Fully Digital Design and Fabrication of a Telescoping Herbst Appliance

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The conventional Herbst* appliance was first described in 1910[1] and has since undergone numerous modifications, primarily due to a high breakage rate and other complications that can occur during treatment.[2-6] The Manni Telescoping Herbst** (MTH) appliance consists of a fixed palatal arch connected to a mandibular acrylic splint with two telescoping rods.[7,8] The rods allow lateral mandibular excursions of as much as 12°, and the splint, which minimizes flaring of the lower incisors, can be partially removed for proper oral hygiene.[4]

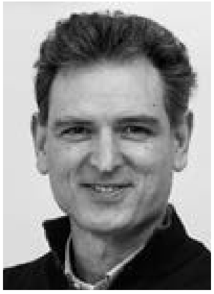
Although the MTH has shown lower failure rates and complications as compared to the traditional Herbst, the Hanks Telescoping Herbst,** and the MiniScope Telescoping Herbst,** treatment can still be interrupted by fractures of the upper first-molar bands, acrylic splint breakages, or detachment of appliance parts. Repair requires removal of the appliance, new impressions, and a complete refabrication of the device.[8]

Digital technologies are rapidly changing both orthodontic diagnosis and appliance production.[9-12] Specialized computer-aided design and manufacturing (CAD/CAM) software already enables the laboratory technician and orthodontist to design a variety of appliances and fabricate them immediately, using three-dimensional printers and biocompatible resins. Metallic devices such as rapid palatal expanders can be manufactured with laser-melting technology.[13] These 3D-printed devices are better customized for each patient and therefore require fewer appointments, while the improved efficiency saves time and reduces costs for the practice.[14]

This article presents a new protocol for designing and producing a fully digital MTH.

KRAVITZ KEYS

- This is a step-by-step guide for a fully digital Herbst appliance.
- The upper component consists of a 3D-printed transpalatal arch with saddle bands.
- The lower component consists of saddle bands on both the first and second premolars.
- This Herbst incorporates a 3D-printed acrylic splint in the lower arch to minimize flaring.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Design and Fabrication

1. With the mandible in an advanced sagittal position, take a digital impression of both arches with a TRIOS 3*** intraoral scanner (Fig. 1A). The esthetic Fränkel maneuver can be helpful in determining the required extent of mandibular advancement (Fig. 1B).[15]
2. Use the Create Shell command in Appliance Designer CAD*** to design digital bands on the upper first molars (a "shell" is a wraparound surface with a fixed thickness and offset distance defined by the user). After setting the Insertion Direction perpendicular to the occlusal plane (Fig. 1C) and the shell thickness to .5mm, outline the surfaces of the first molar, extending to the second molar (Fig. 1D). Select the Remove Undercut option to provide a .05mm offset for bonding space. Use the Modify Model/Spine Cut substep to remove the occlusal portions of the shell (Fig. 1E).
3. Design a transpalatal arch using the Create Bar command (a "bar" is a 3D model based on a customized 2D profile). The parameters and geometries are defined in the Ortho Control panel; in the example, the bar was cylindrical and 1.5mm in diameter (Fig. 1F). Draw the transpalatal arch connecting the right and left first-molar bands, keeping the bar 1mm away from the palatal mucosa to reduce the risk of soft-tissue injury (Fig. 1G). Use the Modify Model/Wax Knife substep to remove the portions of the bar protruding from the inner surfaces of the digital bands (Fig. 1H).
4. Combine the digital bands with the palatal arch using the Combine Models command (Fig. 1I). The Wax Knife option can be used to smooth the edges and refine the virtual appliance.
5. The mandibular splint is combined with premolar bands that accommodate the nuts and screws of the telescoping Herbst rods. Using the Create Shell command, outline the surfaces of the lower first and second premolars (Fig. 2A). Again, the bands should be .5mm thick and perpendicular to the occlusal plane, with a .05mm offset for bonding. Use Modify Model/Spine Cut to remove the occlusal portions of the shell (Fig. 2B).
6. A digital parallelometer ensures that the maxillary and mandibular axles of the Herbst telescoping rods are parallel. To keep a fixed distance between the axles, corresponding to the selected rod length, use Rhinoceros CAD† to design a virtual attachment that precisely fits the nuts of the rods (Fig. 2C). Import the attachment into Appliance Designer (Fig. 2D).
7. Adjust the nut positions using Modify Model/Global Transformations (Fig. 2E). Using the Modify Model/Split Models substep, select first the maxillary nut and then the mandibular one (Fig. 2F). Use the Modify Model/Wax Knife substep to remove the portions of the attachments protruding from the inner surfaces of the digital bands

