Self-Ligation in the Year 2000

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The first self-ligating bracket, the Russell attachment, was developed by a New York orthodontic pioneer, Dr. Jacob Stolzenberg, in the early 1930s.[1] This bracket had a flat-head screw seated snugly in a circular, threaded opening in the face of the bracket (Fig. 1). For the orthodontist, archwire changes were quick and simple. The horizontal screw could be loosened or tightened with a small watch-repair screwdriver to obtain the desired tooth movement. Loosening allowed bodily translation on a round wire, while tightening facilitated root torquing with a rectangular or square wire.

The mechanism of this revolutionary bracket was in stark contrast to the traditional approach of tying steel ligatures tightly around each bracket. And for those patients of Dr. Stolzenberg's who were fortunate enough to receive the Russell brackets, treatment was considerably more comfortable, with shorter office visits and shorter overall treatment time.[2] Perhaps because Dr. Stolzenberg was ahead of his time, the concept of self-ligating brackets fell more or less into obscurity until the early 1970s.

In 1971, Dr. Jim Wildman of Eugene, Oregon, developed the Edgelok* bracket, which had a round body with a rigid labial sliding cap[3] (Fig. 2). A special opening tool was used to move the slide occlusally for archwire insertion. When the cap was closed over the archwire with finger pressure, the bracket slot was converted to a tube. The rigidity of this outer fourth wall rendered the bracket "passive" in its interplay with the archwire.

Passive brackets are inherently imprecise in their ability to control tooth movements because of their total reliance on the fit between the archwire and the bracket slot. This means that tooth control is compromised when undersize wires are used, although nickel titanium wires can be more accurate than stainless steel. The Edgelok was the first passive self-ligating bracket, and the first to enjoy any sort of commercial success.

A similar bracket, designed by Dr. Franz Sander of Ulm, Germany, was introduced two years later.[4] The Mobil-lock** (Fig. 3) required a

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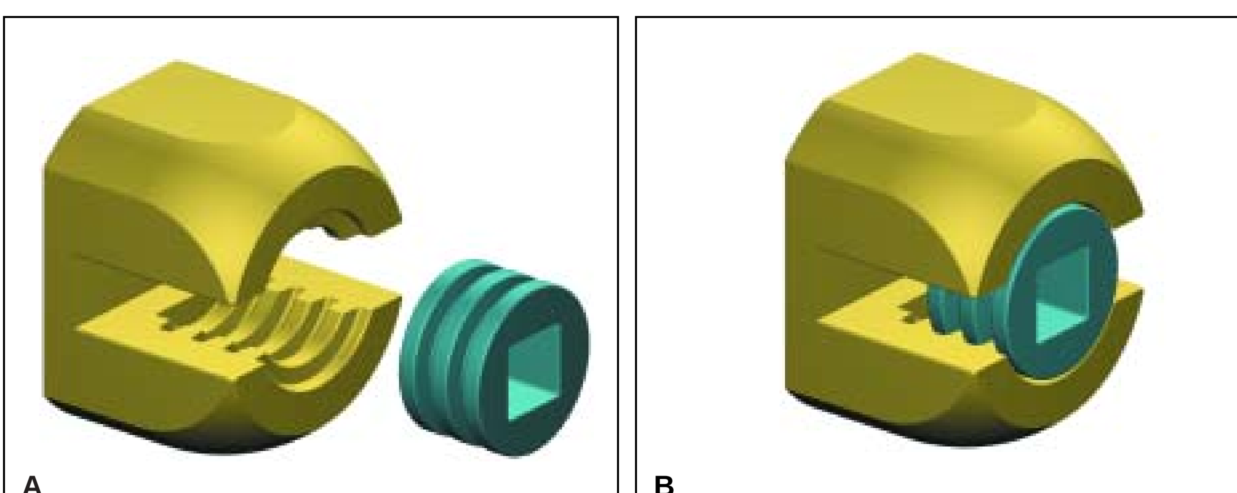

Fig. 1 Russell attachment in open (A) and closed (B) positions.

