DIGITAL ORTHO LAB

Boneborne Rapid Palatal Expansion—the Virtual Way

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This column is compiled by Associate Editor Björn Ludwig, DMD, MS, PhD. Every few months, Dr. Ludwig presents a technique for computer-aided design and manufacturing in the orthodontic office. The online version of each article will include a short video and downloadable files. Your suggestions for future topics are welcome.

Digitalization is changing not only our society in general, but dentistry in particular. In orthodontics, although one might have the impression that digitalization refers exclusively to aligners—since they occupy a dominant position in the media—the spectrum of digital orthodontics is almost unlimited. Computer-aided design and manufacturing (CAD/CAM) is facilitating a high level of innovation in orthodontics by optimizing proven diagnostic and therapeutic procedures.


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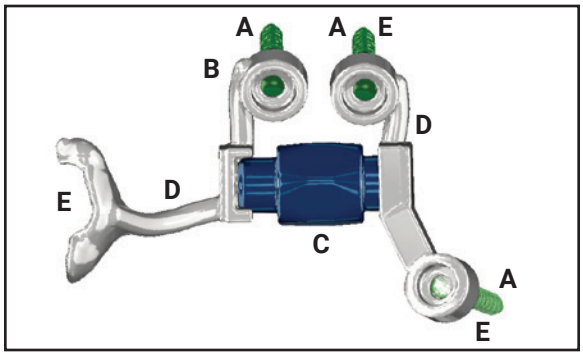

Fig. 1 Basic components of mini-implant-supported rapid palatal expander (MARPE). A. Temporary anchorage devices (TADs). B. Abutments. C. Expansion screw. D. Connecting elements. E. Posterior anchorage (anti-tipping) from molar pads or TADs.**

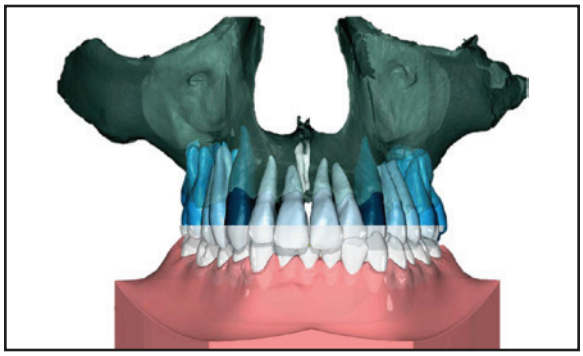

Fig. 2 Initial intraoral scan of 15-year-old male patient with unilateral crossbite and Class III tendency matched with cone-beam computed tomography.

In this first edition of the Digital Ortho Lab, we will describe the procedure for virtually designing a boneborne rapid palatal expander, often called a mini-implant-assisted rapid palatal expander (MARPE). The technique is illustrated by selected diagnostic records of a 15-year-old male patient who presented with a unilateral crossbite and a Class III tendency.

Why MARPE?

Conventional rapid palatal expansion produces such side effects as tipping of teeth, a reduction in buccal bone thickness, and a loss of marginal bone height resulting in gingival recession.[1-4] Boneborne expanders offer several advantages, including more predictable skeletal expansion and fewer dental side effects. MARPE, which seems to be especially well suited for patients during the postpubertal growth spurt,[5] has been associated with a high success rate.[6]

For many years, MARPE appliances were prefabricated products. The expansion appliance was usually inserted first, followed by two to four temporary anchorage devices (TADs)—as with the maxillary skeletal expander (MSE).[7] In the digital world, however, the appliance is always fully customized for the individual patient (Fig. 1).

TABLE 1
SELECTIVE LISTING OF CAD/CAM* SOFTWARE PRODUCTS

Orthodontic (Dental)	CAD Suites
3Shape Appliance Designer***	Meshmixer†
OnyxCeph3‡	Fusion360†
Blue Sky Plan††	Rhinoceros‡‡
EXOCAD§	3D Slicer§§
Blenderfordental§§§	Geomagic Design XTM****

*Computer-aided design and manufacturing.

Appliance Design

To virtually plan and design a boneborne expander, the digital diagnostic records need to be matched (superimposed) using suitable software (Fig. 2). Recommended records are an intraoral scan and corresponding photos, as well as a lateral cephalogram and, if indicated, cone-beam computed tomography (CBCT).

