Efficient Tooth Movement with New Technologies for Customized Treatment

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Within the next few years, most orthodontists will probably be designing treatment plans and evaluating treatment progress by digital means. Considering the fast pace of technological development, a combination of intraoral scanning, digital setups, custom-made brackets and wires, and indirect bonding may soon become the orthodontic standard. This article reviews recent developments in appliances and technology for digital planning and efficient execution of orthodontic treatment.

Digital Treatment Planning

Traditionally, documentation starts with imaging of the dentition. At Radboud University, we have recently completed a study demonstrating that the accuracy of intraoral scans made with the Lava* C.O.S. device is adequate for orthodontic diagnosis, treatment planning, and appliance fabrication.[1] A majority of the patients in our study indicated a preference for the intraoral scanner compared to both alginate and polyvinyl siloxane (PVS) impressions. The mean times required for the procedures were eight minutes for alginate impressions, 16 minutes for intraoral scanning, and 18 minutes for PVS impressions.

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The scanning technology now commonly used in dentistry has been modified to incorporate the palate as well as the dentition in devices such as OrthoCAD's iOC** and 3M Unitek's Lava. A further advantage of the intraoral scanner is the ability to quickly transmit data over the Internet, so that digital dental models can be used for diagnosis and treatment planning within minutes after the scan has been completed, thus avoiding the need for a separate case-presentation appointment.

Three-dimensional digital treatment planning is gaining acceptance as the technology becomes more user-friendly and integrative. Currently available systems allow the orthodontist to analyze a case, make a digital setup of the dentition, and select custom appliances—aligners or customized brackets and wires. For example, OrthoCAD's digital planning system uses scanned PVS impressions or, in its latest version, records from an iOC intraoral scanner.[2] Digital models (iCasts**) can be used to create treatment setups (Fig. 1), digital bracket placement (iQ**), and indirect bonding trays. Seamless integration between the iOC scanner and the Invisalign*** system now makes it possible to produce a completely digital impression system and model, a virtual dental setup, and indirect bonding trays or aligners from a single scanning procedure.

In the Insignia† system recently introduced by Ormco, PVS impressions are digitized with

*Trademark of 3M Unitek, 2724 S. Peck Road, Monrovia, CA 91016; www.3Munitek.com.

**Trademark of Cadent, 640 Gotham Parkway, Carlstadt, NJ; www.orthocad.com.

***Trademark of Align Technology, Inc., 2560 Orchard Parkway, San Jose, CA 95131; www.invisalign.com.

†Trademark of Ormco, 1717 W. Collins, Orange, CA 92867; www.ormco.com.

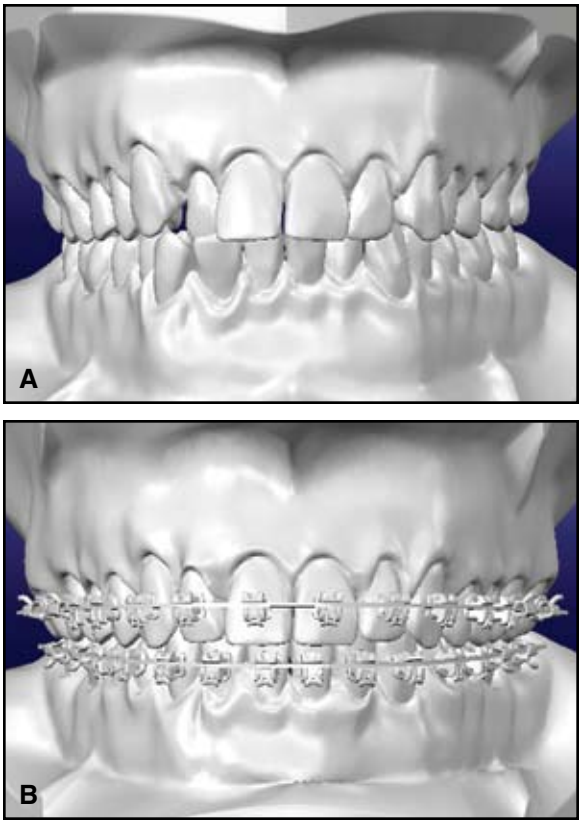

Fig. 1 A. OrthoCAD digital setup. B. Selection of SmartClip* brackets for this patient.**

