

# THE CUTTING EDGE

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*(Editor's Note: This quarterly column is compiled by JCO Technology Editor Ronald Redmond. To help keep our readers on The Cutting Edge, Dr. Redmond will spotlight a particular area of orthodontic technology every few months. Your suggestions for future subjects or authors are welcome.)*

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In this month's column, five authors from the University of Milan, Italy, describe the fabrication and application of their Digital-Titanium (DTi) Herbst. The convergence of new orthodontic scanning technology and CAD/CAM software has produced an appliance that can be milled to precise specifications. Because the DTi is made from grade 5 titanium, it is stronger than a banded Herbst or one cast from the lost-wax process.

In the authors' system, polyvinyl siloxane impressions are required to produce plaster casts that are then coated for scanning, with the resulting .STL data imported into the computer program for CAD/CAM fabrication. I believe an uncoated intraoral scan from a more advanced device such as the iTero scanner could also be used.

The authors note that their glass ionomer cement margins are smaller because of the precision of fabrication and that the appliance requires no prior separation of the teeth, thus improving patient comfort. I would recommend careful monitoring of oral hygiene, since the DTi doesn't cover the interproximal contact areas. Once demand increases and this version of the Herbst becomes

economically viable, however, it should be a useful addition to the orthodontic armamentarium.

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## The Digital-Titanium Herbst

**C**omputer-aided design (CAD) and computer-aided manufacturing (CAM) systems have been vastly improved since their introduction to dentistry in the 1980s.<sup>1</sup> Formerly of interest mainly to prosthodontists and implantologists, CAD/CAM techniques are increasingly being used in other dental specialties, including orthodontics.

In our university clinic, we have used CAD/CAM technology to produce palatal expanders, Michigan bite splints, and occlusal splint guides for presurgical orthodontic treatment.<sup>2</sup> This article introduces a technique we have developed for computer-controlled design and fabrication of a new Herbst\* appliance,<sup>3,4</sup> which we call the DTi (Digital Titanium) Herbst.

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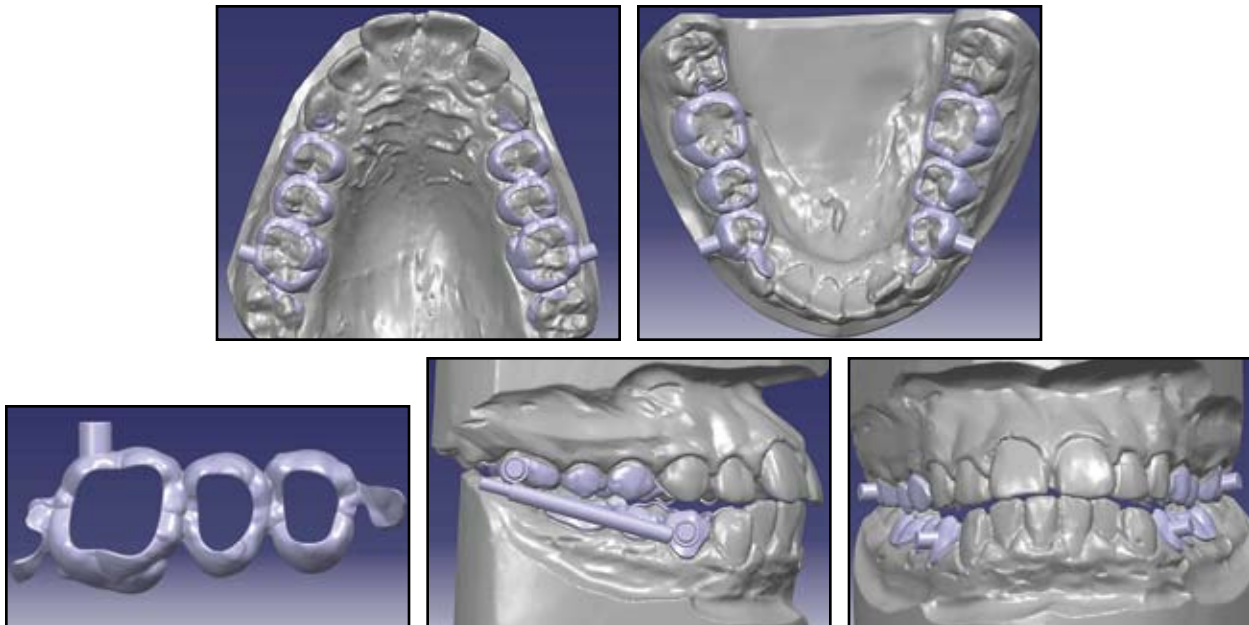


Fig. 1 Virtual DTi Herbst splints and appliance designed with CAD software.

