Foreword

Since the early beginning of orthodontics, clinicians have progressively produced modifications and enhancements to improve force delivery of the appliances and clinician’s efficiency. Major advances since the last century included the development by Dr. Angle of the Edgewise appliance, the introduction of enamel direct and indirect bonding techniques, the advent of the Preadjusted Straight Wire appliances and the development of fully customized Lingual Appliances (IBraces or Incognito). In the last 10 years, self-ligating appliances have captured the imagination of many clinicians and are increasing in popularity. Those brackets have been developed to overcome the limitations of stainless steel and elastomeric ligatures in terms of ergonomics, efficiency, plastic deformation, discoloration, plaque accumulation, and friction.

A self-ligating bracket is a ligature-less system with a mechanical device built in to close off the edgewise slot. Secure engagement may be produced by a built-in clip mechanism replacing the stainless steel or elastomeric ligature. Both active and passive self-ligating brackets have been manufactured, referring to the bracket/archwire interaction. The active type has a spring clip that presses against the archwire. In the passive type, the clip or rigid door does not actively press against the archwire.

Active self-ligating appliances may allow better torque control with undersize archwires than can be achieved with passive appliances; a spring clip might also enhance the potential for bucco-lingual alignment. The resistance to sliding is thought to be lower for passive appliances, however, which may improve the aligning capability of these systems. Self-ligating systems outperform conventional brackets in the in-vitro situation, producing considerably less friction within the appliance systems, but this effect is less marked in-vivo. Clinical data documenting the efficiency of rotational correction and space closure with self-ligating systems remain limited. Use of self-ligating brackets results in a marginal reduction in chairtime required for appliance manipulation. Also, there is limited, retrospective evidence pointing to reduced overall treatment time with fewer scheduled appointments with the use of self-ligating systems.

While many clinicians recommend selected self-ligating appliances to facilitate expansion in non-extraction treatment, there are no published long-term follow-up studies on the stability of this approach.

Vittorio Cacciafesta, DDS, MSc, PhD
Milan, Italy
Preface

Self-ligating brackets—in recent years these words have taken on almost unbelievable magic powers. It is now almost impossible to envisage orthodontic treatment without such brackets. Keywords supporting this idea are: greater user comfort; better differentiation from competitors; more marketing possibilities, economical, shorter chair times, easy-to-use, patient comfort, perfect for your patients, and so on. The conclusion is: everything works easier and quicker. Sometimes the phrase “intelligent system” is used. Somewhat exaggerated, it seems as if the bracket at last can inform the tooth who is now in charge of moving from the false to the correct position. And the tooth? It follows the new brackets obediently, friction-free, and at a breathtaking pace.

By putting this rather ironic text at the front of a specialist book, the authors attempt to make it clear that they are attempting to replace suggestive remarks with facts and to be critical about advertising slogans. All the authors have been working with self-ligating brackets for a long time and will be presenting their investigations and experiences accordingly in this book.

Sometimes it may seem that self-ligating (SL) brackets are a recent invention. This is not the case. The first experiments with brackets that fixed the wire into the slot date back to the 1930s. The era of modern SL brackets began with Speed Brackets around 1980. For almost two further decades the SL brackets existed in the background. The growing number of systems and concepts from recent years is difficult to explain. The explosive growth in popularity became quite uncontrolled, and this book will try to clear the undergrowth as it were.

There have been many publications on this topic during recent years. A lot of experience has been gained regarding friction and treatment times as well as the requirements for clinical use and treatment possibilities. The aim of the authors is to summarize existing knowledge and to complement it with their own experiences and study results, in order to provide readers with an overview of SL brackets that is as comprehensive as can be. Following a chapter on the history of SL brackets, the first part of the book presents aspects dealing with material and techniques, including the evaluation of selected systems. The second part of the book is dedicated to clinical practice. Here also the authors have tried to demonstrate the complexity of the topic from the first to the final treatment steps. Statements are illustrated using numerous case studies. The conclusion drawn from this section could be: SL brackets are and will remain interesting tools, if they are properly used. They are just one of the many therapeutic choices in the hands of a doctor, and not a “magic pill.”

This book is intended to be both a guide and a compendium, teaching beginners how to use this method, helping advanced users to detect sources of errors, and encouraging readers to go in a new, creative direction.

The authors thank everyone who played a part in completing the manuscript by giving advice and help, whether directly or indirectly, and those who motivated us to invest a great amount of work to reach our goal. Without this help the project would not have been realized so quickly. Our special thanks go to the Editorial Department of Thieme Publishers in Stuttgart for their excellent cooperation and the way in which they were able to turn our not always simple ideas into reality.

