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The Damon Low-Friction Bracket: A Biologically Compatible Straight-Wire System

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For many years, orthodontists have ligated brackets with wire or elastomeric ties. Much of our treatment planning and mechanics have been dictated by a mechanical system incorporating significant amounts of friction. This article will present a nearly friction-free system, using high-tech brackets and wires, and describe its dynamic impact on bone, soft tissue, cellular biology, and muscle physiology.

Why a Nearly Friction-Free Bracket?

As orthodontists moved away from multiloop stainless steel archwires to high-tech continuous wires for starting cases, it became apparent that the friction between conventional brackets and ties was impeding the clinical performance of these new wires. A low-friction, self-ligating twin bracket was needed.

Voudouris measured the friction produced by three types of conventional twin brackets compared to three interactive (self-ligating) twins: one active (Sigma) and two passive (Damon SL Fig. 1] and Wildman TwinLock).1 When .019" X .025" stainless steel wires were drawn through the bracket, a conventional twin ligated with O-rings produced 388 to 609 times the friction of passive self-ligating brackets (Fig. 2). Conventional twins with metal ligatures were found to have friction values more than 300 times those of passive self-ligating brackets. The active self-ligating bracket produced 216 times the friction of a passive self-ligating bracket.

The kind of tooth movement shown in Figure 3 could not be achieved with conventional ties. For space closure, leveling, alignment, and archform development to take place, the wire must slide through the brackets.

Design Criteria for the Damon SL Bracket

The Damon SL bracket was designed to satisfy the following major criteria:

- Andrews Straight-Wire Appliance concept2,3
- Twin configuration
- Slide forming a complete tube
- Passive slide on outside face of bracket
- Brackets opening inferiorly in both arches

I am grateful to the genius of Andrews, whose Straight-Wire Appliance technology has been incorporated into every bracket. The twin configuration was maintained for easy visualization in placement and to allow the use of conventional auxiliaries. Configuring the slide as a complete tube enhances torque control, reduces friction, and keeps a light initial wire from "radiusing" from tie-wing slot to tie-wing slot in an extremely distorted occlusion. Locating the slide on the outside face of the bracket and being able to open both maxillary and mandibular brackets inferiorly are two of the most important features of the appliance. When a mandibular self-ligating bracket opens superiorly, it is difficult to see whether the archwire is seated in the slot.

Active vs. Passive Brackets

Active and passive self-ligation refer to the action of the locking slide or clip on the wire.4 SPEED,5 Sigma, and Time brackets have active clips (Fig. 4A,B). The aim of active ligation is to seat the archwire against the back of the bracket slot for rotation and torque control. Some active clips are active only with larger archwire sizes; in their passive state, however, they decrease the lumen of the slot. The smaller the lumen of the archwire slot, the greater the friction when using a light wire in a distorted occlusion. Friction is also greater with sliding mechanics when a larger working wire is used and the archwire is actively seated to the base of the slot, because the flat surface of the rectangular wire contacts the flat surface of the slot base.

Damon SL, EdgeLok, and Wildman TwinLock are self-locking brackets with passive slides. When the slide is closed, the lumen of the slot is full-size (Fig. 4C). Rotations are expressed by using high-tech flexible wires to nearly fill the slot in a labiolingual or buccolingual direction. I prefer to use no larger than an .019" X .025" archwire in an .022" X .028" slot. Encroaching on this .03" tolerance from the wire to the back of the slot increases frictional forces. To maintain rotational control, the bracket must measure approximately .1" from the edge of the slide to the opposing edge of the slot (slot depth). If this dimension is less than .1", the wire size must be increased to maintain control, which increases the friction and the force loads expressed on the teeth.

Archwire changes and appointment intervals are timed to allow uninterrupted vascular supply to the periodontal ligament and surrounding bone. In using sliding mechanics to close space, the intention is not to actively seat the edgewise wire against the base of the slot. Friction is reduced by moving teeth on the corners or edges of rectangular wires rather than on their flat surfaces. Torque is expressed by the edges of the wire against the superior and inferior walls of the contained archwire slot (Fig. 4C). To help achieve the desired torque control, various bracket torques are selected for the anterior teeth prior to bonding.

In active self-ligation, the energy to control rotations is primarily derived from the clip6; in passive self-ligation, the energy is stored and expressed in the high-tech wires. The thrust of the Damon SL system is to minimize friction at all stages of treatment.