### Virtual Patient Records

Precise silicone impressions\*\* are used to pour three sets of plaster casts. The separate upper and lower arches and the occlusion (in a construction bite with the mandible positioned 5mm forward) are scanned from the first set. Individual teeth are separated from the second and third casts and scanned for better definition of the points of contact. This extra effort results in well-defined three-dimensional images of the models, with sufficient detail to design and fabricate the appliance with great precision.

The models are coated with a titanium dioxide spray so that the plaster will not absorb the light from the scanner. Digitization is performed with a structured-light scanner\*\*\* that projects a sequence of coded light patterns on the model surfaces. A camera records the deformation induced by the surface of the object, and the 3D coordinates are calculated to produce a virtual image. These digital images are superimposed to produce a definitive prototype, and acquisition artifacts are removed. The result is a set of virtual

models of the upper and lower dental arches and the arches in occlusion in .STL format, which is easily imported into the CAD software.

At this point, the orthodontist can perform a virtual orthodontic setup and, if desired, integrate the virtual models with records from cone-beam computed tomography for treatment planning.

### Fabrication of the DTi Herbst

Our Herbst appliance uses splints for dental support rather than either standard orthodontic bands,<sup>5-7</sup> which can separate or break under forces from the telescopic cylinders, or thicker bands, which are uncomfortable for the patient, requiring separators during the try-in and before cementation. Made of .5mm-thick titanium, the splints cover the mesial and distal occlusal surfaces as far

\*\*President putty and President light body wash material, Coltène/Whaledent AG, Feldwiesenstrasse 20, 9450 Altstatten, Switzerland; [www.coltene.com](http://www.coltene.com).

\*\*\*Maestro Dental Scanner, AGE Solutions, Av. Rinaldo Piaggio 32, 56025 Pontedera, Italy; [www.age-solutions.com](http://www.age-solutions.com).

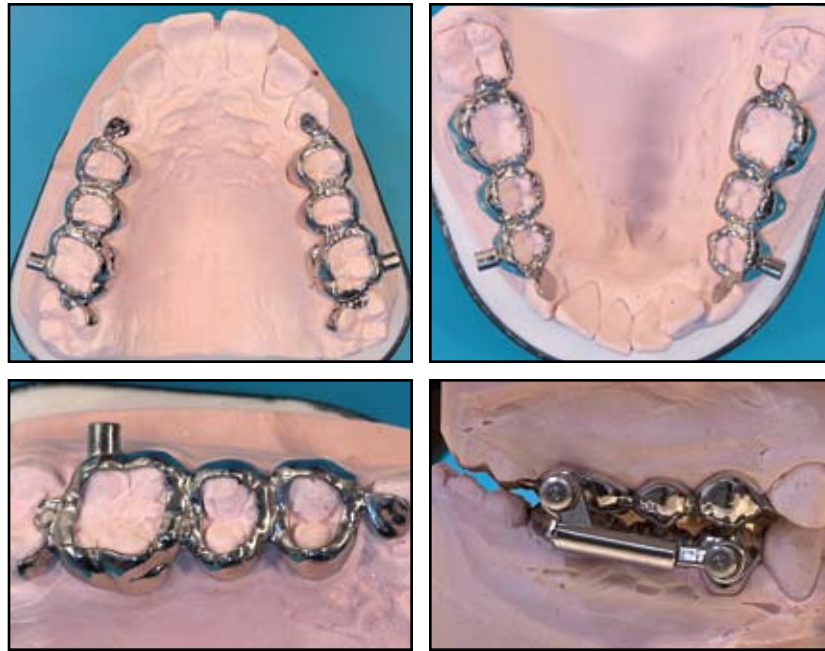


Fig. 2 DTi Herbst splints and assembled appliance fabricated by CAM milling.

as the interdental contact points from first premolar to first molar, precisely reproducing the anatomy of the teeth. Two dental supports are added in each quadrant for stability: one extending distally along the mesiolingual surface of the second molar, the other resting on the occlusal surface of the canine.

In the virtual design stage, screw housings for the telescopic components are placed at the lower first premolars and upper first molars (Fig. 1). Lingual 3mm × 1.5mm horizontal slots can be added at the first molars to accommodate a lingual or transpalatal arch. Undercuts are made on the inner surfaces of the splints to improve cement retention.