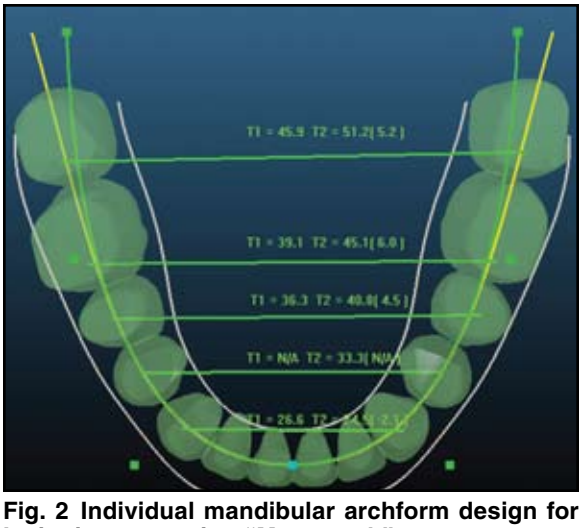

Fig. 2 Individual mandibular archform design for Insignia† case using "Mantrough" system.

computed tomography to produce highly detailed digital models. A unique feature of the Insignia system is the "Mantrough" (mandibular trough),[3] an analysis of the shape and size of the patient's mandibular cortical bone (Fig. 2). The orthodontist adjusts the digital setup using a real-time 3D interface, while referring to the patient's intra- and extraoral photographs and radiographs for consideration of esthetic treatment goals. After the clinician approves the final setup, the customized brackets, tubes, and archwires are fabricated (Fig. 3), and bracket-positioning jigs are provided for accurate indirect transfer (Fig. 4). Because traditional dental setups do not reveal the limits of the alveolar bone, we can expect that the Mantrough

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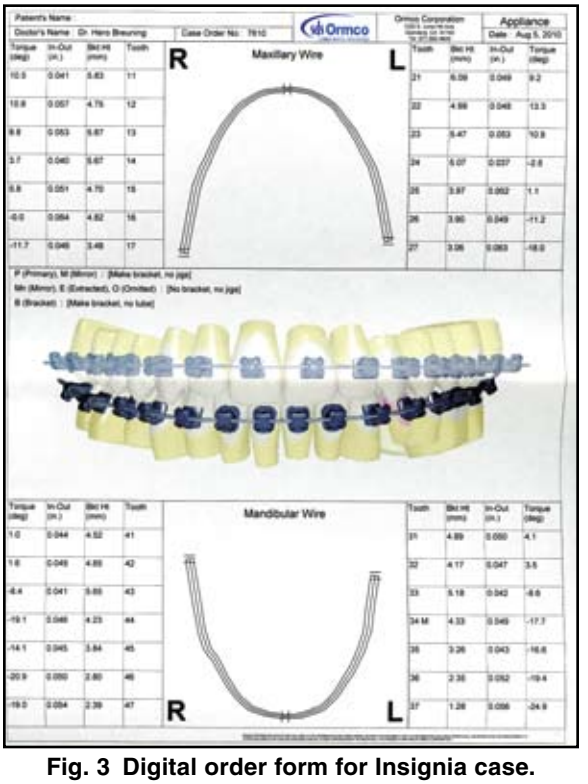

Fig. 3 Digital order form for Insignia case.

will be a major improvement. A clinical trial of the Insignia system is currently under way in our university clinic.

A substantial rise in the popularity of lingual appliances can be expected with the development of integrated systems for digital planning and fabrication of customized lingual brackets and wires. In 3M Unitek's Incognito* system, brackets are printed in wax with a rapid-prototyping machine and then cast in gold.[4] Transfer trays are produced for indirect bonding, and wires are bent using a computer-aided robot (Fig. 5). Accurate indirect bonding and computer-designed and -fabricated wires will be especially beneficial in lingual orthodontics.

In-House Customization

Although customized brackets and archwires seem to be the next step in orthodontics, the efficiency and accuracy of such systems need to be studied in randomized clinical trials. Of course, even if treatment time can be reduced and treatment outcomes improved, customized systems will certainly increase the cost of orthodontic treatment. Ideally, once their performance is validated and their use becomes more widespread, prices will be reduced. In the meantime, orthodontists can begin by using in-house customization of bracket slot size and torque.

The combination of customized slot sizes, as in Gianelly's Bidimensional method—.018" slots for the incisors and .022" slots for the canines, premolars, and molars[5]—and customized torque values for each patient can reduce the need for wire bending, especially in the finishing phase. Although the use of differential torque values for the incisors is becoming more common, variable torque in canine, premolar, and molar brackets can currently be achieved only with customized systems such as Incognito and Insignia. Tooth-by-tooth selection of bracket torque, in contrast to a generic bracket prescription, can reduce round-tripping and the need for wire bending.[6,7] Since most companies already sell brackets with different torque values (Fig. 6), this method is a viable alternative to more expensive customized bracket prescriptions.