Bjoern Ludwig, MD
Dirk Bister, MD, DD
Sebastian Baumgaertel, DMD, MSD, FRCD(C)
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Recent advances in fixed appliance treatment in orthodontics are based on a combination of applied knowledge and the use of materials relating to that knowledge. For self-ligation, the applied knowledge consists of the generally transferable skills involved in diagnosis and treatment. The hardware consists of brackets, archwires, and bands, which are used for treatment with conventional fixed appliances. All of the approaches used in self-ligation are identical to those used for general treatment with conventional fixed appliances.

Fixed appliance treatment is easier when straight-wire techniques are used, and auxiliary elements are often useful. The basic principles, however, are the same for self-ligation as in conventional orthodontics—for example, bracket placement is of paramount importance for good finishing. Inadvertent errors in bracket placement can be compensated for either by repositioning the brackets or by using first-, second-, or third-order bends. Self-ligation does not confer any advantages in this respect.

**Self-Ligating Brackets**

Like ordinary fixed appliances, a self-ligating bracket consists of a bracket base and a body containing slots and tie-wings (Fig. 2.1). The difference between conventional and self-ligating brackets lies in the way in which the archwire is engaged in the slot. In self-ligation, the bracket itself contains a clip or other mechanism, which is used instead of either elastic or metal ligatures.

Just like conventional brackets, self-ligating brackets really only serve one function: they are the junction between the element generating the force (wire or auxiliary) and the tooth—so that they are simply a means to an end. The use of self-ligating brackets has given rise to a number of treatment philosophies, which are believed to offer significant advantages over ordinary ligation. However, it is important to remember that the tooth is not aware of how the force is being applied to it—whether it is by self-ligation or ordinary ligation.

A number of challenges that apply to traditional brackets also apply to self-ligating brackets: the fit of the bracket base to the tooth, the precision of the archwire slot, etc. There are few differences between self-ligation and ordinary ligation, as the method of production for the two systems is identical. Depending on how self-ligating brackets are manufactured, there may be a number of technical issues with the locking mechanism, which are described in greater detail in the section on "Rotation and Friction" below.

An ideal self-ligating bracket should have the following characteristics:

- Anatomically appropriate curvature of the bracket base including retention and undercut
- Marking of the vertical and horizontal axis
- An appropriately designed layout for good bracket positioning

**Bracket Base**

The bracket base connects the bracket to the tooth and therefore must have retentive elements such as mesh, undercuts, or other retentive features which allow for good band strength. The adhesive enters the undercuts and allows mechanical retention, which should be resistant to everyday masticatory forces on the one hand, but should still be capable of being debonded without damaging the enamel surface on the other.

**Shape of the Base**

An ideal base should follow the curvature of the respective tooth surface for a good fit. This should enable the operator to place the bracket securely in the appropriate position on the tooth without rocking. A poorly fitting base can result in unprecise torque, angulation, and rotation once the full-sized wire is completely engaged. In order to produce an appropriately fitting bracket base, the manufacturer needs to pay attention to a number of factors.

The buccal surfaces of individual teeth show only very minor anatomical variations. An anatomically preformed bracket base is ideal and will fit well in the majority of cases. A precisely fitting base needs to take into account both the occlusal—gingival and also the mesiodistal curvature of the tooth surface. This is a challenge from the manufacturing point of view as a tooth surface is not built with a uniform curvature and a single radius like a circle, where a bracket can be positioned anywhere on the surface with equally good results. A tooth surface has many diverse radii and curvatures, depending on the location on the surface—and this applies to both the occlusal—gingival and mesiodistal directions (Fig. 2.2).

![Fig. 2.1 a, b The general design of a self-ligating bracket.](image-url)
The importance of the congruence of the bracket base and the surface of the tooth has been known for a long time. Most manufacturers now offer brackets that have different surface characteristics with increased or decreased convergence. These convergences were originally determined by cross-sectional analysis of teeth that were cut in order to measure the curvature. It was therefore only possible to obtain a small number of convergences per analyzed tooth; due to the intense labor involved, the sample size per tooth type was usually small. Despite this, the results from the original studies are still often used in the manufacturing of bracket bases even today. Modern three-dimensional reconstructions of tooth surfaces are nowadays used in computer models and this method allows better correlation of the bracket base with the actual surface of the teeth, due to the increased number of teeth that can be analyzed and averaged. Some manufacturers use this technique to design and construct their bracket bases and therefore claim to produce better-fitting bracket bases than others, but it is important for the bracket base to be manufactured in such a way that the data obtained can be used in a meaningful way. This is most likely to be possible with metal injection molding (MIM) or ceramic injection molding (CIM). Both of these techniques allow the individualized and fitted shape to be transferred when the bracket is
produced. A number of bracket manufacturers produce a bracket base from premanufactured plates, which are then bent into the desired shape. In a separate step, this bracket base is then connected to the bracket itself (see the section on “Bracket Body” below). It is not possible to produce the ideal surface characteristics that a bracket should have using these techniques. This is due to the very small size of the bracket base, resistance to deformation by the metal itself, and manufacturing issues with the application of forces to the small surfaces.

