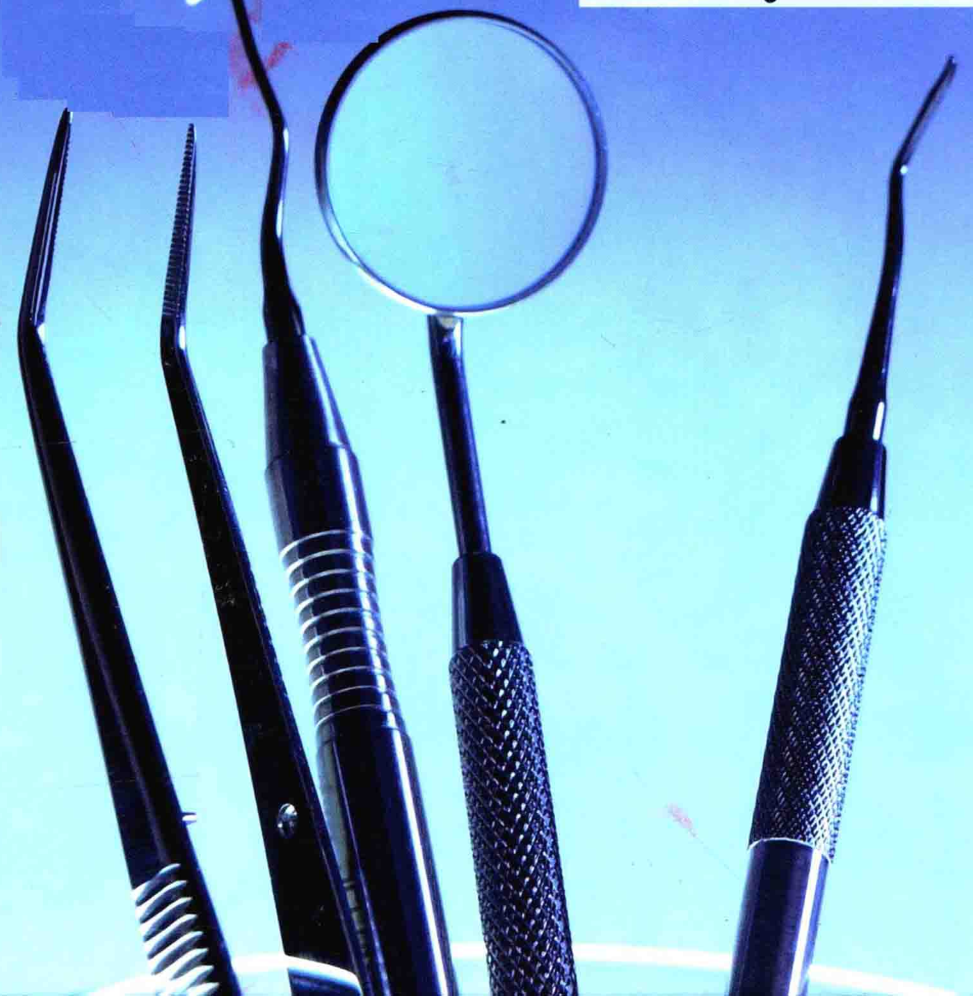
Contemporary Orthodontics

Kaley Ann



Contemporary Orthodontics

Edited by **Kaley Ann**

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Preface

I am honored to present to you this unique book which encompasses the most up-to-date data in the field. I was extremely pleased to get this opportunity of editing the work of experts from across the globe. I have also written papers in this field and researched the various aspects revolving around the progress of the discipline. I have tried to unify my knowledge along with that of stalwarts from every corner of the world, to produce a text which not only benefits the readers but also facilitates the growth of the field.

Orthodontics is a rapidly growing field of science and is considered as an important field of medicine. The aim of this book is to provide innovative possibilities and novel ways of looking at this field besides the ones elucidated in excellent publications already present. It provides the basic information, other clinical experiences and further offers a window to the future by mapping three sections namely, Technology, Technique, and Methodology. The book aims at serving the readers a valuable means of exploration of the application of knowledge, information and answers to some orthodontic questions and topics.

Finally, I would like to thank all the contributing authors for their valuable time and contributions. This book would not have been possible without their efforts. I would also like to thank my friends and family for their constant support.