After completion of the CAD phase, design instructions are sent to a CAM laboratory for fabrication.† CAM machines work either by removing material (using a computer numerical control miller or lathe, as in the case of the DTi Herbst) or

by affixing material (using stereolithographic 3D printing for plastics or laser sintering/fusion for metals). Polishing is the final step (Fig. 2).

The DTi Herbst is manufactured from grade 5 titanium, an alloy containing 89% titanium, 6% aluminium, and 4% vanadium. This material's distinctive physicochemical properties make it particularly useful in medical and dental applications. On contact with oxygen, the alloy forms a thin titanium dioxide film that protects the material from variations in temperature and pH and from oxidation, through a process called "passivation". Grade 5 titanium is highly resistant to corrosion, even in contact with fluids in the oral cavity, due to its poor reactivity with many basic and acidic compounds. Mechanically, it is extremely stable, with high tensile strength (895-1,250 MPa)—a narrow range compared with other alloys such as steel (100-2,300 MPa). It is also resistant to traction and has a favorable resistance-to-weight ratio, melting temperature, and tensile modulus.

Figure 3 shows a 13-year-old male with a severe Class II malocclusion and deep bite. Because

†Cleis DS, Via XXV Aprile No. 21, 24040 Fornova San Giovanni, Italy; www.cleisds.com.



**Fig. 3** DTi Herbst bonded in 13-year-old male patient with juvenile idiopathic arthritis, severe Class II malocclusion, and deep bite.

the patient suffers from juvenile idiopathic arthritis, he was treated with the DTi Herbst to modify his growth.<sup>8,9</sup> Uniformity of the areas of contact between the dental surfaces and the appliances was carefully verified before the Herbst was affixed with glass ionomer cement‡ and the telescopic cylinders were mounted to activate the appliance.

### Discussion

The incidence of breakage with the splint-Herbst design is lower than with banded alternatives.<sup>10,11</sup> Still, because of the variability of traditional fabrication, the material is sometimes not thick enough. Lost-wax casting makes it possible to manage the cementation gap, but the separation spray undergoes changes in density, while the coating can be affected by the setting and thermal expansion of the material. The conventional technique also produces casting defects such as air bubbles, crystal microcracks, and coating- and coal-residue inclusions, which can reduce the mechanical resistance of the appliance. Finally,

because the appliance components are positioned manually, there is a greater likelihood of inaccurate placement and soldering defects.

In contrast, virtual design and fabrication allow splint thicknesses and cementation gaps to be precisely specified in the design phase and casting and soldering defects to be eliminated in the manufacturing phase (Table 1). The DTi Herbst provides better stability than traditional splints because of its exact fit; discrepancies between the finished product and the virtual design have been on the order of 10-30 microns, as measured by the milling machine. Patients are happier when separators are not needed, and oral hygiene is easier because an adequate distance between the splints and the gingival margins is ensured.

In addition, several authors have demonstrated that grade 5 titanium is highly biocompatible. Its ion stability makes it resistant to corrosion, and corrosion-derived ions are the main cause of immune responses to metals.<sup>12-15</sup> Grade 5 titanium splints exhibit superior adhesion due to the oxidizing capacity of the material, which is actually able to interact with the cement. Adhesion can be further improved by the addition of retentive areas on the inner surfaces of the splints.

‡Multi-Cure Glass Ionomer Band Cement, 3M Unitek, 2724 S. Peck Road, Monrovia, CA 91016; www.3MUnitek.com.

**TABLE 1**  
**COMPARISON OF HERBST APPLIANCE FEATURES AND BENEFITS**

	<b>DTi Herbst</b>	<b>Traditional Herbst</b>
Technique	Standardized	Operator-dependent
Thickness	Controllable	Uncontrollable
Cementation gap	Predictable	Variable
Casting defects	Never	Likely
Splints	Milled block	Soldered
Elastic separators	Not required	Required with banded Herbst
Plaque accumulation	Minimal	Common
Adhesion	Excellent	Poor
Oral hygiene	Easier	More difficult
Allergenic materials	None	Possible

**Conclusion**

The use of CAD/CAM technology and space-age materials such as grade 5 titanium makes the design and production of our DTi Herbst simpler, faster, and more accurate than conventional Herbst fabrication. The cost of the appliance is currently about 50% higher because of the laboratory space and precision required in the CAM process and the initially low production levels, but we expect this discrepancy to be reduced as demand increases.

ACKNOWLEDGMENTS: The authors would like to thank Angelo Magni of Cleis DS for his fundamental contributions to this work.

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