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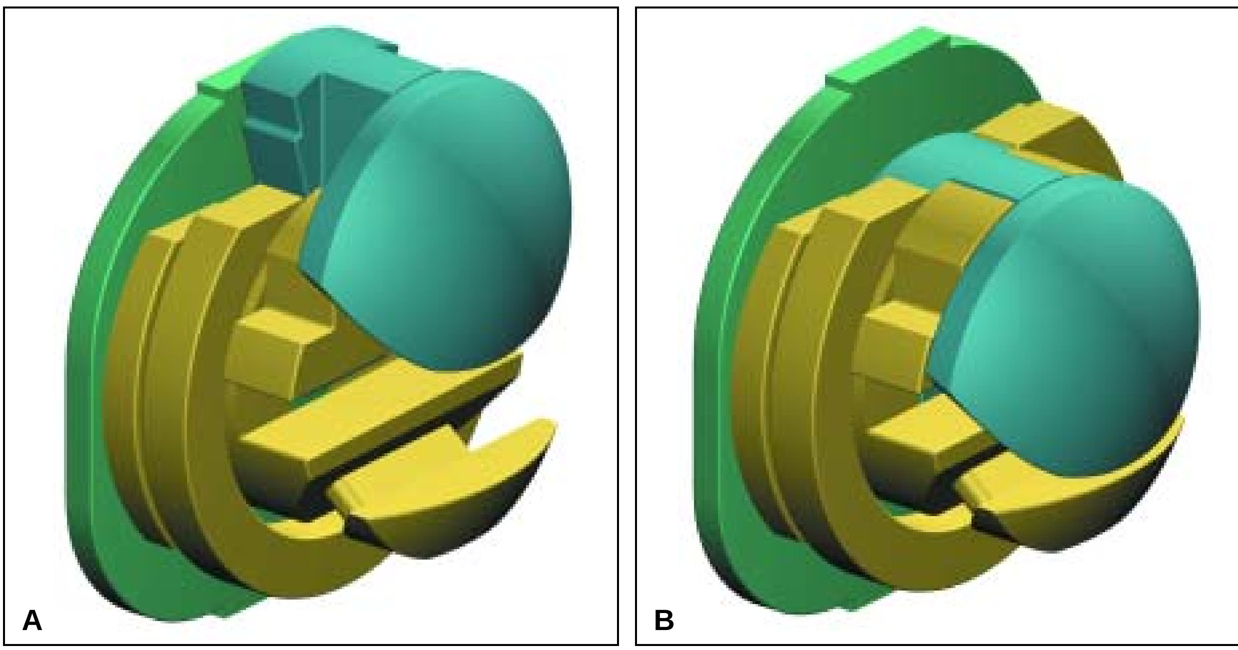

Fig. 2 Edgelok bracket in open (A) and closed (B) positions.