Editor

Contents

Part 1

Technology

Self-Ligating Brackets: An Overview

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1. Introduction

The specialty of orthodontics has continued to evolve since its advent in the early 20th century. Changes in treatment philosophy, mechanics, and appliances have helped shape our understanding of orthodontic tooth movement. In the 1890's, Edward H. Angle published his classification of malocclusion based on the occlusal relationships of the first molars. This was a major step toward the development of orthodontics because his classification defined normal occlusion. Angle then helped to pioneer the means to treat malocclusions by developing new orthodontic appliances. He believed that if all of the teeth were properly aligned, then no deviation from an ideal occlusion would exist. Angle and his followers strongly believed in non-extraction treatment. His appliance, (Fig. 1), consisted of a tube on each tooth to provide a horizontally positioned rectangular slot. Angle's edgewise appliance received its name because the archwire was inserted at a 90-degree angle to the plane of insertion. The rectangular wire was tied into a rectangular slot with steel ligatures (Proffit, 2000). A later shift in thought occurred when one of his pupils, Charles Tweed, observed that some of the patients formerly treated by Angle exhibited a noticeable amount of relapse. Tweed then re-treated a number of these cases by extracting four bicuspids to resolve the crowding and in turn, developed his own treatment mechanics. Another shift in orthodontics occurred when Larry Andrews introduced the straight wire appliance. Instead of bending wires to place teeth in the proper orientation with an edgewise bracket, Andrews' appliance had the angulation and torque values built into the brackets commonly known as the appliance prescription. In theory, these pre-adjusted brackets eliminated the need to repeatedly bend first, second, and third order bends each time the patient progressed to the next wire. The straight wire appliance revolutionized orthodontics by making the bracket much more efficient. Since then, many orthodontic companies have developed their own bracket systems with specific prescriptions, treatment philosophies, and mechanics. However, they all shared one common characteristic - ligatures must be placed around tie wings on brackets to hold arch wires in the bracket slot.

2. Ligatures and ligation properties

Different types of ligatures have been used to hold the archwire in the bracket slot. Steel or elastomeric ligatures have been used mainly. The steel ligatures are made of chrome-alloy stainless steel with dimensions vary from .009" to .012" Inch in diameter and twisted with a hand instrument. In some cases, these ligatures are coated with tooth-colored material such as teflon for aesthetic reasons. Steel ligatures produce a variable effect on the bracket/archwire junction depending on their tightness. The advantages with the steel ligatures are that they do not deteriorate in the oral environment and they retain their shape and strength. They also provide less retention of bacterial plaque and are easier to clean than the elastomeric ligatures (Ridley et al., 1979). The drawbacks with steel ligatures are that they are time-consuming and tiresome on the hand of operator (Maijer & Smith, 1990; Shivapuja & Berger, 1994). Harradine, (2003), found that the use of wire ligatures added almost 12 minutes to the time needed to remove and replace two archwires. They also require careful tucking in of the ends to avoid soft tissue trauma and even then can occasionally be displaced between appointments and cause discomfort (Schumacher et al., 1990; Bendar & Gruendeman, 1993).

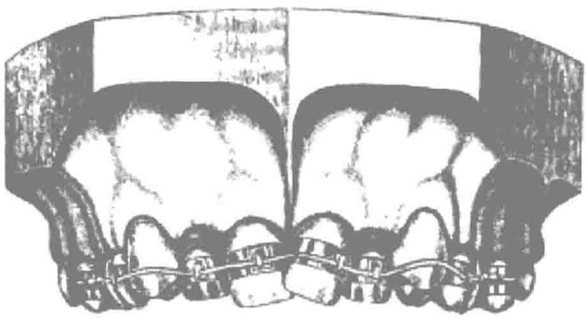

Fig. 1. Early edgewise appliance.

The introduction of elastomeric ligatures in the 1970s is also another milestone in orthodontics which largely replaced steel ligatures. These are quicker and easier to place, and they can be used in chains to close spaces within the arch or prevent spaces from opening. However, conventional ligation with elastomerics fails to provide and maintain full archwire engagement. In addition, they potentially impede good oral hygiene which is a novel situation in orthodontics. Moreover, the physical properties of elastomeric ligatures are imperfect. Elastic ligatures undergo permanent deformation in shape and thus force decays with time. The force decay under constant force application to elastomeric material showed that the greatest amount of force decay occurred during the few hours (Wong, 1976). In addition, they stain permanently shórtly after being placed in the oral cavity. More important, elastomeric ligatures have been shown to increase friction in the sliding mechanic systems (Sims et al., 1993; Thomas et al., 1998), and increase the resistance to movement in bracket/archwire systems by 50-175g (Echols, 1975).