Positioning errors can also result from canting the bracket or from migration of the bracket between positioning and polymerization. This may lead to poor slot orientation and in turn to undesired tooth movement (Fig. 2.4).

**Bond Strength**

The ideal orthodontic bracket adhesive should have two main properties: on the one hand, it should ensure a sufficient bond strength to be able to withstand the everyday stresses of mastication and manipulation. On the other hand, it should also allow easy removal of the bracket without damage to the enamel. As these two properties are diametrically opposed, orthodontic adhesives compromise by trying to deliver an adequate bond strength for most clinical situations—neither too strong nor too weak.

Most studies would agree that the minimum bond strength necessary for orthodontic treatment is in the
The following advertising slogan appears in a brochure highlighting the advantages of self-ligating systems: "Everything’s simpler and you save on everything!" Other advertising materials are more specific, and the following list details the main advantages claimed by manufacturers of self-ligating systems:

- Increased patient comfort
- Ease of operator handling
- Mechanism that is easy to open and close
- Allows faster ligation than conventional brackets
- Better oral hygiene
- Reduced friction characteristics leading to shorter treatment times
- Shorter appointment times (less chairside time)
- More efficient treatment (fewer appointments and increased intervals between appointments)

Clearly, self-ligating brackets cannot produce any of these advantages unless they are used by an experienced clinician who understands the basic principles and the strengths and weaknesses of the bracket systems. Some cases involve a degree of difficulty at which self-ligating brackets (SLBs) and wires alone are insufficient for solving the problem. Even in the hands of the most experienced operator, SLBs may need to be supplemented with auxiliaries. As SLBs are only one of the many tools available to contemporary orthodontists, it is the operator’s responsibility to establish the most suitable way to treat a malocclusion and to select the most appropriate strategies and tools. This chapter presents supplementary information on adjuncts and auxiliary techniques, which may be helpful when treating different malocclusions using self-ligating brackets.

The use of self-ligating brackets does not redefine the principles of orthodontics. Most of the treatment approaches that are already known still apply—to move a tooth into a desired spot, you require time, anchorage, and space. Treatment should only be contemplated once these three parameters have been considered carefully and the treatment objectives have been designed around them.

### Practical Application of Self-Ligating Brackets

“Open the door, insert the archwire, close the door!” That is how simple the use of an SLB should be. However, this may be more wishful thinking than reality. There are two main weaknesses that affect the use of self-ligation in orthodontics—the ligating mechanism itself and the operator who uses it.

Self-ligating brackets are difficult to manufacture. The materials used, particularly for the locking mechanism, have to be able to withstand masticatory forces as well as the stress that normally occurs during orthodontic treatment, while at the same time they have to have the ideal properties to allow precise fabrication. Assembling the ligation mechanism and coupling it to the rest of the bracket is a challenging manufacturing process. The mechanism needs to be manufactured to extremely high standards, and this is particularly difficult because different materials are used for the bracket base and the locking mechanism, and by default their respective tolerances differ. The resulting bracket is a delicate device that requires careful and diligent handling.

There is no single self-ligating bracket available today that is capable of tolerating inept and “forced” handling by the operator. The opening of the locking mechanism, insertion of the archwire, and closure of the locking mechanism have to be undertaken carefully and require an understanding of the locking mechanism itself as well as careful tactile handling. Most operators experience a steep learning curve associated with the use of self-ligation. Regardless of which
**Table 8.1** The learning curve for an untrained layperson using traditional brackets (red) and self-ligating brackets (blue). Even after some practice, elastic ligation took three times longer than self-ligation.

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It is not always possible to assess the user-friendliness of a particular self-ligating bracket system after training on a demonstration model. Whatever the system, it takes considerable time for the operator to become accustomed to self-ligation and to no longer using wire or elastomeric ligatures. However, there is also a learning curve when conventional ligation is used. Comparisons of the learning curves for previously untrained personnel show that self-ligation is actually learned more quickly than ligation with elastomeric elements or tie-wings, and that it takes less time to ligate the wire using SLBs, even for inexperienced operators. In the authors’ experience, however, it appears to be difficult for operators to learn the effective use of self-ligation once they have previously been trained in the use of conventional ligation techniques (Table 8.1).