Biocompatible Mechanics

Orthodontists often think in terms of "getting in" the largest archwire the patient can possibly tolerate. Large-dimension, high-tech wires are often placed at the bonding appointment and retied until the teeth are leveled and aligned. Thus, the archwire sequence is based on a bracket and ligature system with significant amounts of friction. These wires can overpower the friction in the system, but, I feel, with far greater patient discomfort and longer treatment times than if patients are started with small-dimension, high-tech archwires in a nearly friction-free bracket system.

Starting cases with .014" superelastic nickel titanium or occasionally .012" superelastic nickel titanium wires produces a response I have never seen before. Leveling and alignment occur in much less time, with no apparent harmful effects on roots, bone, or tissue. I've had far fewer complaints from patients about discomfort from tooth movement.

In conventional treatment, if high maxillary cuspids are engaged, the normal response is for the adjacent teeth to move superiorly in response to the cuspids moving inferiorly. With low-friction mechanics, cuspids erupt without adversely affecting the adjacent teeth (Fig. 5).

Headfilms and intraoral photographs clearly show that the lip musculature is not overpowered by the light archwires. The orbicularis oris and mentalis muscles produce a "lip-bumper" effect on the maxillary and mandibular incisors. Figure 6 shows alignment of an extraction case without any retracting forces applied to the cuspids. The teeth take the path of least resistance, which is to move into the extraction sites. In nonextraction cases (Fig. 7), light-force mechanics with .014" superelastic nickel titanium wires produce posterior expansion (Fig. 7B,C). The composite headfilms (Fig. 7D,E) show that the incisors maintain their anteroposterior positions.

Many clinicians are guilty of making clinical decisions based primarily on mechanics, without giving sufficient consideration to biological principles. How many times have we all applied greater force when teeth do not move as desired? Even though the above responses are dramatic, they are not surprising when you review the literature on the complex cellular biology of tooth movement.

Cellular Biology

Proffit proposed that the optimum force levels for orthodontic tooth movement would be just high enough to stimulate cellular activity without completely occluding blood vessels in the PDL.7 If a force is great enough to occlude the blood vessels and cut off the blood supply, a hyalinized, avascular area is formed that must revascularize before teeth can move. Pain is related to the development of ischemic areas in the PDL.

Although the mechanism of tooth movement is not completely understood, the role of vascular supply is prominent in the literature. Tuncay suggested that oxygen is the trigger mechanism in the periodontium.8 According to Proffit, if vascularity is critical to tooth movement, there is no doubt that light, continuous forces produce the most efficient tooth movement and that heavy forces should be avoided.7 Rygh recommended light, continuous forces for more effective tooth movement in areas with cortical bone or bone with few marrow spaces.9

Proffit noted that "root remodeling is a constant feature of orthodontic tooth movement, but that permanent loss of root structure occurs only if repair does not replace the initially resorbed cementum. Activating an appliance too frequently, short-circuiting the repair process, can produce damage to the teeth or bone that a longer appointment cycle would have prevented or at least minimized. If the appliance is springy and light forces produce continuous frontal resorption, there is no need for further activation."7

Warita compared the application of a light, continuous force (5g/f) vs. a light, dissipating force (10g/f) for 39 days on rat molars. He found 1.8 times greater tooth movement with the light, continuous force. "Histological observation showed that the PDL applied with light continuous force tended to be more physiologically preserved than that applied with light dissipating force."10

I believe it's time to explore new treatment possibilities with the new technologies we now have available. It is surprising how little of our clinical treatment mechanics are based on the known cellular biology of tooth movement. Clearly, the use of light, continuous forces and appropriate appointment timing can dramatically enhance patient comfort and shorten treatment.

Archwire Sequencing

After the Damon SL bracket was developed, much time and effort were spent clinically to determine the archwire sequences that work best in this nearly friction-free system (Table 1). Other favorite wire sequences can be used, but self-ligation adds a dimension to archwire selection that must be carefully considered.

The archwire system should apply a low, continuous force that permits teeth to move in accordance with the biological principles previously discussed. Therefore, the first archwire, .014" superelastic nickel titanium (.012" superelastic nickel titanium in severe cases), is flexible enough to fully engage in the closed bracket without restricting the sliding of the teeth along the archwire. I have found a high degree of archwire play in the slot to be desirable. Although a large-dimension, highly flexible rectangular high-tech wire could be placed, the forces generated by wires larger than .014" superelastic nickel titanium limit the advantages of the system. These rectangular flexible wires actually increase friction and patient discomfort while slowing tooth movement.