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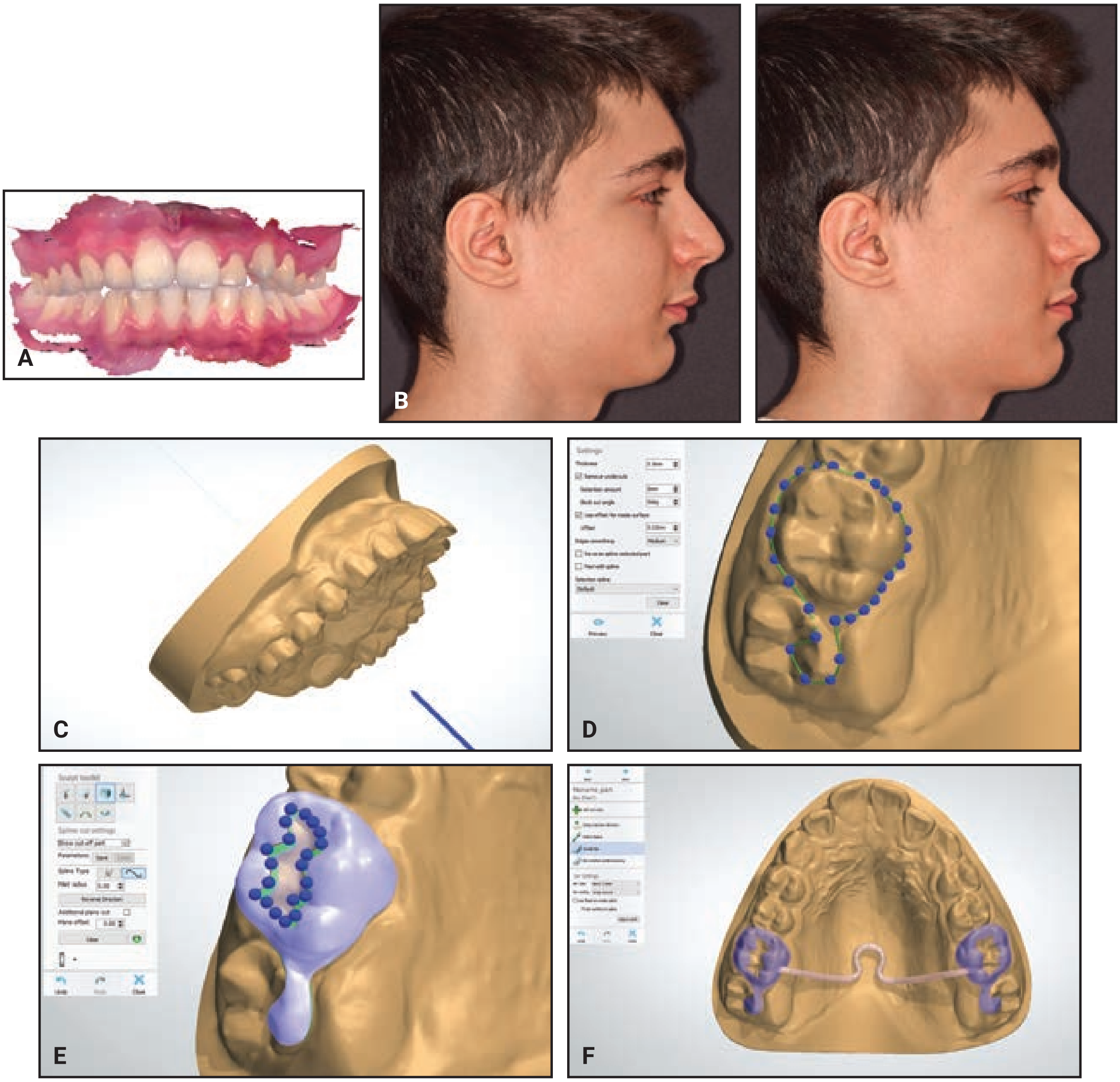