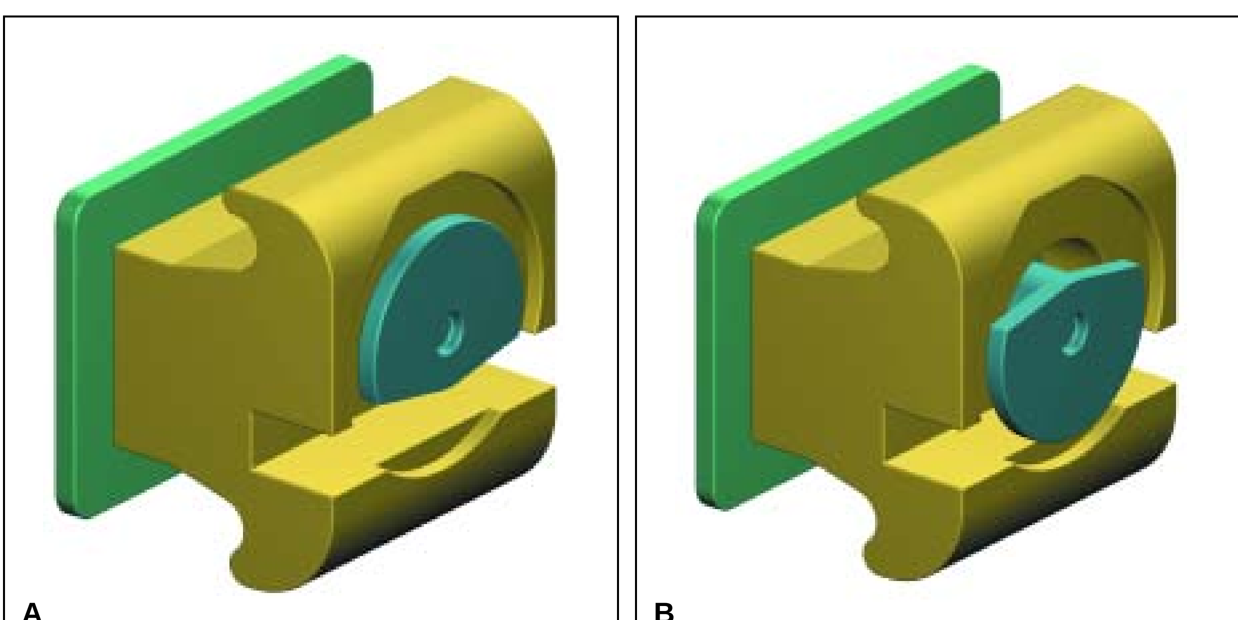

Fig. 3 Mobil-lock bracket in open (A) and closed (B) positions.

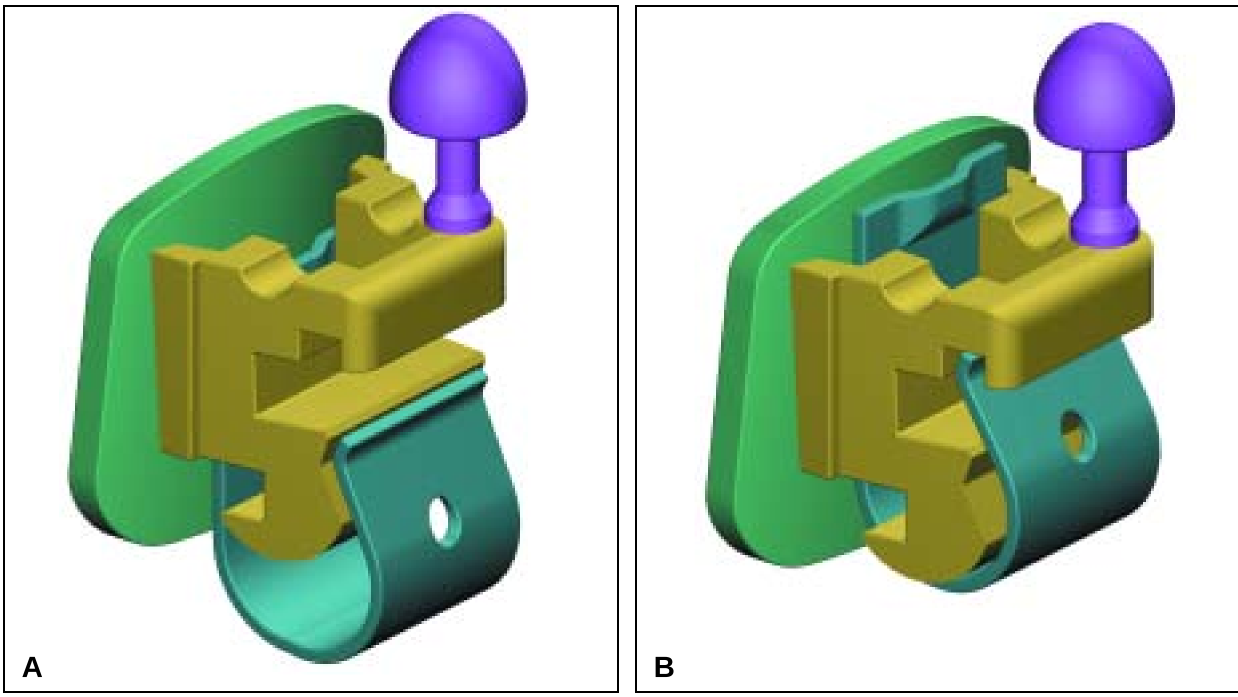

Fig. 4 SPEED bracket in open (A) and closed (B) positions.

special tool to rotate the semicircular labial disk into the open or closed position. As with the Edgelok, the passive outer wall transformed the bracket slot into a tube that loosely contained the archwire. Perhaps because of the simultaneous introduction of elastomeric ligatures, however, neither the Edgelok nor the Mobil-lock gained much of a following.[5]

At about the same time, Dr. Herbert Hanson of Hamilton, Ontario, was creating prototypes of a self-ligating bracket that by 1976 became the basic SPEED*** design. After four more years of design refinement and clinical trials, the bracket was introduced on the market in 1980.[6] Further modifications have since enhanced the basic design,[7] and the commercial success of the SPEED appliance has rekindled orthodontists' interest in self-ligation.