The second archwires, .016" X .025" superelastic nickel titanium for .022" brackets and .014" X .025" superelastic nickel titanium for .018" brackets, are used to complete leveling, eliminate rotations, further archform development, and initiate torque control. The nearly friction-free system greatly facilitates leveling and preparation of the arch for the final stainless steel archwires. The .025" dimension of the rectangular second wire nearly fills the depth of the slot for rotation alignment. Careful attention should be paid to bracket positioning after this archwire has been in place for one appointment interval.2,3,11 Brackets should be repositioned as necessary to take full advantage of the Straight-Wire system for the remainder of treatment.

The third and last archwire, an .019" X .025" (.022" slot) or .016" X .025" (.018" slot) Tru-Arch Pre-Posted stainless steel wire (Fig. 8A), completes torque and archform, controls the vertical dimension during major mechanics, and finishes the case. It is critical that the high-tech wire be of the same or greater dimension labiolingually or buccolingually as the finishing wire. If the high-tech wire is allowed to completely express its function, the stainless steel working and finishing archwire is nearly passive when fully engaged—a boon for patient comfort.

Archwires with prewelded hooks are available in multiple sizes. The hooks are used for attachment of elastics, springs (Fig. 8B), and elastic module tiebacks (Fig. 8C). A medium-size (9mm or 12mm), low-continuous-force nickel titanium spring is hooked from the end of the archwire to the archwire hook, which is best placed just anterior to the cuspid bracket (Fig. 8B).

Space closure and major mechanics should be accomplished prior to engaging the second molars, except in maximum-anchorage cases. This facilitates sliding mechanics for space closure (Fig. 9) and enhances control of posterior arch width. There is less buccolingual control as archwire length increases from the anterior radius of the archwire to the second molar area.

In the past, clinicians have expressed difficulty in finishing cases with self-ligating appliances. Today, finishing is simplified by totally capturing the archwire within the slot, allowing full expression of the edgewise appliance (Fig. 10A,B, 10C). In looking at conventional elastomeric and wire ligatures under five-power magnification, I found far less rotational and torque control. Torque is always fully expressed in the Damon SL, since the continuous slot forms a complete tube. The archwire must be completely engaged, or the slide will not close. Because of the precision of the appliance, finishing times have been greatly reduced.

Adult Treatment

Most orthodontists will agree that with conventional brackets and wires, treating adults takes longer than treating children. New technology has dramatically narrowed the gap in treatment time. Could it be a result of increased vascular supply to the PDL and surrounding bone?

Children have a far greater capacity for reestablishing blood supply in an ischemic area. Rygh recommended that light, continuous forces be used in adults.9 Could it be that low-force mechanics do not interrupt the vascular supply in either children or adults, leveling the playing field of tooth movement? Further research is obviously needed in this exciting area.

Conclusion

The impact of today's new technology can be summarized as follows:

- 1. Improves the quality of treatment due to greater control.
- 2. Improves patient comfort during tooth movement.
- 3. Shortens treatment time for most cases.
- a. Aligns teeth faster.
- b. Saves time with sliding mechanics.
- c. Requires less time for finishing.
- 4. Reduces the number of office visits per patient.
- 5. Shortens chairtime for each visit.
- 6. Expands treatment planning options.
- 7. Simplifies treatment mechanics.
- 8. Makes it easier to keep appliances clean.
- 9. Improves the work environment for staff.
- 10. Improves practice efficiency and profitability.
- 11. Attracts a larger segment of the population (more adults).

The Damon SL system provides nearly friction-free mechanics with high-tech brackets and wires. It appears to have a dynamic impact on cellular biology and on bone, tissue, and muscle physiology. The challenge for orthodontists is to reevaluate their clinical procedures to take maximum advantage of this new technology.