Fig. 4 Insignia indirect bracket-placement jigs.

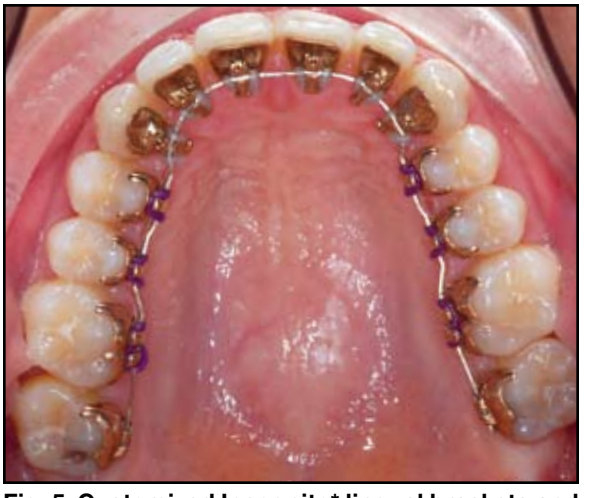

Fig. 5 Customized Incognito* lingual brackets and archwires.

Variable slot sizes, torque values, and ligating systems impact both torque expression and sliding. In a review article, Archambault and colleagues found that the engagement angle (play) in an .018" slot ranges from 31° with an .016" × .016" wire to 4.6° with an .018" × .025" wire.[8] In an .022" slot, the engagement angle ranges from 18° with an .018" × .025" wire to 6° with an .021" × .025" wire. Active self-ligating brackets produce an engagement angle of about 7.5° in an .022" slot with an .019" × .025" wire, whereas passive self-

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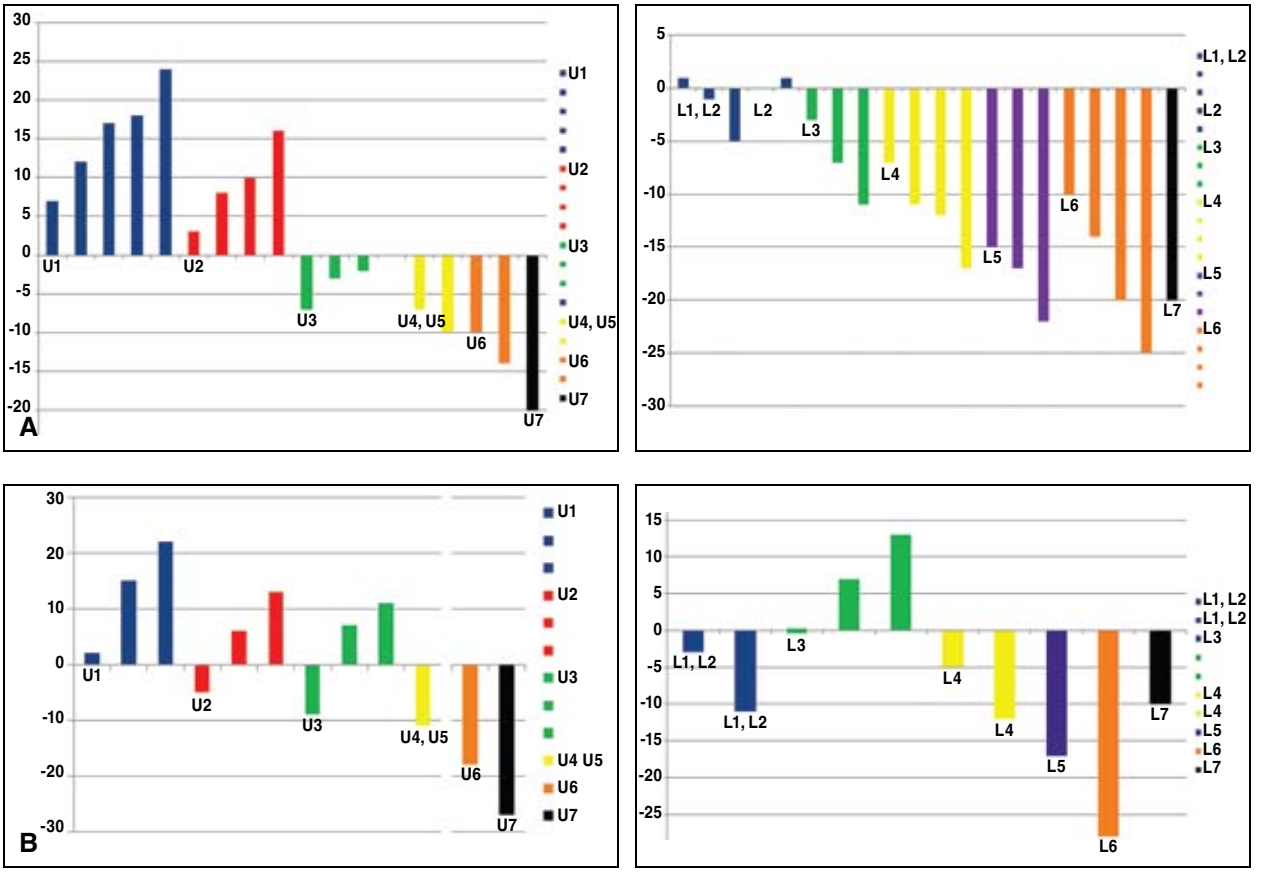