The SPEED bracket features a curved, flexible "Super-Elastic Spring Clip" that wraps occlusogingivally around a miniaturized bracket body (Fig. 4). The clip is moved occlusally–using either a universal scaler at the gingival aspect of the bracket body or a curved explorer inserted into the labial window—to permit archwire placement, then seated gingivally with finger pressure. The labial arm of the Spring Clip, which forms the flexible fourth wall of the bracket slot, not only constrains the archwire, but interacts with the archwire. This sets the SPEED system apart from all other currently available self-ligating brackets as the only "active" design (Table 1).

The Spring Clip, through elastic deflection, gently imparts a light, continuous level of force on the archwire, resulting in precise and controlled tooth movement. Hanson describes this as the "homing action of the spring"—the ability of the SPEED bracket to reorient itself three-dimensionally until the archwire is fully seated in the slot. Any subsequent rotation, tipping, or

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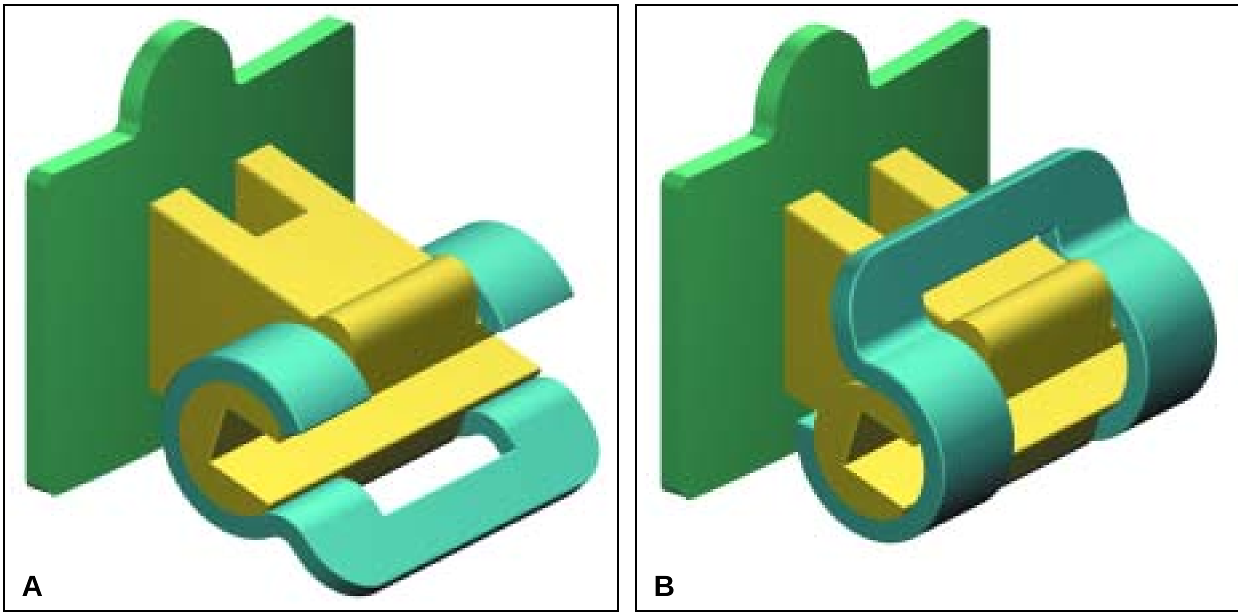

Fig. 5 Activa bracket in open (A) and closed (B) positions.

TABLE 1
CURRENTLY AVAILABLE SELF-LIGATING BRACKETS

Name	Mode of Action	Moving Component	Brackets Available
Damon SL I & II	Passive	Solid indented sliding cover	Mx/Md 5-5
SPEED	Active	Highly flexible Spring Clip	Mx/Md 7-7
Time	Passive	Rigid arm	Mx/Md 5-5
TwinLock	Passive	Solid labial slider	Mx/Md 5-5

torquing, during tooth movement of any kind, results in a labial deflection of the spring that reactivates this homing behavior.

In 1986, the self-ligating Activa* bracket (Fig. 5), designed by Dr. Erwin Pletcher, offered another alternative. The Activa bracket had an inflexible, curved arm that rotated occlusogingivally around the cylindrical bracket body. The arm could be moved into a "slot-open" or "slot-closed" position with finger pressure alone; once closed, the rigid outer wall of the movable arm converted the bracket slot into a tube. As with the Edgelok bracket, the passive configuration of the Activa bracket limited its interplay with the archwire. Drawbacks such as the ease with which patients could open the bracket and a large mesiodistal bracket width eventually led to its commercial demise.