FIGURES

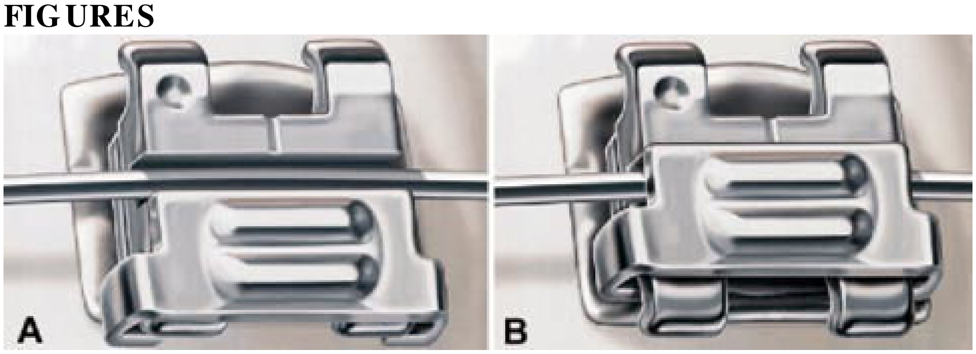

Fig. 1 Damon SL bracket. A. Open. B. Closed.

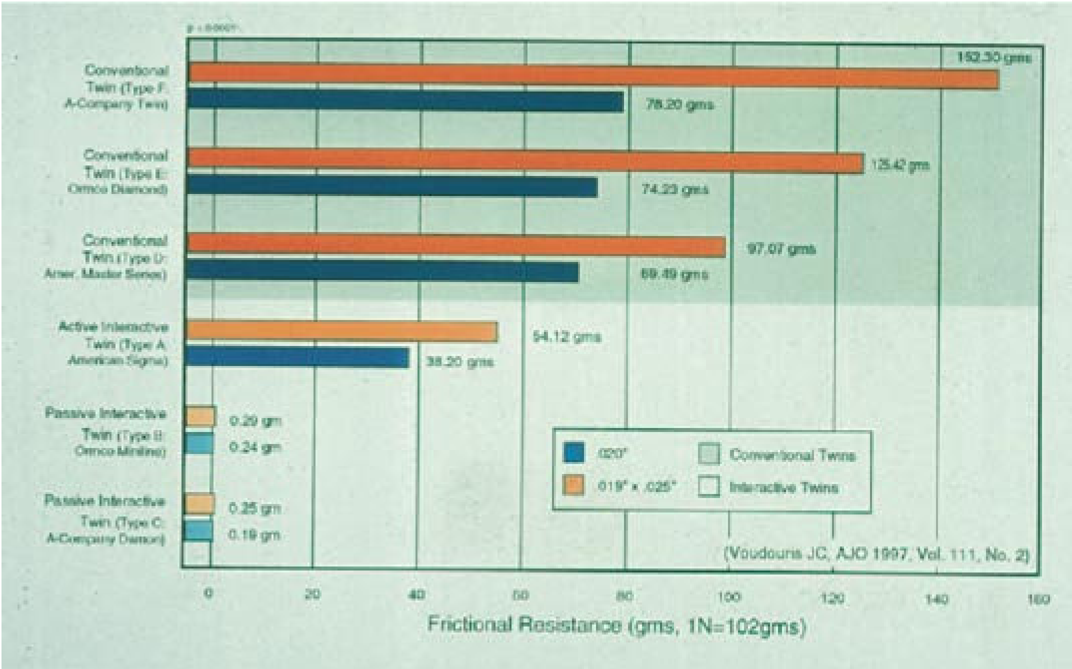

Fig. 2 Friction resistance levels of passive and active self-ligating brackets and conventional twin brackets with .020" and .019" × .025" stainless steel archwires at 0° angulation (reprinted by permission – Ref. 1).