Fig. 1 Transpalatal arch design. A. Digital impression from intraoral scanner. B. Fränkel maneuver used to determine mandibular advancement. C. Insertion Direction set perpendicular to occlusal plane in Appliance Designer CAD.* D. Surfaces of first molar outlined, extending to second molar. E. Occlusal portions of shell removed. F. Parameters and geometries of transpalatal arch defined (continued on next page).**

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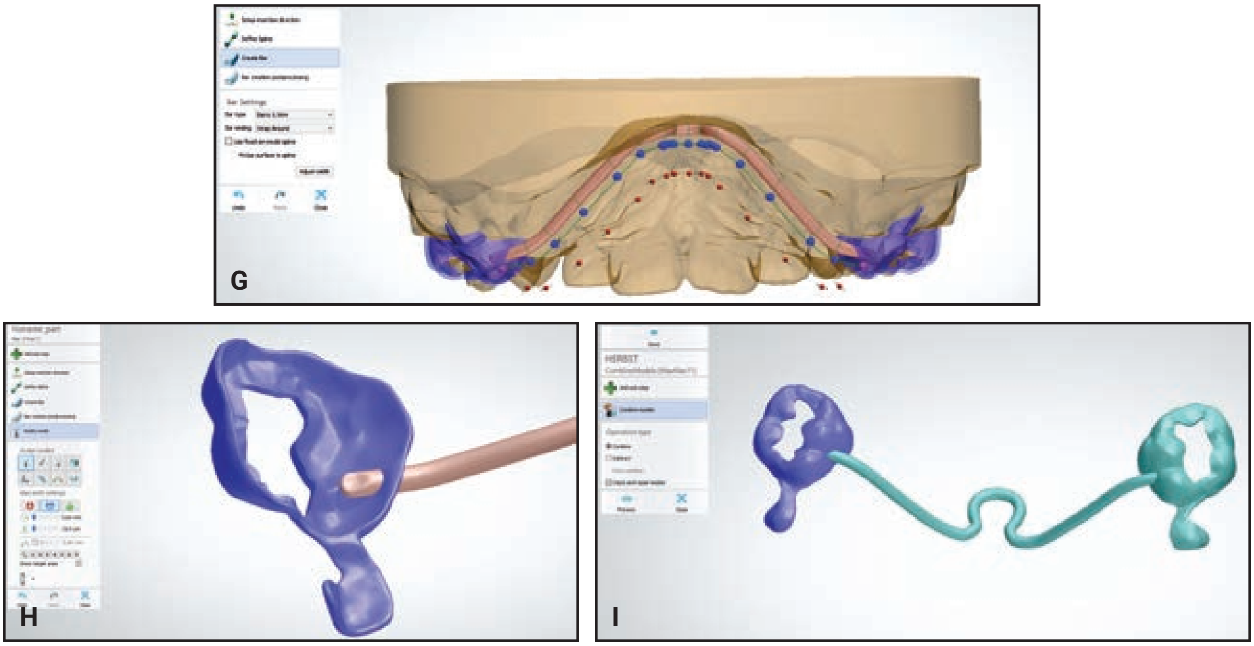


Fig. 1 (cont.) G. Transpalatal arch connecting right and left molar bands drawn 1mm away from palatal mucosa to minimize risk of soft-tissue injury. H. Portions of bar protruding from inner surfaces of digital bands removed. I. Digital bands combined with transpalatal arch.

(Fig. 2G). Combine the attachments with the maxillary and mandibular appliances using the Combine Models command (Fig. 2H).

8. Use the Combine Models command first to merge the mandibular digital bands, then to merge these with the mandibular dental model (Fig. 2I). Remove the undercuts after setting the Insertion Direction perpendicular to the occlusal plane (Fig. 2J).