In 1995, another self-ligating model entered the marketplace. Designed by Dr. Wolfgang Heiser of Innsbruck, Austria, the Time† bracket is similar in appearance to the SPEED

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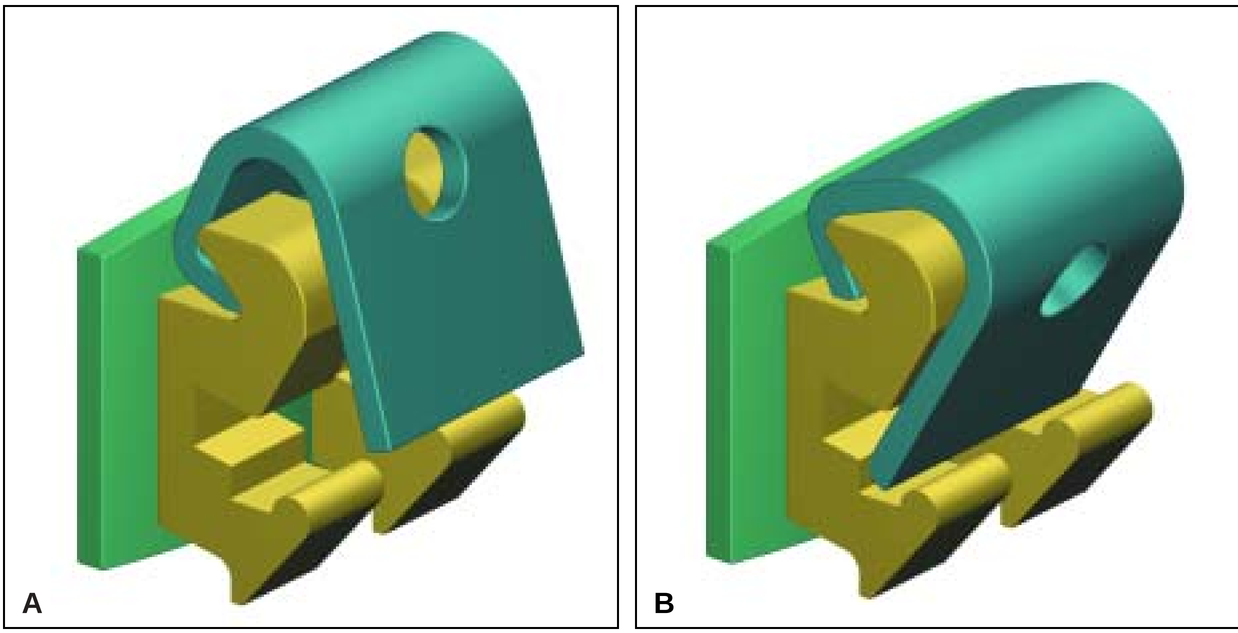

Fig. 6 Time bracket in open (A) and closed (B) positions.