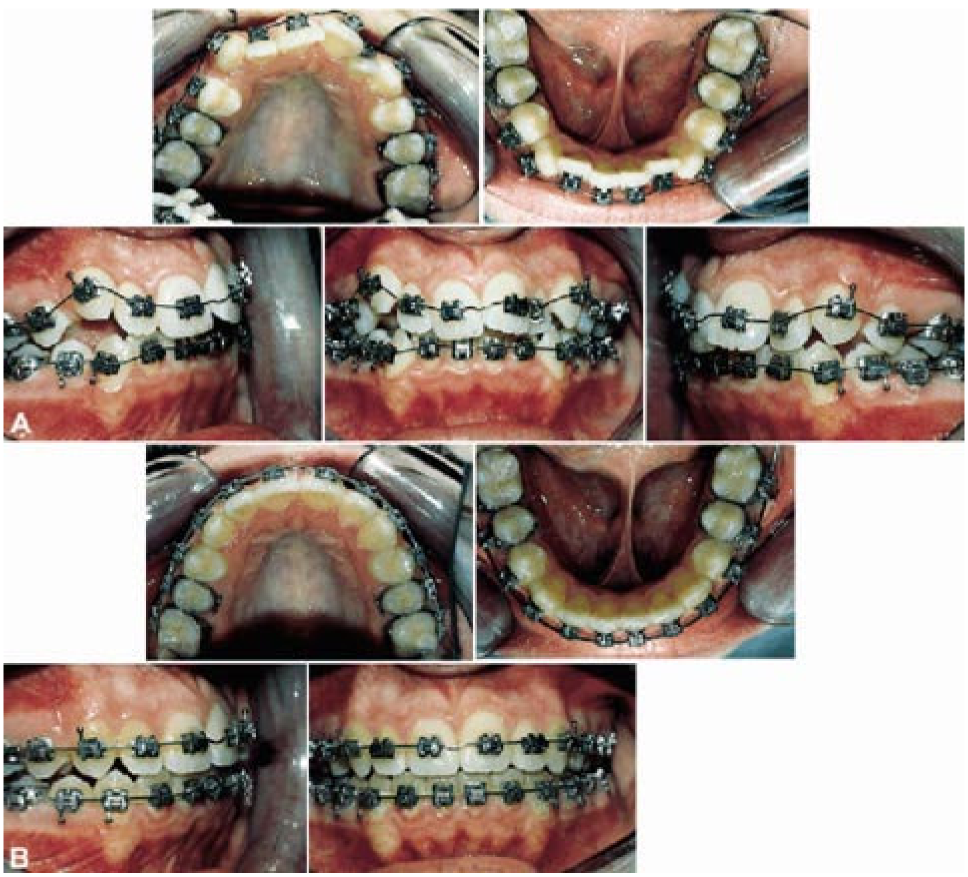

Fig. 3 A. Initial appliance: .022" Damon SL brackets with .014" superelastic nickel titanium wires in both arches. At first return visit, .016" × .025" superelastic nickel titanium archwires were placed. B. Second visit, after four months and two weeks of treatment.

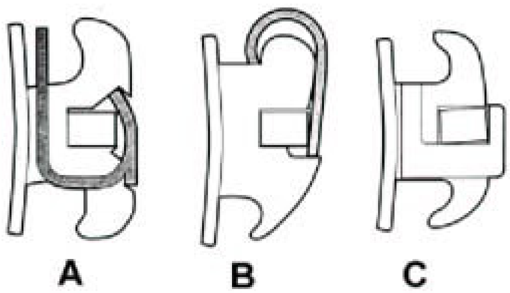

Fig. 4 Sigma (A) and Time (B) brackets have active arms that seat larger archwires into bases of bracket slots. Damon SL (C) has passive slide that does not totally seat archwire into base of archwire slot, facilitating sliding mechanics.