2.1 Properties of an Ideal orthodontic ligation system

Regardless of the type of bracket and ligation used, there are several desirable properties for an ideal orthodontic ligation system.

1. Secure and robust ligation

Secure , full archwire engagement maximizes the potential long range of action of modern low modulus wires and minimizes the need to regain control of teeth where full engagement is lost during treatment. Once a wire is ligated, it is desirable that it is resistant to inadvertent loss of ligation. Wire ligatures are good in this respect while elastic ligatures are more easily lost. Elastic ligatures also experience significant force decay over time (Taloumis et al., 1997).

2. Full bracket engagement

Full archwire engagement into the bracket slot is desirable to attain full expression of torque particularly at finishing stages of treatment. Wire ligation can maintain adequate archwire engagement between office visits. On the other hand, elastic ligatures frequently exert insufficient force even on fairly flexible wires.

3. Quick and easy ligation

Wire ligation is a lengthy procedure and this is the main reason they are not frequently used. Elastic ligatures are much faster to remove and replace (Türkkahraman et al., 2005)

4. Low friction

For sliding mechanics, brackets that experience low friction are the most desirable. Low friction is important during the leveling and aligning stages of orthodontic treatment. It will allow a more efficient force delivery, less force dissipation and thus a faster expression of the wire. Low friction is efficient during space closure as well. Wire ligatures are superior to brackets ligated by elastic ligatures in this respect and shown to produce only 30-50% of the frictional forces produced by elastomerics (Shivapuja et al., 1994). Still, forces may reach undesirable levels relative to levels considered ideal for tooth movement (Khambay et al., 2004).

5. Improves patient comfort and hygiene

Wire ligatures can cause tissue laceration if the cut ends are exposed but they are very hygienic. Elastic ligatures are more comfortable than wire ligatures but have the side effect of being less hygienic.

Sliding mechanics in conventional brackets rely on filling the slot with the largest wire possible to provide a certain degree of force control (direction and magnitude) needed to move teeth. With enough force, teeth eventually move to the desired position. Because archwires are held into place with either metal or elastic ligature ties, heavy forces must be introduced into the system in order to overcome the friction created at the bracket/archwire interface before tooth movement can occur. However, some argue that the heavy forces generated by large sized wires and traditional ligation methods are not physiologic because they create force systems high enough to overpower the lip, tongue, and cheek muscular. Clinicians and manufacturers alike sought to develop a product that could replicate the time saving properties of elastomeric modules while lessening or eliminating the friction they caused. This eventually led to the development and popularization of selfligating brackets because they satisfy both criteria and offer a philosophy of orthodontic treatment that greatly differs from this classical school of thought.

3. Self-ligating brackets

3.1 Definition

Self-ligating brackets are ligatureless bracket systems that have a mechanical device built into the bracket to close off the edgewise slot. The cap holds the archwire in the bracket slot and replaces the steel/elastomeric ligature. With the self-ligating brackets, the moveable fourth wall of the bracket is used to convert the slot into a tube.

3.2 Philosophy of self-ligating bracket proponents

Light forces are the key to self-ligation. Proponents suggest that low force, low-friction systems allow teeth to travel to their physiologic position because they do not overpower the musculature or compromise the periodontal tissues. Ischemia is not induced in the surrounding periodontal tissues because the forces generated by the small dimension, high-tech archwires are too low to completely occlude the periodontal vascular supply. Heavy forces on teeth cause hyalinization in the periodontal ligament space which brings tooth movement to a halt. Self-ligating brackets place enough force on the teeth to stimulate tooth movement without completely disrupting the vascular supply and therefore, tooth movement is more effective and physiologic. The final position of the teeth after treatment with the self-ligating bracket systems is determined by the balanced interplay between the oral musculature and periodontal tissues and not by heavy orthodontic forces. Moreover, the design in passive self-ligating bracket also enables teeth to move in the path of least resistance. When the gate is in its closed position, the bracket essentially becomes a tube in which the flexible nickel-titanium archwire can move freely. By greatly reducing the amount of friction with passive self-ligating brackets, low force archwires can work to peak expression and stimulate teeth to move in a more biologically compatible method (Fig. 2). Teeth movement is also more efficient when they are allowed to move individually, and passive self-ligating brackets offer more freedom for teeth to move to their natural position even though they are still interconnected because the archwire is never tightly engaged with the bracket slot (Damon, 1998).