Fig. 6 A. Upper and lower torque values for In-Ovation R‡ self-ligating brackets. B. Upper and lower torque values for Damon Q† self-ligating brackets.

ligating brackets show 14° of play between the same bracket and wire (Fig. 7). Of course, the orthodontist must weigh the benefits of individual bracket selection against the time and expense of maintaining an adequate inventory.

While it is reasonable to expect a reduction in the need for wire bending and in treatment time when brackets with specific slot sizes, torque values, and ligating systems are selected for each case, no studies of the effect of differential torque selection on treatment efficiency have been published.

Indirect Bonding and Efficient Tooth Movement

Indirect bonding has been shown to be more accurate than direct bonding in both lingual and labial applications.[9] Customized bonding bases are essential, however, especially in lingual treatment.[4] Although conventional indirect bonding techniques do not work with digital models, 3D printers can mill or print digital models for fabrication of indirect bonding trays from OrthoCAD and other companies. The efficiency of indirect bonding can be further improved with clear dual transfer trays made from materials such as Emiluma†† transparent silicone. Positioning is more accurate because the dentition is more visible, and bonding

†Trademark of Ormco, 1717 W. Collins, Orange, CA 92867; www.ormco.com.

‡Trademark of GAC International, 355 Knickerbocker Ave., Bohemia, NY 11716; www.gacintl.com.

††Trademark of Ultradent Products, Inc., 505 W. 10200 S., South Jordan, UT 84095; www.ultradent.com.

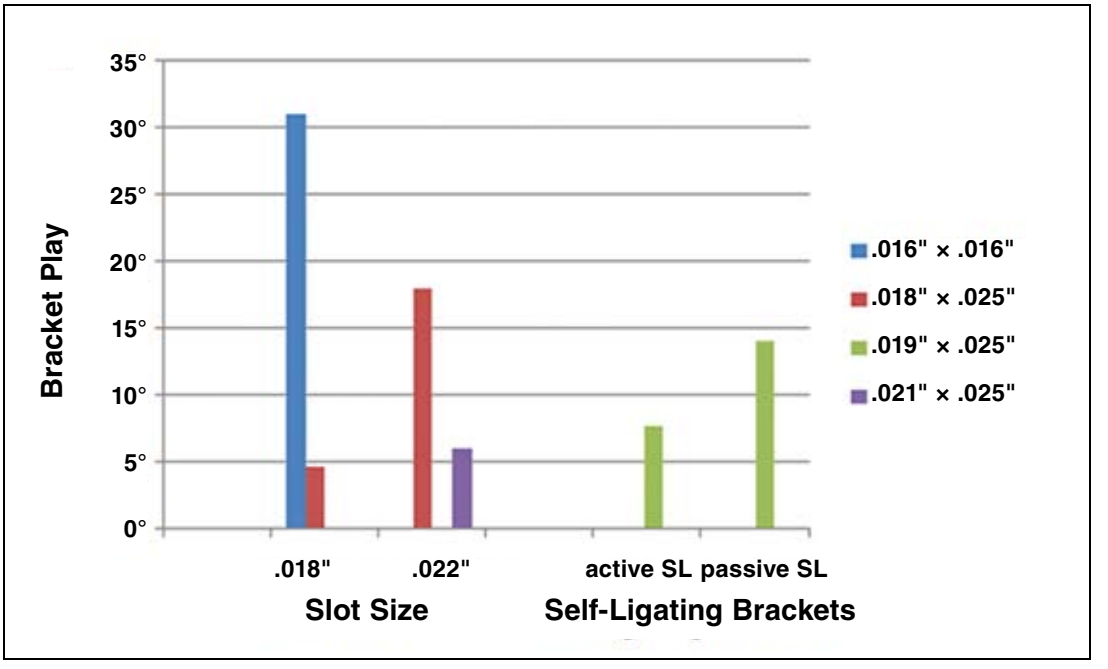

Fig. 7 Degrees of bracket play by slot size and ligation method.

time is reduced with the use of an ultraviolet-light-activated adhesive, making the procedure more comfortable for the patient[10] (Fig. 8).