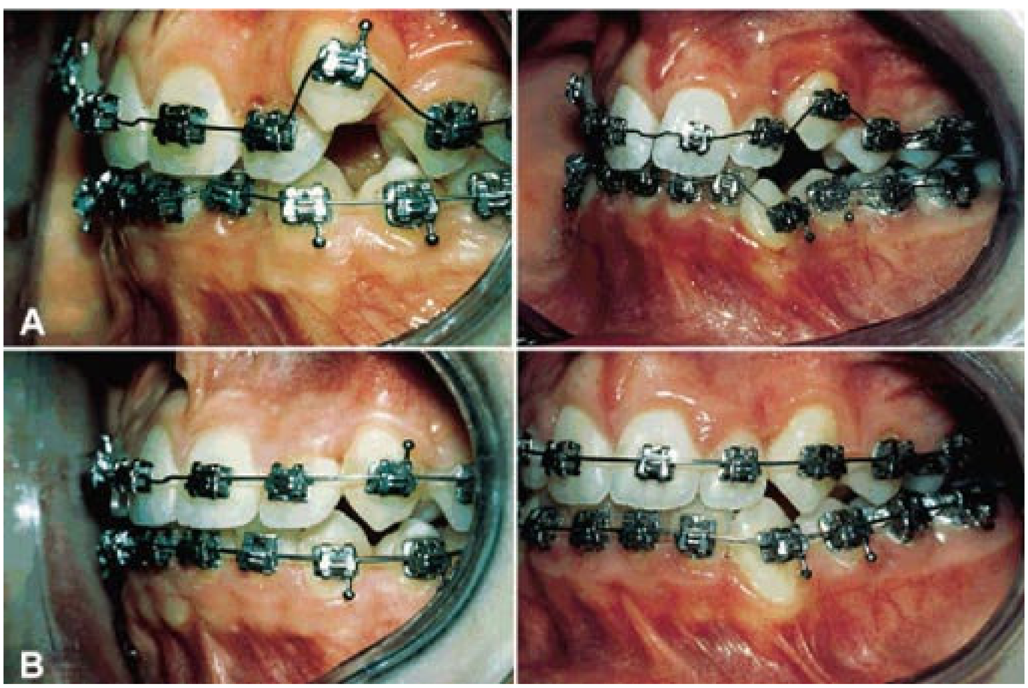

Fig. 5 A. Cases started with .014" superelastic nickel titanium wires in .022" slots. B. Second appointment, 10 weeks into treatment. Note cuspid eruption without lateral or bicuspid intrusion.

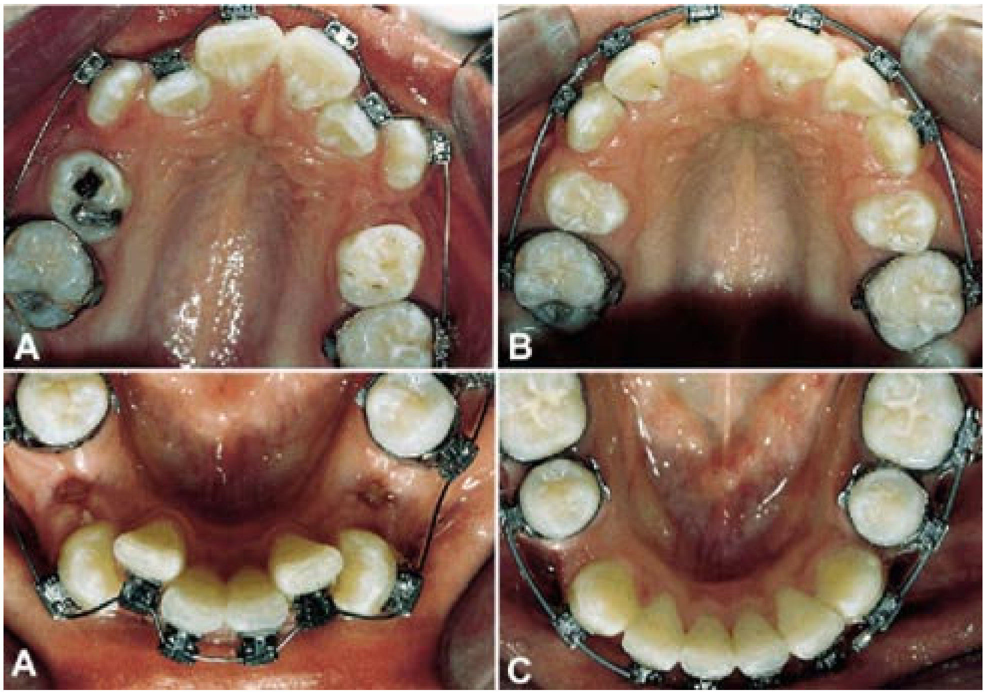

Fig. 6 A. Extraction case at beginning of treatment. B. Third appointment, four months into treatment. C. Fourth appointment, six months and one week into treatment. Note that with light-force, low-friction mechanics, crowding is relieved by teeth moving into extraction sites with only muscle support from orbicularis oris and mentalis. No additional retracting forces were applied.