9. Design the acrylic splint using the Create Bar command. Set the Insertion Direction perpendicular to the occlusal plane (Fig. 2K), and define the central spine by connecting the occlusal surfaces of the mandibular teeth (Fig. 2L). Draw the splint borders by outlining the surfaces of the mandibular teeth from second molar to second molar (Fig. 2M). Define the Create Bar parameters and geometries in the Ortho Control panel (Fig. 2N). Finalize the splint by selecting Subtract Model, with a .05mm offset for the interior surface (Fig. 2O). Adjust the occlusal contacts with the maxillary arch using the Modify Model substep and the Virtual Articulator tool (Fig. 2P). This tool automatically adapts the splint design to both static and dynamic occlusions, according to the patient's specific parameters (Bennett Angle, Condyle Inclination, Lateral Inclination, and Protrusive Inclination).

10. Export the design as stereolithographic (STL) files. Send the transpalatal bar and mandibular band files remotely to a laser-melting manufacturer‡ for production in a cobalt chromium or titanium alloy. The acrylic splint can be fabricated in the office or by a dental laboratory, using 3D printers and biocompatible resins (Fig. 3A).

11. After receiving the 3D-printed appliance, laser-weld the Herbst nuts to the upper and lower sections (Fig. 3B). The precise positions of the nuts are indicated by the virtual attachments. Attach the acrylic splint to the properly positioned mandibular bands using the same biocompatible resin (Fig. 3C).

12. Polish the appliance before placing it in the mouth (Fig. 3D).

Discussion

The Herbst appliance is one of the most effective and efficient devices for the treatment of Class II malocclusion.[16] Precise fabrication is critical, however, to avoid complications and ensure the success of the therapy. As illustrated in this article, digital technologies can be helpful to both the orthodontist and the dental technician in designing and fabricating a Herbst appliance. A

