar and ensuring coincidence between the background plane (determined during the photography) and the virtual frontal plane.

7. Resize the maxilla so that the dimensions of the teeth are as close as possible to those of the background image. From the "articular jaw correction" window, translate and/or rotate the position of the virtual cast in manual mode until the incisal edges of the maxillary teeth match as accurately as possible to those of the background image and the virtual articulator is aligned with the background image (Fig. 4B, C). After exiting the DentalCAD program, the background image can be removed from the installation directory to avoid interfering with the view of the design window. Optionally, the portrait picture can be loaded separately and used for digital smile design.
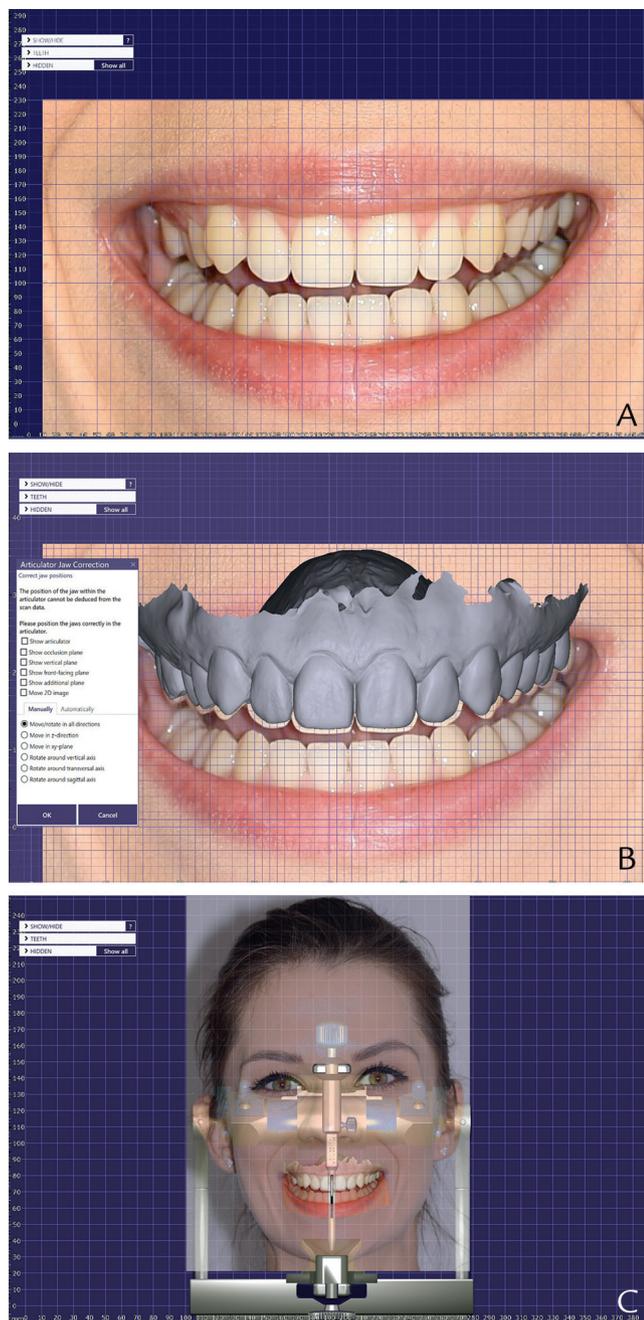
Figure 4. A, B, Cast aligned with background image. C, Virtual articulator enabled.

Figure 5. Profile photograph.

the maxillary teeth. For a more straightforward procedure, index only 1 of the profile photographs. If both photographs are used, the precision of the hinge axis position would be improved, but difficulties arise from condylar asymmetry. The profile images serve for the anteroposterior (sagittal) positioning of the maxillary cast relative to the hinge axis.

9. Optionally, if the maxillary teeth are not sufficiently displayed in the profile image, use an indexing piece to allow alignment with the digital cast. For example, a facebow fork (bite fork; Amann Girrbach) can be positioned on the maxillary arch with occlusal registration material (Futar; Kettenbach) and a custom sagittal orientation flag attached to the fork with an adhesive (Super Glue; Tex Year) (Fig. 5). By using the fork, the indexing between the virtual cast and the profile image can be easier and more accurate. Scanning the indexing piece allows an easier alignment of the cast against the profile images (Fig. 6A, B). For indexing between the fork and the maxillary cast, the intraoral scan of the cervical two-third of the premolars and anterior teeth not covered by the occlusion registration material can be used.