Elastic ligatures create friction and require more force and more frequent adjustments

Self-ligating brackets allow freedom of movement, resulting in faster treatment with gentler forces

Fig. 2. Traditional archwire ligation vs. self-ligating brackets.

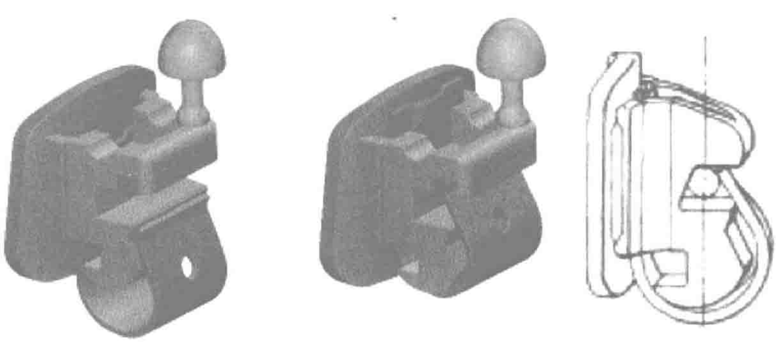

Fig. 3. Active self-ligating brackets in open and closed positions.

3.3 Classification

Two types of self-ligating brackets have been developed, active and passive. These terms refer to the mode in which they interact with the archwire. The active type (Fig. 3) has a spring clip that encroaches on the slot from the labial/buccal aspect and presses against the archwire providing an active seating force on the archwire and ensuring engagement such as In-Ovation (GAC International, Bohemia, NY, USA), SPEED (Strite Industries, Cambridge, Ontario, Canada), and Time brackets (Adenta, Gilching/Munich, Germany).
In the passive type (Fig. 4), the clip does not press against the archwire. Instead, these brackets use a rigid door or latch to entrap the archwire providing more room for the archwire such as Damon (Ormco/"A"Company), SmartClip™ (3M Unitek, USA), and Oyster ESL (Gestenco International, Gothenburg, Sweden).

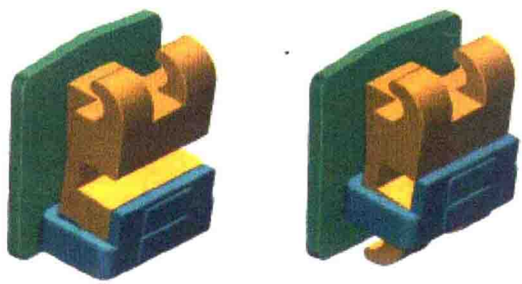

Fig. 4. Passive self-ligating brackets in open and closed positions.

3.4 History and development of self-ligating brackets

Self-ligating brackets were first introduced in the mid-1930s in the form of the Russell attachment by Stolzenberg (Fig. 5). The bracket had a flat-head screw seated snugly in a circular, threaded opening in the face of the bracket that allows for quick and simple archwire changes. Loosening the screw made the system passive and allowed bodily translation on a round wire while tightening it made it active and provided root torquing on a square or a rectangular wire. The bracket system was more comfortable for the patient and resulted in shorter office visits as well. Unfortunately, the Russell attachment did not gain much popularity and virtually disappeared from the market.

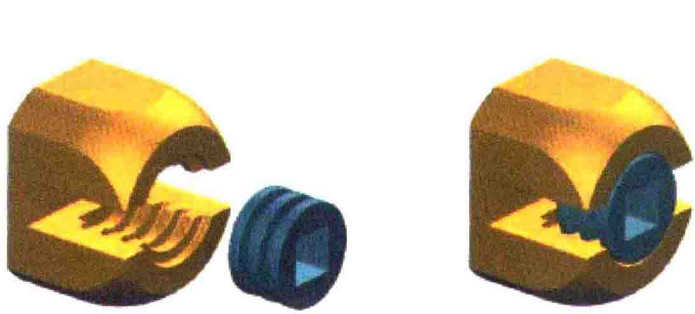

Fig. 5. Russell attachment in open and closed positions

The first modern passive self-ligating bracket (Edgelok- Ormco Corporation, Glendora, CA) was introduced in the early 1970s. The bracket had a round body with a rigid labial sliding cap (Fig.6). Because of its passive nature, orthodontists found precise control of tooth movement to be a challenge. Although many design refinements have been introduced since, the basic design has remained unchanged.