There are many software products on the orthodontic market suitable for designing any kind of MARPE (Table 1); OnyxCeph3‡ was utilized for this patient. Pure CAD suites can support the more advanced operator by facilitating individual

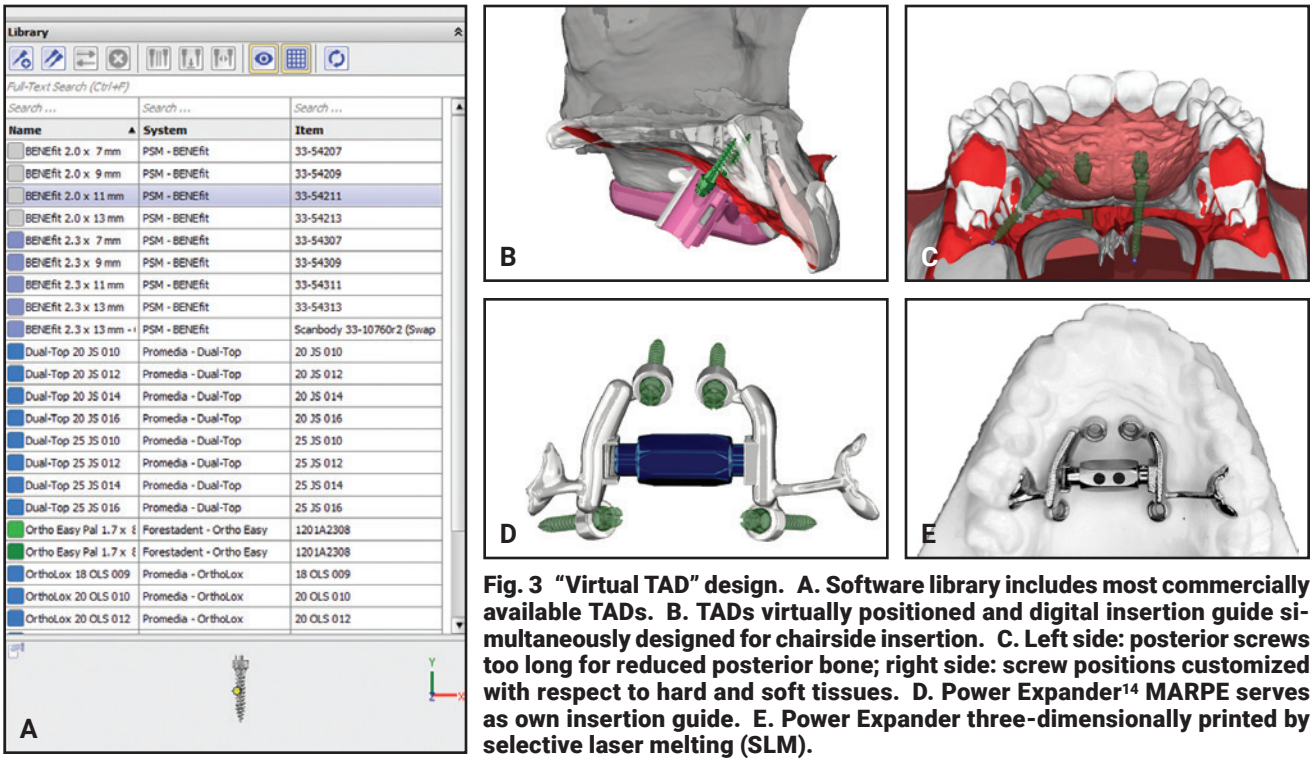

Fig. 3 "Virtual TAD" design. A. Software library includes most commercially available TADs. B. TADs virtually positioned and digital insertion guide simultaneously designed for chairside insertion. C. Left side: posterior screws too long for reduced posterior bone; right side: screw positions customized with respect to hard and soft tissues. D. Power Expander[14] MARPE serves as own insertion guide. E. Power Expander three-dimensionally printed by selective laser melting (SLM).

functions such as finite-element analysis.

In the first step of appliance planning, the "virtual TADs" are digitally positioned (Fig. 3). The virtual TADs should be surrounded by adequate bone while avoiding critical anatomical structures such as teeth and nerves and respecting the soft tissue. Bicortical positioning is often helpful.[8] The TAD length, diameter, and design must be adapted to the individual patient's anatomy[9] since, for example, the vertical bone height is often reduced in the posterior palate.[10] The insertion angle seems to be crucial. TAD placement can be optimized and adapted to varying bone thicknesses if the bone morphology of the palate is properly evaluated (preferably with CBCT).[11,12]

Once the virtual TAD location is established, a digital insertion guide is designed for three-dimensional printing, either in-house or in a laboratory. The guide allows the MARPE and mini-screws to be installed in one session,[1,2,8,9] which requires careful digital planning for anatomical site transfer.[10,13] This aspect will be covered in more detail in future Digital Ortho Lab articles.