10. Restart the DentalCAD application and load 1 of the profile photographs. Working only in the lateral view, resize and index the profile photograph to the maxillary scanned cast (Fig. 6C). As the photographs are loaded in the frontal plane, the profile image must be rotated 90 degrees to match the sagittal plane and translated to the side from which the photograph was registered (left or right) (Fig. 6D).

11. Translate the cast-picture ensemble sagittally in the virtual articulator by selecting the "Rearticulate models virtually" option and work only from the lateral view until the center of the
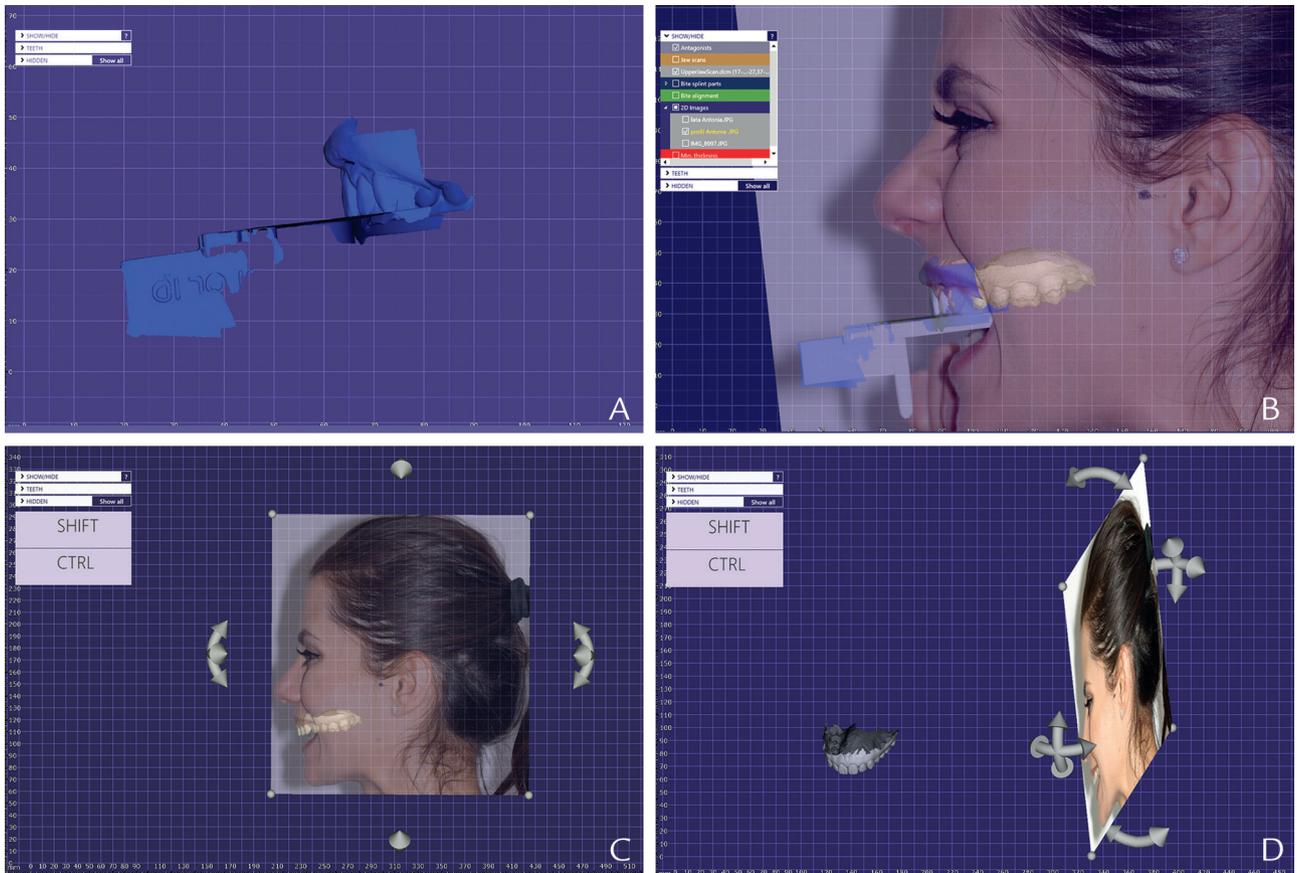
8. Determine and mark the hinge axis on the skin. Using one of the standard methods,[25] mark the points corresponding to the terminal hinge axis with an appropriate pencil (Tattly Temporary; Peagreen Designs) (Fig. 5). Make the profile photograph with the camera lens placed horizontally, perpendicular to the patient's profile plane, and focused on the maxillary interincisal point. The patient should show a wide exaggerated smile that displays as much as possible of