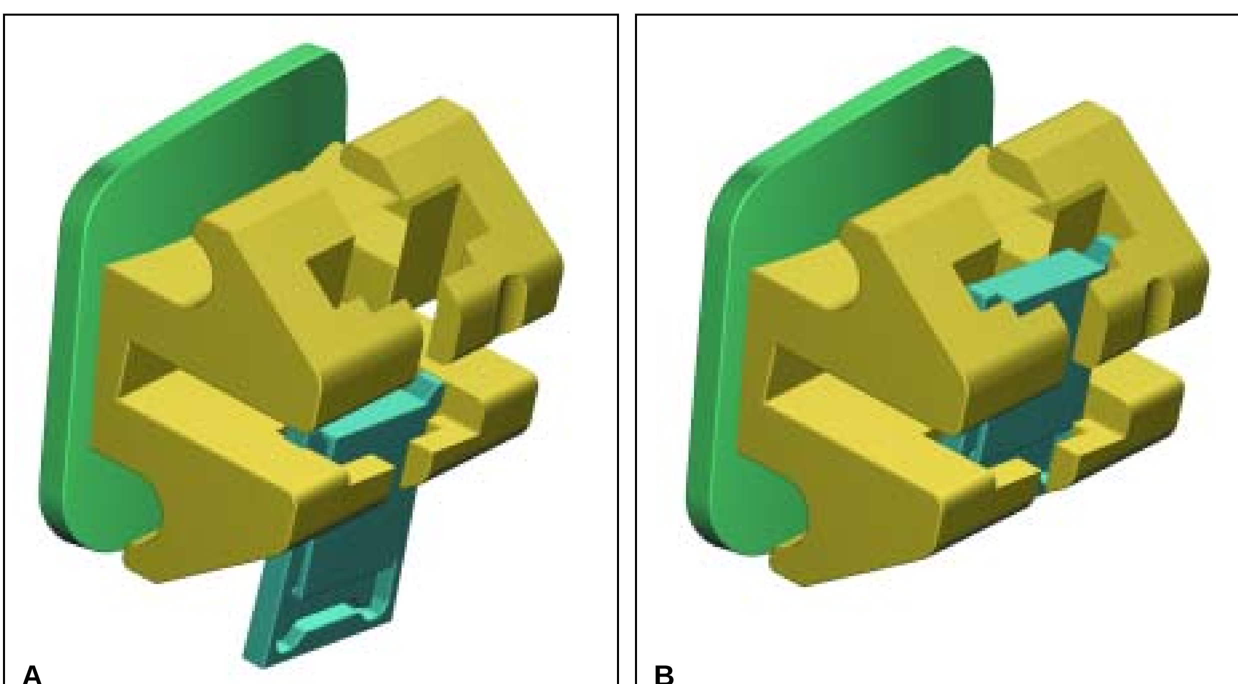

Fig. 7 TwinLock bracket in open (A) and closed (B) positions.

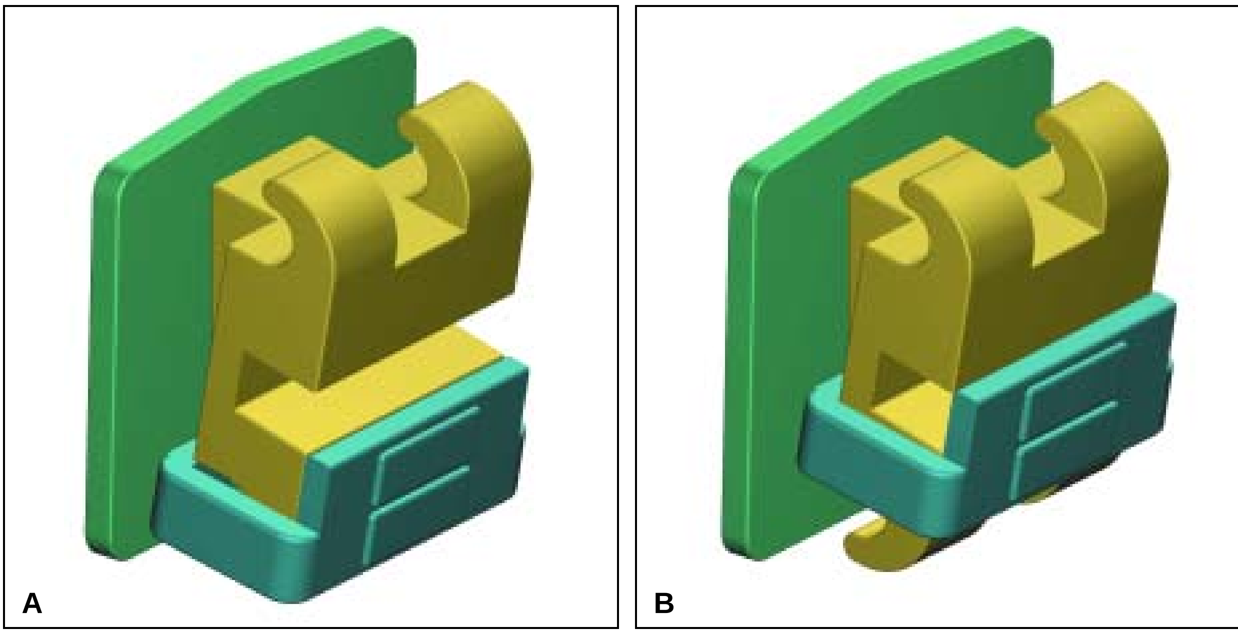

Fig. 8 Damon SL I bracket in open (A) and closed (B) positions.

bracket (Fig. 6), but its design and mode of action are significantly different.[8] About the size of a conventional bracket, the Time features a rigid, curved arm that wraps occlusogingivally around the labial aspect of the bracket body. A special instrument is used to pivot the arm gingivally into the slot-open position or occlusally into the slot-closed position. The stiffness of the bracket arm prevents any substantial interaction with the archwire, thereby rendering Time a passive bracket.