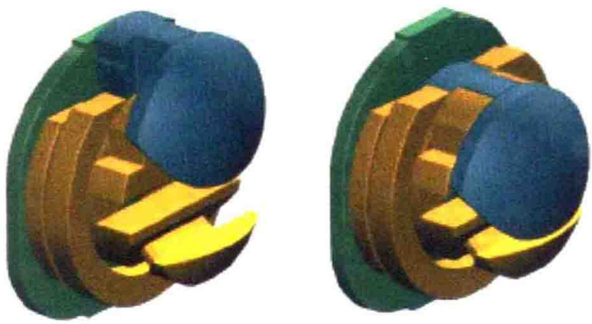

Fig. 6. Edgelok bracket in open and closed positions.

The prototypes of the first active self-ligating bracket (SPEED, Spring-loaded, Delivery) were introduced into the market in 1980. The bracket features a curved, flexible super-elastic nickel-titanium spring clip that embraces the bracket body and passes through the archwire slot.

In 1986, the self-ligating Activa bracket offered another alternative. The Activa bracket had an inflexible, curved arm that rotated occlusogingivally around the cylindrical bracket body (Fig. 7). The arm could be moved into a slot-open or slot-close position with finger pressure alone. Once closed, the rigid outer wall of the movable arm converted the bracket slot into a tube. Another self-ligating bracket model, Time entered the marketplace in 1995. The Time bracket (Fig. 8) features a rigid, curved arm that wraps occlusogingivally around the labial aspect of the bracket body. The stiffness of the bracket arm prevents any substantial interaction with the archwire, thereby rendering Time a passive bracket (Berger & Byloff, 2001).)

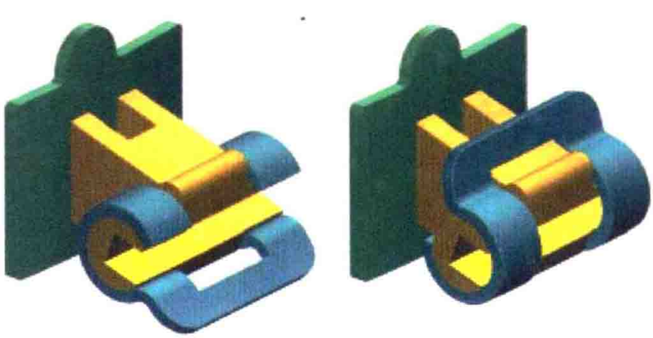

Fig. 7. Activa bracket.

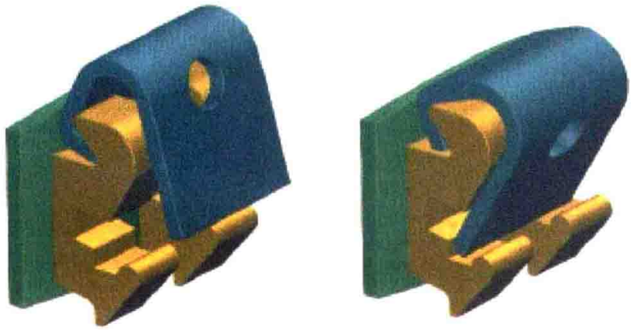

Fig. 8. Time bracket.

Perhaps the most renowned self-ligating bracket system was introduced by Dr. Dwight Damon in 1996. The Damon™ SL I is an edgewise twin bracket with a metal labial cover that straddles the tie wings. In 1999, the next generation Damon™ SL II was brought to the market (Fig. 9). It differed from the original Damon™ SL I by incorporating a flat rectangular slide between the tie wings. A special plier is used to open the metal gates incisally in the maxillary arch and gingivally in the mandibular. Once the slides are closed, the bracket becomes a passive tube. The Damon™ SL bracket system was designed to satisfy the following major criteria (Damon 1998):

a. Andrews Straight-Wire Appliance concept
b. Twin configuration
c. Slide forming a complete tube
d. Passive slide on the outside face of bracket
e. Bracket opening inferiorly in both arches