Figure 6. A, B, Facebow plastic fork aligned with cast. C, D, Profile photograph aligned.
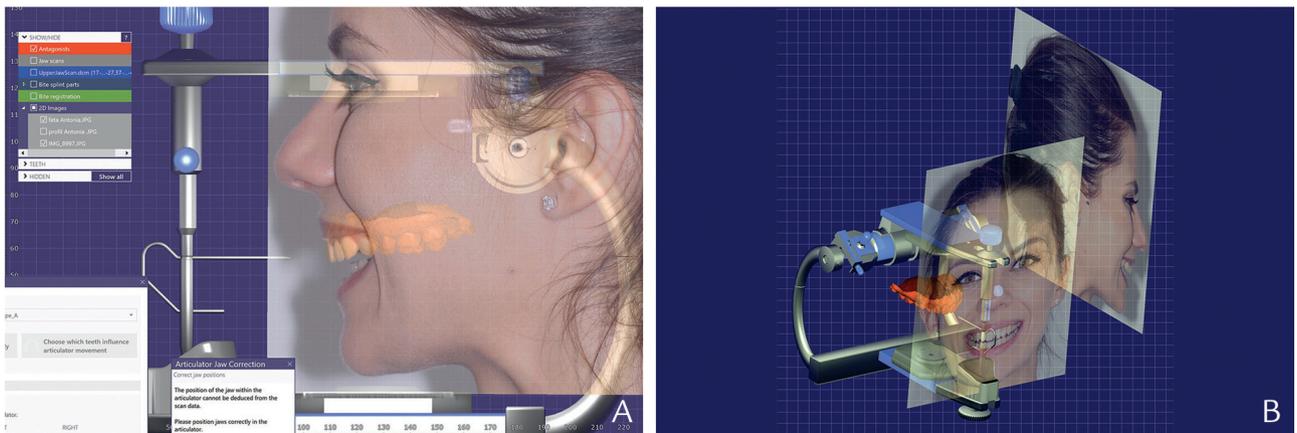

Figure 7. A, Condylar ball of virtual articulator aligned with cast-photograph assembly. B, Planes transferred to virtual articulator.

condylar ball overlaps the hinge axis marking point (Fig. 7).

DISCUSSION

The use of 2D images for digital smile design in dental CAD-CAM applications has been described,[26] but the authors are unaware of reports of transferring the reference planes through standardized photographs. The method described represents a rapid and straight-forward way to locate the maxillary cast on the virtual articulator. The location of the hinge axis used in the protocol of the method is subject to a positioning error of few millimeters, but it is predictable and the error does not have any major impact on the definitive restorations.[27]

For patients missing anterior teeth, occlusion rims indexed with the original virtual cast can be used. For patients who cannot smile wide enough to show their teeth, the technique could be modified with a facebow fork with an orientation flag placed in the frontal plane as an indexing aid in a similar manner to the profile technique.

The accuracy of the method depends on the correct position of the patient and the correct overlapping of the virtual cast outline over the background photograph. The dimensional matching of the digital cast with the background image may show some degree of incongruence due to the "stepped" zoom function of the graphic display or the cylindrical aberrations induced by the photographic lens. However, the possibility of overlapping the entire photograph during the second stage of the technique is an additional element of validating the correctness of the reference plane. The method is less accurate than systems with automatic indexing algorithms,[17] but they are more expensive and not entirely free of accuracy risks. Studies are needed to verify this technique.

SUMMARY

The virtual facebow transfer can be practically made in DentalCAD application based on standardized frontal and lateral photographs of the patient. The technique ensures the correct alignment of the digital maxillary cast to the virtual articulator with respect to the patient's planes and the skin markings of the condylar axis.