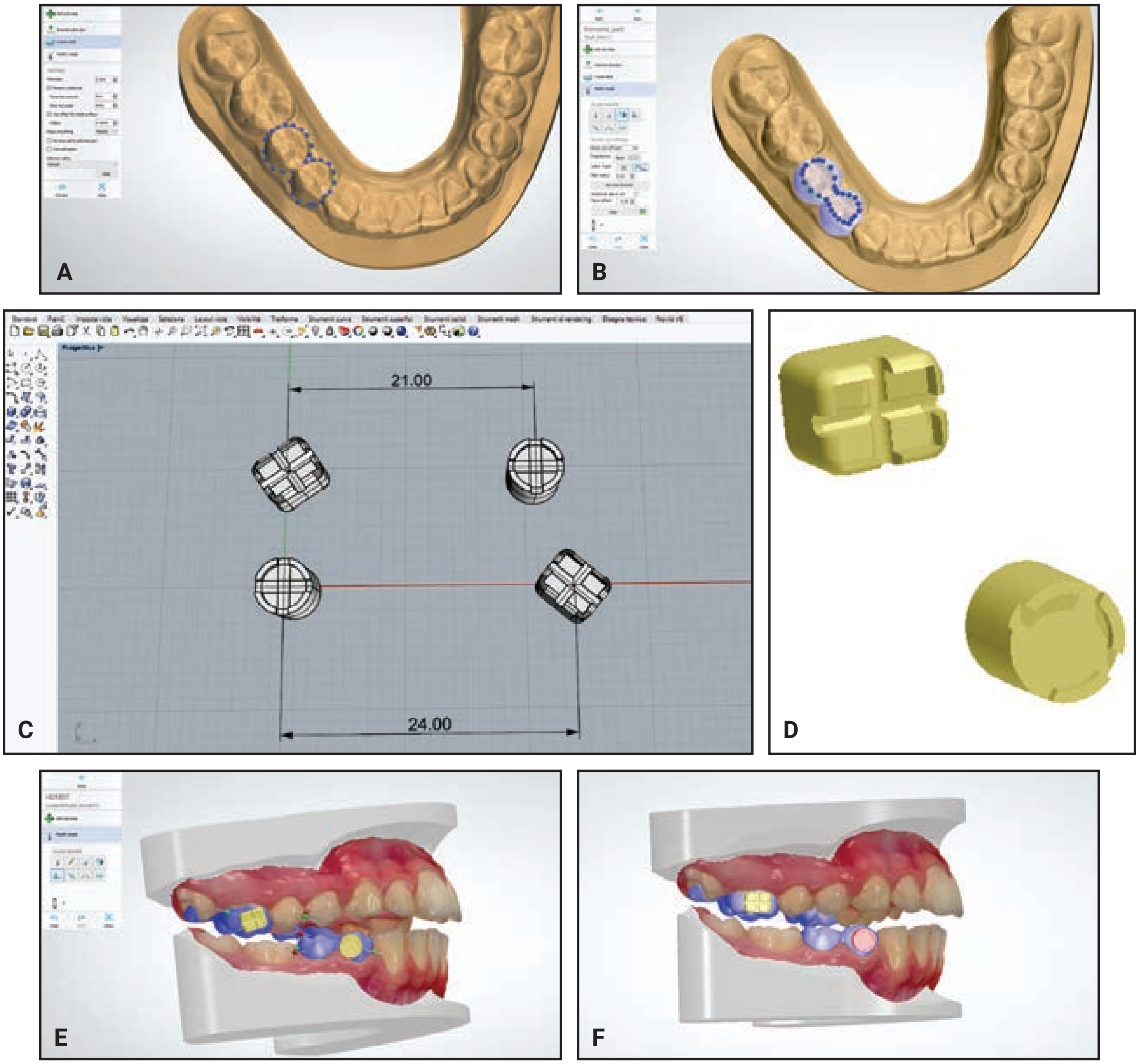
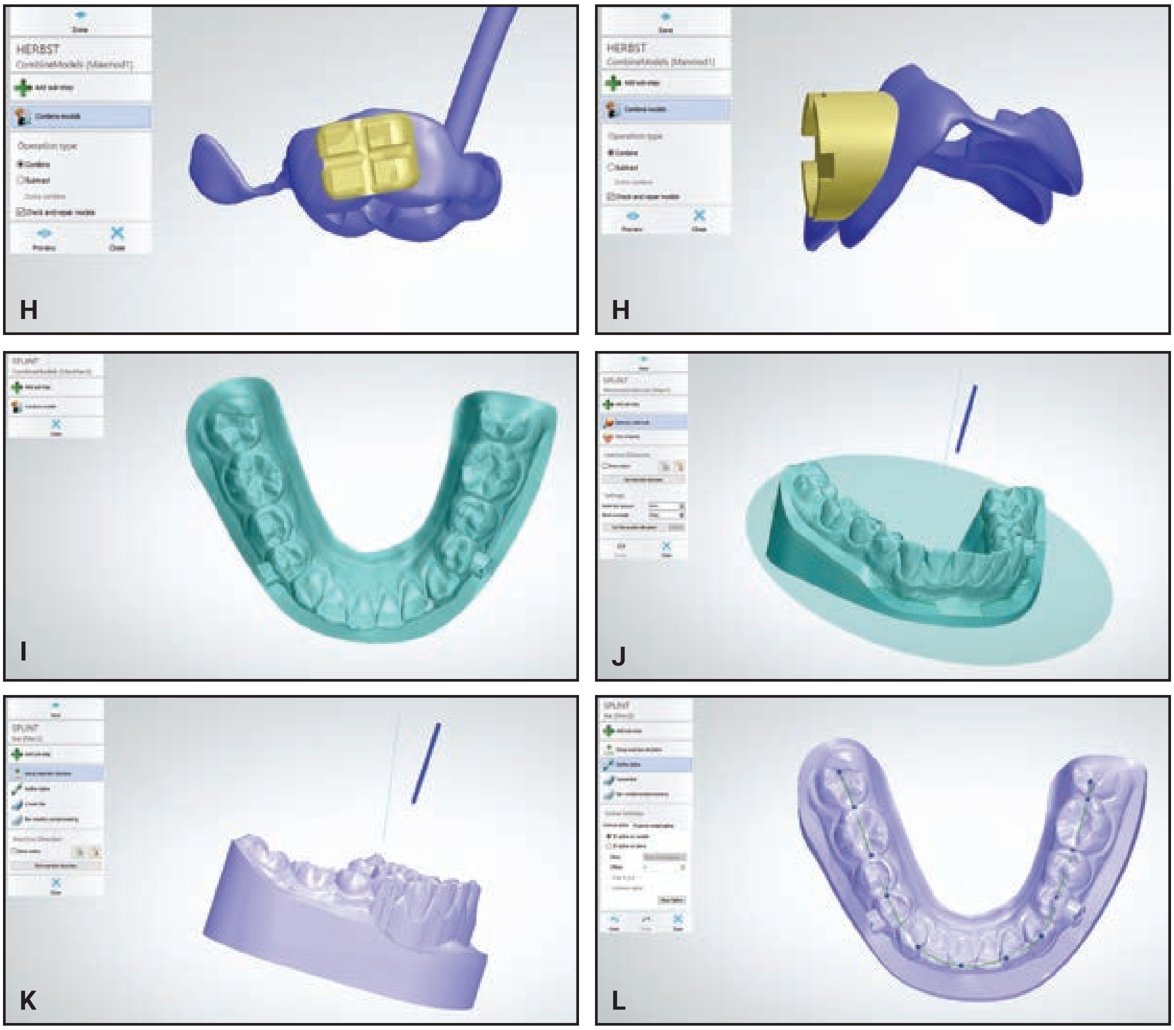