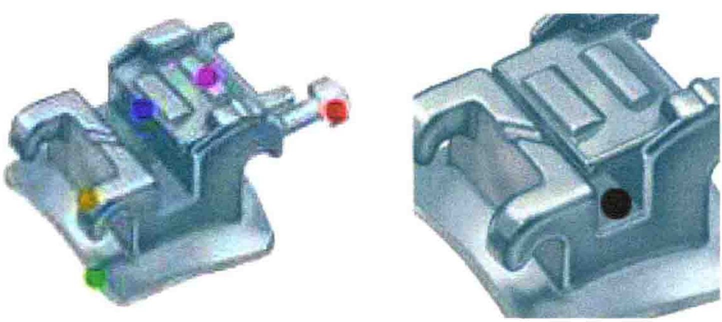

Fig. 9. Damon™ SL II brackets in open and closed positions.

In 2002, the In-Ovation R™ by GAC was introduced. This bracket features an interactive clip because it can provide both passive and active control depending on the archwires used. Round leveling wires can freely move to correct rotations during the initial leveling and aligning phase, while full size rectangular wires are fully engaged into the base of the bracket by the clip in the later stages of treatment for better torque control. A new In-Ovation C™ is now available which has a partial ceramic face for better esthetics (Figure 10).

Fig. 10. The GAC In-Ovation R™ and In-Ovation C™ bracket.

In 2004, 3M Unitek introduced the SmartClip™ self-ligating bracket, which is different from other self-ligating brackets in that it does not have a slide or clip to hold the wires (Fig.11). Instead it contains a nickel-titanium clip on each side of the twin bracket that locks in the wire. The archwire is inserted by using finger pressure to push it past the flexible clip. Remove requires a special instrument from 3M Unitek™.

Fig. 11. The unitek smart clip™ bracket.

With the increasing popularity of self-ligating brackets, many different bracket designs are brought to the orthodontic marketplace each year. Consequently, the use of SLBs has increased exponentially; over 42% of American practitioners surveyed reported using at least one system of self-ligating brackets in 2008 (Keim et al., 2008). This figure was just 8.7%in 2002 (Keim et al., 2002). When choosing a self-ligating bracket system, it is important to understand the different types of systems (active vs. passive) in order to obtain the best and most efficient orthodontic results.

4. Clinical performance of self-ligating brackets

Recent advances in bracket technology have resulted in a number of new selfligating bracket systems and greater interest in their use. Much of this interest is in response to information comparing the benefits of self-ligating systems with conventional edgewise brackets and claiming that self-ligating bracket systems provide superior treatment efficiency and efficacy. The proposed benefits include reduced friction between archwire and bracket, reduced clinical forces, reduced treatment time, faster alignment, faster space closure, different arch dimensions, better alignment and occlusal outcomes, less patient pain, and more hygienic. However, these data come from marketing materials, nonrefereed sources, or refereed journals. The purpose of this section is to review the clinically significant effects of self-ligating brackets on orthodontic treatment with respect to the quality of available scientific evidence. Comparing between self-ligating and conventional brackets in different aspects will be addressed as well. These include:

4.1 Subjective pain experience

It is well documented that discomfort is a potential side effect during fixed appliance orthodontic therapy and this can negatively influence the desire to undergo treatment, compliance, and treatment outcome (Patel, 1992; Scheurer et al., 1996). A potentially significant variable that influences treatment-related discomfort is the amount of force applied to the dentition by the orthodontic archwire, particularly during the early stages of treatment. Classical histological studies suggest that light forces are more biologically efficient and less traumatic during orthodontic tooth movement (Reitan, 1956). Therefore, the use of increased force levels might be expected to be associated with increased discomfort. One of the factors affecting prospective tooth movement and hence the amount of force required is the degree of friction that exists between the archwire and bracket; this frictional resistance being influenced primarily by the physical characteristics of the archwire and bracket materials (Ireland et al., 1991), archwire dimensions (Taylor & Ison, 1996), and the method of archwire ligation (Ireland et al., 1991; Shivapuja & Berger, 1994). Indeed, a number of self-ligating bracket systems have been developed in recent years, including Damon ™ , In-Ovation ™ , and SmartClip ™ with the proposed benefit of reduced frictional properties (Read-Ward et al. , 1997 ; Thorstenson & Kusy, 2001 ; Henao & Kusy, 2004). Proponents and manufacturers of these systems suggest that their physical properties produce lower force levels during tooth alignment and sliding mechanics, a more biologically compatible force level and, therefore, a possible reduction in pain associated with orthodontic tooth movement (Berger & Byloff, 2001; http://www.damonbraces.com).