The TwinLock* bracket (Fig. 7), a second endeavor by Dr. Jim Wildman, was introduced in 1998.[9] Its flat, rectangular slide, housed between the tie wings of an edgewise twin bracket, is moved occlusally into the slot-open position with a universal scaler. It then slides gingivally with finger pressure to entrap the archwire in a passive configuration.

Similar self-ligating bracket designs were introduced in 1996[10] and 1999 by Dr. Dwight Damon of Spokane, Washington. The Damon SL I* (Fig. 8) and the Damon SL II* are both edgewise twin brackets; the difference between these two generations is that the first featured a labial cover that straddled the tie wings, while the second incorporates a flat, rectangular slide between the tie wings. In both versions, the slide moves incisally on the maxillary brackets and gingivally on the mandibular brackets. Special opening and closing pliers are required to move the slide. Both the Damon SL I and the Damon SL II form rectangular edgewise tubes by means of a solid outer wall.

Advantages of Self-Ligating Brackets

Each inventor of self-ligating brackets has found that they allow greater patient comfort, shorter treatment time, reduced chairtime, and more precise control of tooth translation[2,5,9-11] (Table 2).

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TABLE 2
COMPARISON OF SELF-LIGATED AND CONVENTIONALLY LIGATED BRACKETS

	Self-Ligated	Conventionally Ligated
Esthetics	Some designs permit significant miniaturization	Limited miniaturization
Force Level	Permits use of lighter forces	Requires heavier force levels
Force Delivery	Light initial force	High initial force
Friction	Predictable, very low	Stainless steel: High Elastomeric: Very high
Infection Control	Significantly reduced risk of percutaneous injury	Increased risk of percutaneous injury
Instrumentation	Fewer instruments required during archwire changes	Many instruments required during archwire changes
Ligation	Movable, integral component creates outer fourth wall	Stainless steel or elastomeric ligatures
Ligation Stability	Retains original form throughout treatment	Loses initial shape and tightness
Office Visits	Shorter, less frequent visits	Longer, more frequent visits
Oral Hygiene	Wingless designs easy to clean	Difficult to clean—food traps
Patient Comfort	Only slight discomfort with wire changes	Teeth usually sore after ligation
Sliding Mechanics	Ideally suited for efficient tooth translation	Slow due to binding of archwire
Treatment Time	Overall treatment reduced by about four months	Longer, especially in extraction cases

Every self-ligating bracket, whether active or passive, uses the movable fourth wall of the bracket to convert the slot into a tube. Numerous studies have demonstrated a dramatic decrease in friction for self-ligating brackets, compared to conventional bracket designs.[12-15] Such a reduction in friction can help shorten overall treatment time, especially in extraction cases where tooth translation is achieved by sliding mechanics. Several authors have indicated that the use of self-ligating brackets can reduce treatment time by about four months and save significant chairtime in changing archwires. These factors add up to a considerable cost saving.[11,16,17]

Percutaneous injury to the index finger or thumb during archwire changes accounts for 57.9% of all clinical injuries sustained by orthodontists,[18] with a similar incidence reported by orthodontic assistants and hygienists.[19] Self-ligation reduces the risk of such injuries and potential transmission of HBV, HCV, or HIV for both the orthodontist and the staff. It also protects the patient from soft-tissue lacerations and possible infections from the cut ends of steel ligatures.

Elastomeric ligatures not only show a rapid rate of decay and deformation,[20] but they are often associated with poor oral hygiene. With the elimination of ligatures (as well as tie wings and other types of food traps in some designs), self-ligating appliances can significantly improve the hygiene of all patients.

Self-ligating brackets can also be superior to conventional appliances in treating patients with complications, such as hemophilia,[21] swollen gingival tissue due to persistent mouthbreathing or the use of Accutane for acne treatment, and periodontally compromised tissue.

Conclusion

As more orthodontic practices embrace the concept of self-ligation, it is becoming apparent that stainless steel and elastomeric ligatures will eventually be as outdated as full banding is today. Considering the advantages of self-ligating brackets for the clinician, staff, and patient, they may well become the "conventional" appliance systems of the 21st century.

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