Fig. 2 Mandibular splint design. A. Digital bands designed by outlining surfaces of lower first and second premolars. B. Occlusal portions of shell removed. C. Virtual attachment designed to fit nuts of Herbst telescoping rods in Rhinoceros CAD.† D. Attachment imported to Appliance Designer. E. Nut positions adjusted. F. Maxillary and mandibular nuts selected (continued on next page).

Fig. 2 (cont.) G. Portions of attachments protruding from inner surfaces of digital bands removed. H. Attachments combined with maxillary and mandibular appliances. I. Mandibular digital bands merged, then merged with mandibular dental model. J. Undercuts removed after setting Insertion Direction perpendicular to occlusal plane. K. Insertion Direction set perpendicular to occlusal plane. L. Central spine defined by connecting occlusal surfaces of mandibular teeth (continued on next page).



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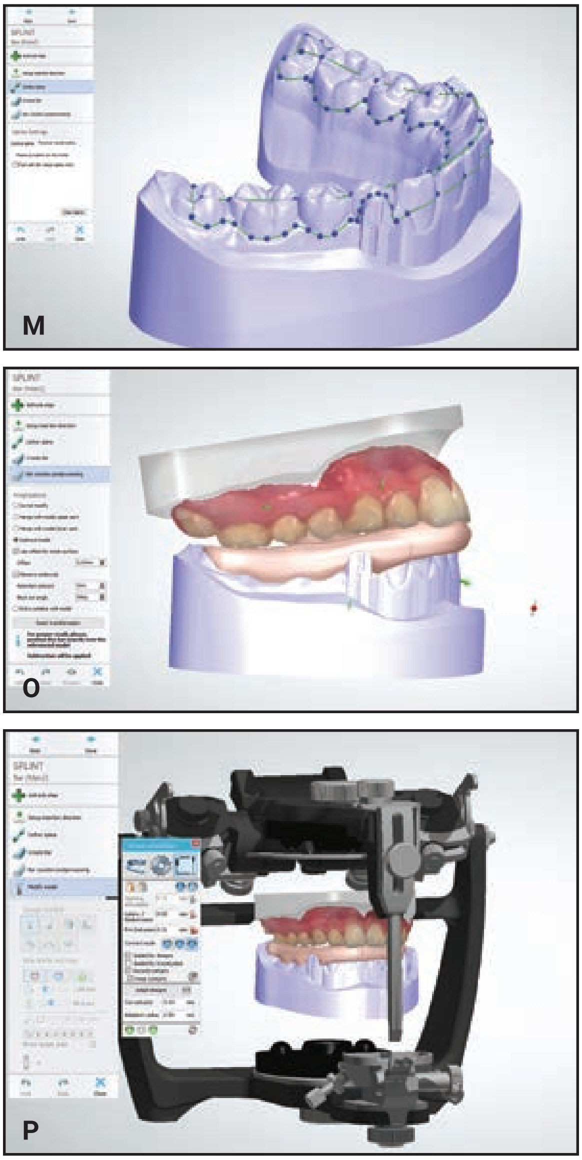