As mentioned above, a detailed understanding of self-ligating mechanisms is often the key to using the system successfully. It is mandatory to have the recommended instrumentation for opening and closing the brackets. It may be useful to remember that closure of most mechanisms can be undertaken without instrumentation using gloved fingers, which often proves to be more efficient than religating conventional brackets with elastomeric ligatures. Manufacturers produce instruments specifically designed for their own bracket systems, most of which are not compatible with other systems.
Fig. 8.3a–k  Different types of instruments for opening the mechanism in self-ligating brackets.

a–c The SmartClip bracket (3 M Unitek) with special pliers.
d–f The Quick bracket instrument (Forestadent), similar to a dental probe.
g–h The In-Ovation instrument (GAC).
i–k The Discovery SL instrument (Dentaurum), resembling a scaler (images with kind permission from Dentaurum).

**CLINICAL PEARL**

Although the dedicated adjuncts appear expensive, it is advisable to use the instruments recommended by the manufacturer (Fig. 8.3).

Specifically, the probe-like instruments for self-ligating brackets can be easily confused between different manufacturers or indeed between various systems produced by the same manufacturer. It may be advisable to mark the various instruments for particular systems if several self-ligating systems are used in the same practice. The locking mechanism itself is a fine-tuned mechanical device that is likely to fail if it is handled inappropriately and with too much force (Fig. 8.4).
Once an arch or locking mechanism has been bent or distorted, it cannot be repaired. It is often best to use conventional ligation on the damaged bracket (if possible) or to replace the bracket.

The locking mechanism will also fail if composite finds its way into the mechanism, particularly during the bonding procedure. This can often be avoided if the correct amount of bonding agent is carefully applied in the middle of the bracket base.

**CLINICAL PEARL**

Excess bonding material should ideally be removed immediately after seating the bracket, to prevent the bonding material from interfering with the self-ligating mechanism.

The self-ligating mechanism can also be damaged during chewing, particularly when there are strong masticatory forces; this is often the case in patients with a deep bite. This type of damage can often be prevented by using bite-opening devices (see the following section on “Bite Planes,” p. 183).

Another reason for irreversible damage to the locking mechanism occurring is forced engagement of the archwire in the bracket slot. This can be a problem particularly if large or excessively stiff wires are used. The fit of the archwire needs to be carefully checked before the operator attempts to close the locking mechanism. The lid can be irreversibly damaged during closure of a poorly fitting archwire. The propensity to cause damage depends on the wire size and material, the position of the tooth, and the position of the bracket on the tooth itself. Any of the above parameters are important, as they can lead to the archwire not being fully engaged in the bracket slot. The lid may subsequently not shut properly if the wire cannot be seated properly in the bracket slot and this may lead to ineffective treatment. Additional instruments (such as a wire director) are often useful for engaging the archwire properly into the bracket slot before closing the locking mechanism (Fig. 8.5). Several manufacturers now also offer self-ligating molar brackets. These can be useful, as they allow extraoral preparation of the archwire for detailing or cinch-back bends, with subsequent easy insertion into molar SLBs. This reduces the risk of debonding the bracket or otherwise damaging it in comparison with creating the bends intraorally (Fig. 8.6). Table 8.2 highlights the potential reasons for damage to the locking mechanisms and offers suggestions for ways to prevent these problems.
Case Study 8.9 (Fig. 8.35)

Patient: D.F.H., male, age 16.

Diagnostic records: models, panoramic radiograph, lateral cephalometric radiograph, intraoral/extraoral photographs.

Main findings: mandibular second molars mesially impacted.

Treatment aims: uprighting of teeth 37 and 47.

Appliances: self-ligating molar tubes, uprighting springs, miniscrew implant.

Alternative treatment strategy: extraction of teeth 37 and 47 with alignment of teeth 38 and 48.

Active treatment time: 8 months.

Retention: three-dimensional retention with a Hawley retainer.

Fig. 8.35 1–15

1–6 Well-progressing treatment with self-ligating brackets. The progress panoramic radiograph shows mesially impacted mandibular second molars. After extraction of teeth 38 and 48 and surgical exposure of teeth 37 and 47, brackets were bonded and miniscrew implants were placed to allow molar uprighting with an uprighting spring and to avoid reciprocal side effects. The springs were activated to allow distalization and uprighting at the same time.

7, 8 Uprighting a molar creates momentum that may have an undesired effect on the anterior dentition. Use of a miniscrew implant can absorb the undesired reciprocal momentum.
The initial uprighting phase (9). The front teeth of the patient were debonded after alignment of the dentition was completed (10). Posterior sectional mechanics were used for continuation of the molar uprighting. A mini-implant which was inserted between 44 and 45 was used for anchorage.

The miniscrew implant absorbs reactive forces and prevents negative biomechanical effects on the anterior dentition during molar uprighting.

Panoramic radiographs before and after successful molar uprighting.

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