The MARPE is then digitally constructed with respect to the selected mini-implant positions. Many designs have been developed over the past two decades: Wilmes and colleagues introduced the Hybrid Hyrax§§§§ expander in 2007,[15,16] and similar

**PowerScrew, Tiger Dental, Bregenz, Germany; www.tigerdental.com.
***Trademark of 3Shape, Copenhagen, Denmark; www.3shape.com.
†Autodesk, Inc., San Rafael, CA; www.autodesk.com.
‡OnyxCeph, Chemnitz, Germany; www.onyxceph.de.
††Blue Sky Bio, Libertyville, IL; www.blueskyplan.com/orthodontic.
‡‡Robert McNeel & Associates, Seattle, WA; www.rhino3d.com.
§Registered trademark of Align Technology, Inc., San Jose, CA; www.aligntech.com.
§§3D Slicer is a free, open-source, multi-platform software package; www.slicer.org.
§§§Blender for Dental International, Brisbane, Australia; www.blenderfordentala.com.
****Registered trademark of 3D Systems, Inc., Rock Hill, SC; www.3Dsystems.com.
§§§§Registered trademark of Dentaurum, Inc., Newtown, PA; www.dentaurum.com

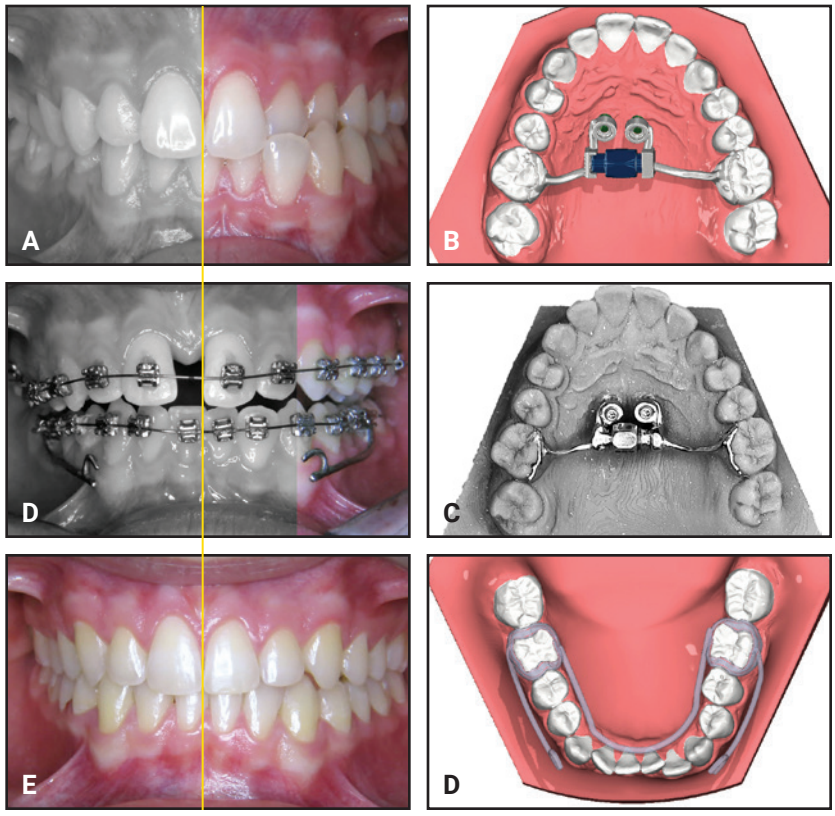

Fig. 4 Treatment of patient shown in Figure 2. A. Before treatment. B. Digital design of Hybrid Hyrax§§§§ MARPE[15,16] (use QR code to download STL file). C. SLM-printed††† Hybrid Hyrax with PowerScrew. D. Digitally designed Tandem Appliance used with Class III elastics. E. After treatment.**

hybrid expanders were published by Garib and colleagues in 2008,[17] Lee and colleagues in 2010,[18] Winsauer and colleagues in 2013,[19] and Moon and colleagues in 2015 (the MSE).[20] Interestingly, because of their fully customized, patient-centered 3D design, the MARPE appliances have gradually become more difficult to differentiate.

Finally, the STL files for the MARPE are sent to a 3D metal-printing service that uses selective laser melting.[1,2] Metal printing enables infinitely customizable CAD/CAM designs to be produced for clinical usage.

The 15-year-old patient shown in Figure 2 was treated with a Hybrid Hyrax and Class III elastics, utilizing a CAD/CAM-produced Tandem Appliance (Fig. 4).[21] Keep in mind, however, that while the digital lab clearly optimizes diagnostic and therapeutic procedures, the technology does not perform the treatment. Only the orthodontic specialist can do that, with the support of CAD/CAM tools and relevant scientific findings.

**PowerScrew, Tiger Dental, Bregenz, Germany; www.tigerdental.com.
§§§§Registered trademark of Dentaurum, Inc., Newtown, PA; www.dentaurum.com.
†††SLM 50, Realizer, DW Lingual Systems GmbH, Bad Essen, Germany; www.lingualsystems.de.

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