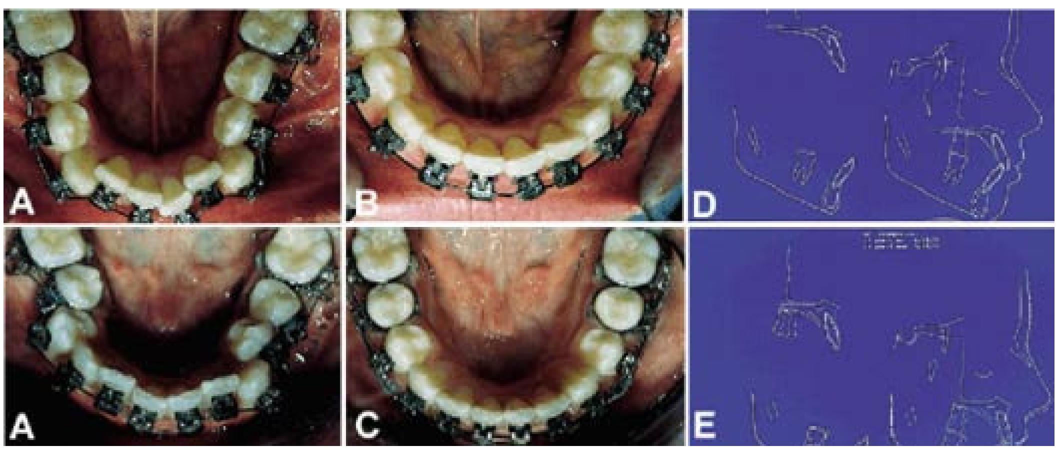

Fig. 7 A. Nonextraction cases at beginning of treatment. B. .014" superelastic nickel titanium wire at second appointment, five months into treatment. C. Third appointment, six months and two weeks into treatment. Note that with light-force mechanics, teeth and archform take path of least resistance (posterior expansion). Composite tracings after 10 months (D) and 13 months (E) show minimal labial movement of incisors.

Fig. 8 A. Pre-Posted .019" X .025" stainless steel archwires. B. Space closure using medium-size nickel titanium springs. C. Elastic module tiebacks used after space closure.

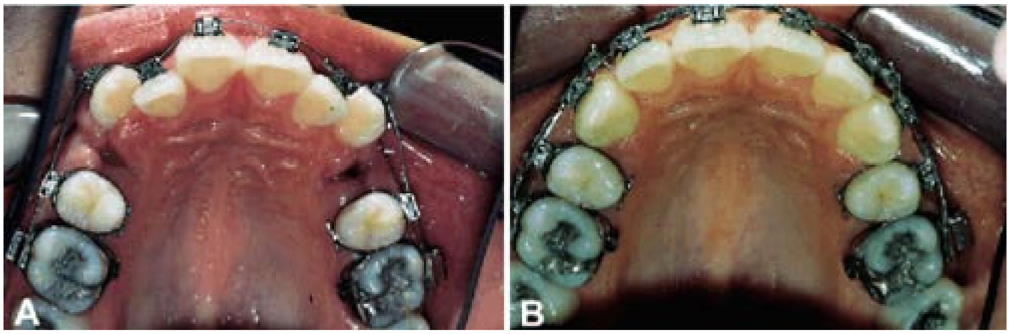

Fig. 9 Adult treatment. A. Initial .014" superelastic nickel titanium archwire. B. Space closed by fourth appointment after bonding, nine months and one week into treatment. Note control of archform and tooth position.

Fig. 10AB Control in finishing adult treatment. A. Before treatment. B. Fifth appointment after bonding, 12 months into treatment.

Fig. 10C After 14 months and two weeks of treatment (total of eight appointments).

TABLES

TABLE 1
ARCHWIRE SEQUENCING

.018" Slot	.022" Slot	Function
.014" or .012" SE NiTi	.014" or .012" SE NiTi	Start tooth movement, level, align (minimal friction)
.014" × .025" SE NiTi	.016" × .025" SE NiTi or .014" × .025" SE NiTi	Complete leveling of rotations, archform; start torque
.016" × .025" Pre-Posted SS	.019" × .025" Pre-Posted SS	Complete torque, archform; control vertical under major mechanics; finishing

Table. 1

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11 McLaughlin, R.P. and Bennett, J.C.: Bracket placement with the preadjusted appliance, J. Clin. Orthod. 29:302-311, 1995.

FOOTNOTES

1 Sigma: American Orthodontics, 1714 Cambridge Ave., Sheboygan, WI 53082.

2 Andrews Straight-Wire, Damon SL, Wildman TwinLock, EdgeLok, Tru-Arch Pre-Posted: Trademarks of Ormco/"A" Company, 1717 W. Collins Ave., Orange, CA 92867.

3 SPEED: Strite Industries Ltd., 298 Shepherd Ave., Cambridge, Ontario, N3C 1V1 Canada.

4 TIME: Registered trademark of Adenta GmbH, P.O. Box 82199, Gutenbergstr. 9, D-82205 Gilching/Munich, Germany. Distributed by American Orthodontics.