Archwire dimension and flexibility also have a considerable effect on the correction of individual tooth positions. As discussed in a previous article, starting treatment with full-size superelastic rectangular wires can reduce round-tripping by allowing early torque control.[11] According to Kusy, the difference between trigonometrically measured effective torque and actual torque can be attributed to manufacturing variables such as oversize slots with beveled edges and undersize wires.[12] Ideal finishing with undersize wires is unlikely without wire bending, even if customized bracket torque is applied.

The efficiency of finishing can be improved by using the SureSmile§ system,[13] in which the dentition including the brackets (either labial or lingual) is scanned intraorally during treatment to produce an accurate digital setup of the desired

§Trademark of Orametrix, 2350 Campbell Creek Blvd., Richardson, TX 75082; www.suresmile.com.

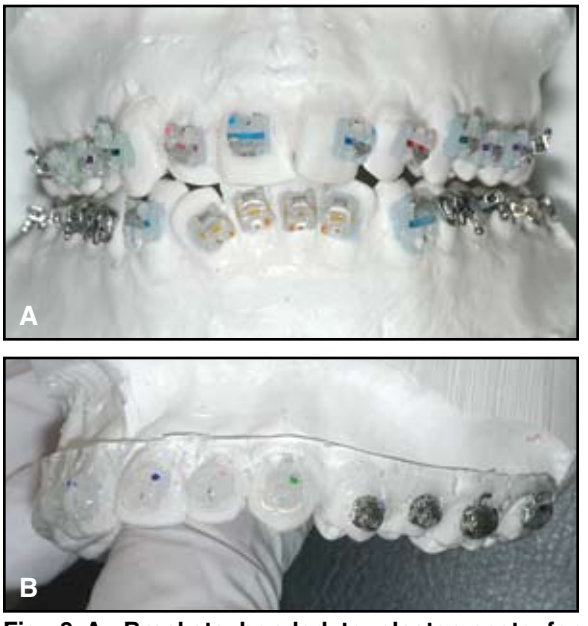

Fig. 8 A. Brackets bonded to plaster casts for fabrication of custom bases, ensuring accurate placement. B. Emiluma translucent silicone bonding tray used for ultraviolet-light-activated indirect bonding.

TABLE 1
FEATURES AVAILABLE IN DIGITAL ORTHODONTIC SYSTEMS

	Intraoral Scanning	Digital Setup	CBCT Setup	Indirect Bonding	Aligners	Custom Brackets	Custom Wires
Incognito				✓		✓ (lingual)	✓
Insignia		✓		✓		✓ (labial)	✓
Invisalign	✓	✓			✓		
OrthoCAD	✓	✓		✓			
SureSmile	✓	✓	✓				✓

treatment result. Finishing wires are then fabricated by a bending robot; digitally designed retention wires can also be ordered. The SureSmile system will soon allow the submission of .STL files from other OraMetrix-approved intraoral and cone-beam computed tomographic scanners (including iCAT§§) and will eventually produce initial archwires as well as finishing wires.

Conclusion

Several companies already offer systems that integrate intraoral scanning, digital setups, and customized brackets and archwires (Table 1). Enhanced treatment efficiency can be expected when these systems are combined with indirect bonding. "In-house customization"—a combination of differential slot sizes and individual torque selection—and robotic bending of finishing wires should also improve the efficiency of treatment and shorten treatment times.

It must be emphasized that the efficacy of these new approaches has not been proven. According to Israel and colleagues, OrthoCAD iQ was no more reliable in positioning brackets in a research setting than traditional indirect bonding techniques.[14] Ideally, all the systems mentioned in this article should be studied in randomized clinical trials.

The impact of these digital systems could be significant, changing the role of the orthodontist from technician to designer. While learning new skills is always challenging, I believe the time and effort needed to master these techniques will be worthwhile.

§§Imaging Sciences International, 1910 N. Penn Road, Hatfield, PA 19440; www.imagingsciences.com.

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