To date (March, 2011), there have been four published clinical trials investigating degree and differences in perceived pain using self-ligating and conventional brackets (Pringle et al., 2010; Mile et al., 2006; Scott et al., 2008; Fleming et al., 2009). Of these, one split-mouth study considered pain reports after both the first and second visits, with patients indicating which system was associated with the greatest discomfort (Mile et al., 2006). Data in three of the trials are presented as continuous pain scores from 0 to 100 on a 100-mm visual analogue scale (VAS) which is one of the most commonly used tools in the measurement of perceived discomfort during orthodontic treatment (Pringle et al., 2010; Scott et al., 2008; Fleming et al., 2009). One trial reported pain scores at 15 time intervals (Pringle et al., 2010), while two trials used four time points: 4 hours, 24 hours, 3 days, and 7 days after appliance placement (Scott et al., 2008; Fleming et al., 2009). The findings from these studies conflicted slightly with one study reporting a tendency to less pain experience with Damon 3 SLBs, although this finding did not reach statistical significance (Pringle et al., 2010). Three studies (Pringle et al., 2010; Scott et al., 2008; Fleming et al., 2009) were regarded as being at low risk of bias, and they reported similar outcomes permitting statistical comparison; pain scores at four analogous time intervals were extracted from each study to facilitate this. Pain intensity over the first 7 days was reported in these three studies involving 160 patients, with 83 in the SLB group and 77 in the conventional bracket group. Patients in the SLB group reported a mean difference in pain intensity of 0.99 to 5.66 points lower than in the conventional bracket group, the greatest difference being reported 3 days after appliance placement. However, differences were not of statistical significance.

Two studies, (Mile et al., 2006; Fleming et al., 2009), reported greater pain experience during chairside manipulation of self-ligating appliances. However, as the mechanisms of archwire engagement and disengagement are very different using SmartClip (Fleming et al., 2009) and Damon 2 (Mile et al., 2006), it was felt that direct statistical comparison of this research finding would be invalid.

4.2 Bond failure rate

Treatment efficiency involves several factors including breakages. A higher bracket failure rate results in extra visits for the patient and additional clinical time required for repairs. The higher bracket failure rate demonstrated by any bracket system would need to be offset by any time saving in ligation time as well as overall treatment time.

Two studies have considered failure of bonded attachments over 20 weeks (Miles et al., 2006) and 12 months (Pandis et al., 2006) using Damon 2. The date used for assessing failure or time taken for failure to occur was not reported, and only first-time failures for each tooth were recorded. Miles et al., 2006, reported significantly more Damon brackets deboned during the study. This higher failure rate could be due to operator inexperience with the slide mechanism and also due to the bracket design because a shear force can be inadvertently applied when operating the slide. The Damon 2 (as most self ligating bracket designs) is also larger incisogingivally than the conventional twin bracket used and so more likely to interfere with the occlusion.

Pandis et al., 2006, assessed the failure rate of self-ligating and edgewise brackets bonded with a self-etching adhesive and conventional phosphoric acid etching in patients followed for 12 months of active treatment. Similar treatment plans, and mechanotherapy were selected for the study. GAC Microarch edgewise brackets and Oromco Damon 2 brackets were bonded using a split mouth design, using the 3M Transbond Plus Self-etching primer (SEP) and Transbond XT paste; and conventional acid etching, with Orthosolo primer and Enlight paste, applied at an alternate sequence so that the adhesives were equally distributed on the maxillary and mandibular right and left quadrants. No difference was found for the failure rate of self-ligating vs. conventional bracket and between the two bonding modes used. Also, no difference was identified between maxillary and mandibular arch in failure incidence whereas a statistically significant difference was shown for right-sided appliance which may be assigned to masticatory habits.

4.3 Plaque retention and periodontal health

Iatrogenic decalcification of tooth enamel and the development of visible white spot lesions are undesirable and unfortunate consequences of fixed orthodontic therapy, potentially undermining the esthetic benefits often achieved through correction of the malocclusion. It is well documented that fixed appliances increase bacterial plaque accumulation and the risk for white spot lesions (Gorelick et al., 1982; Geiger et al., 1983). During treatment, there is demonstrated increased retention in the amounts of Streptococcus mutans and lactobacilli in saliva and dental plaque (Forsberg et al., 1991). Bonded orthodontic brackets hinder