REFERENCES

1. Ruge S, Kordass B. 3D-VAS- initial results from computerized visualization of dynamic occlusion. Int J Comput Dent 2008;11:9-16.
2. Kordass B, Gartner C, Sohnel A, Bisler A, Voss G, Bockholt U, et al. The virtual articulator in dentistry: concept and development. Dent Clin North Am 2002;46:493-506.
3. Gaertner C, Kordass B. The virtual articulator: development and evaluation. Int J Comput Dent 2003;6:11-23.
4. Infante L, Yilmaz B, McGlumphy E, Finger I. Fabricating complete dentures with CAD/CAM technology. J Prosthet Dent 2014;111:351-5.
5. Ferrario VF, Sforza C, Serrao G, Schmitz JH. Three-dimensional assessment of the reliability of a postural face-bow transfer. J Prosthet Dent 2002;87:210-5.
6. Oancea L, Stegaroiu R, Cristache C. The influence of temporomandibular joint movement parameters on dental morphology. Ann Anat 2018;218:49-58.
7. Morneburg TR, Pröschel PA. Impact of arbitrary and mean transfer of dental casts to the articulator on centric occlusal errors. Clin Oral Investig 2011;15:427-34.
8. Walker F, Ayoub AF, Moos KF, Barbenel J. Face bow and articulator for planning orthognathic surgery: 1 face bow. Br J Oral Maxillofac Surg 2008;46:567-72.
9. Kwon TG, Choi JW, Kyung HM, Park HS. Accuracy of maxillary repositioning in two-jaw surgery with conventional articulator model surgery versus virtual model surgery. Int J Oral Maxillofac Surg 2014;43:732-8.
10. Samuels RHA, Brezniak N. Orthodontic facebows: safety issues and current management. J Prosthet Dent 2002;87:210-5.
11. Walker F, Ayoub AF, Moos KF, Barbenel J. Face bow and articulator for planning orthognathic surgery: 2 articulator. Br J Oral Maxillofac Surg 2008;46:573-8.
12. Cooke MS, Orth D, Wei SH. A summary five factor cephalometric analysis based on natural head posture and the true horizontal. Am J Orthod Dentofacial Orthop 1988;93:213-23.
13. Cooke MS, Orth D, Wei SH. The reproducibility of natural head posture: a methodological study. Am J Orthod Dentofacial Orthop 1988;93:280-8.
14. Chiu C, Clark R. Reproducibility of natural head position. J Dent 1991;19:130-1.
15. Solaberrieta E, Otegi RJ, Mínguez R, Etxaniz O. Improved digital transfer of the maxillary cast to a virtual articulator. J Prosthet Dent 2014;112:921-4.
16. Solaberrieta E, Minguez R, Barrenetxea L, Sierra E, Etxaniz O. Novel methodology to transfer digitized casts onto a virtual dental articulator. CIRP J Manufac Sci Technol 2013;6:149-55.
17. Solaberrieta E, Mínguez R, Barrenetxea L, Otegi JR, Szentpétery A. Comparison of the accuracy of a 3-dimensional virtual method and the conventional method for transferring the maxillary cast to a virtual articulator. J Prosthet Dent 2015;113:191-7.
18. Solaberrieta E, Garmendia A, Minguez R, Brizuela A, Pradies G. Virtual facebow technique. J Prosthet Dent 2015;114:751-5.
19. Lam WYH, Hsung RTC, Choi WWS, Luk HWK, Cheng LYY, Pow EHN. A clinical technique for virtual articulator mounting with natural head position by using calibrated stereophotogrammetry. J Prosthet Dent 2018;119:902-8.
20. Lam WYH, Hsung RTC, Pow EHN. A 2-part facebow for CAD-CAM dentistry. J Prosthet Dent 2016;116:843-7.
21. Joda T, Brägger U, Gallucci G. Systematic literature review of digital three-dimensional superimposition techniques to create virtual dental patients. Int J Oral Maxillofac Implants 2015;30:330-7.
22. Ritto FG, Schmitt ARM, Pimentel T, Canellas JV, Medeiros PJ. Comparison of the accuracy of maxillary position between conventional model surgery and virtual surgical planning. Int J Oral Maxillofac Surg 2018;47:160-6.
23. Ghanai S, Marmulla R, Wiechnik J, Muhling J, Kotrikova B. Computer-assisted three dimensional surgical planning: 3D virtual articulator: technical note. Int J Oral Maxillofac Surg 2010;39:75-82.
24. Solaberrieta E, Mínguez R, Barrenetxea L, Etxaniz O. Direct transfer of the position of digitized casts to a virtual articulator. J Prosthet Dent 2013;109:411-4.
25. Dawson PE. Functional occlusion from TMJ to smile design. 1st ed. St. Louis: Mosby/Elsevier; 2007. p. 100.
26. Martins AV, Albuquerque RC, Santos TR, Silveira LM, Silveira RR, Silva GC, Silva NRFA. Esthetic planning with a digital tool: a clinical report. J Prosthet Dent 2017;118:698-702.
27. Shillingburg HT, Hobo S, Whitsett LD, Jacobi R, Brackett SE. Fundamentals of fixed prosthodontics. 4th ed. Chicago: Quintessence Publishing Co. Inc; 1997. p. 64.

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