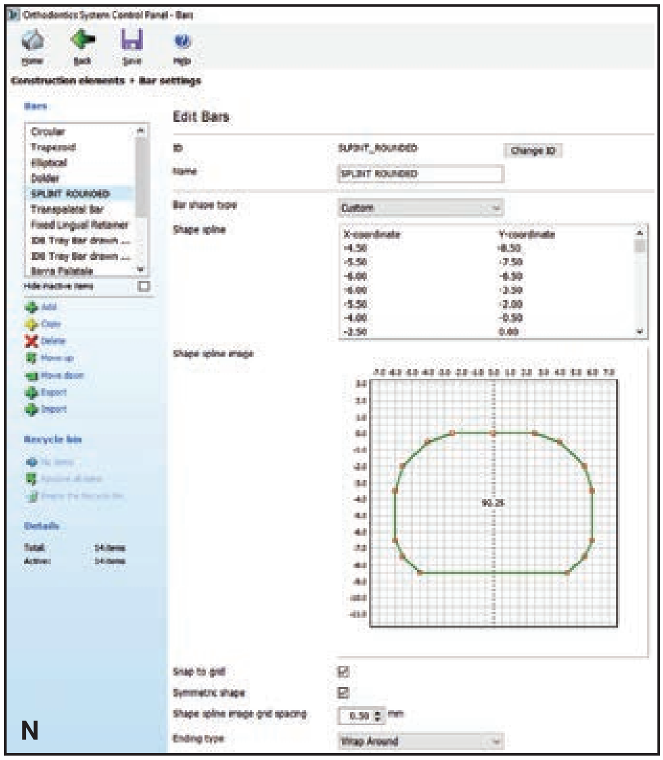

Fig. 2 (cont.) M. Splint borders drawn by outlining surfaces of mandibular teeth from second molar to second molar. N. Create Bar parameters defined in Ortho Control panel. O. Splint finalized with .05mm offset for interior surface. P. Occlusal contacts with maxillary arch adjusted using Virtual Articulator tool.

fully digital workflow is simple and accurate, and there is no need for a new impression in case of appliance breakage; a copy of the digital archive is sufficient.

The bands for the digital MTH are custom-fitted to the dental surfaces and can be extended to adjacent teeth in the form of a band, pad, or wire. Since they do not extend between the contact points, there is no need for preliminary separators, saving time and improving the patient's experience.

A digital parallelometer enables precisely parallel placement of the Herbst nuts and rods between the maxilla and mandible, thus preventing stress on the screws and minimizing the risk of breakage. The Virtual Articulator tool considerably reduces the amount of chairtime needed to adjust the appliance in the mouth.

Fig. 3 Appliance fabrication. A. Acrylic splint produced using 3D printer†† and biocompatible resin.‡‡ B. Herbst nuts for laser welding to upper and lower appliance. C. Acrylic splint attached to mandibular bands using biocompatible resin. D. Finished appliance.

The mandibular splint can be designed either with a flat surface for the opposing arch or with indentations to enhance mandibular stability in sliding movements. During treatment, the lower splint can easily be relined with acrylic while in the mouth to improve stability and retention. Alternatively, the clinician can take a new intraoral scan of both arches and design a new splint, which can be 3D-printed in the office and delivered the same day.

Mini-implants in both arches are increasingly being used with this version of the Herbst appliance to improve anchorage control and promote skeletal effects.[5,17] The digital workflow allows the clinician to incorporate temporary anchorage devices into the design, match the cone-beam computed tomography data with the intraoral scan, plan the correct miniscrew positions, and produce a surgical guide. Thus, the appliance can be delivered on the same day as miniscrew insertion for immediate loading.

††Phrozen Sonic Mini 4K, Phrozen Technology, Hsinchu, Taiwan; www.phrozen3d.com.
‡‡KeySplint Soft, Keystone Industries, Gibbstown, NJ; www.dental.keystoneindustries.com.

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