Self-Ligating Versus Conventional Orthodontic Brackets - A Review of Treatment Efficiency and Adverse Effects

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Abstract

AIM: To compare clinical outcomes of orthodontic treatment with self-ligating and conventional brackets by reviewing high-quality clinical studies in human subjects, with assessment of treatment efficiency, root resorption, pain and periodontal status.
METHODS: An electronic and manual literature search of MEDLINE–PubMed was conducted for the period January 2003 to March 2023. The initial search retrieved 157 records; 57 were screened and 36 met predefined inclusion criteria. Data were extracted and synthesised for outcomes relating to treatment efficiency, root resorption, patient-reported pain and periodontal parameters.
RESULTS: Across the selected studies no statistically significant differences were observed between self-ligating and conventional bracket systems for treatment efficiency, degree of root resorption, pain levels or periodontal status. Nevertheless, several studies reported numerical trends favouring self-ligating brackets for some outcomes. Heterogeneity in study design, outcome measurement and follow-up duration limited direct comparability.
CONCLUSION: Current clinical evidence is insufficient to conclude that orthodontic treatment is more or less efficient with self-ligating brackets compared with conventional brackets. Well designed, adequately powered randomised trials with standardised outcome measures are required to determine any clinically relevant differences.

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1 Introduction

The initial phase of fixed-appliance orthodontic treatment is concerned with tooth alignment, the effectiveness of which depends on several variables. The underlying tissue biology plays a significant role. Another fundamental mechanism that enables tooth movement through the alveolar bone is the response of the periodontium to the applied orthodontic force (Sandy et al., 1993). Consequently, periodontal health, tissue vitality, and cellular and connective tissue responses all contribute to the success of orthodontic tooth movement. Although these biological factors are not directly under the control of the orthodontist, other influences can be achieved through the choice of bracket system and archwire (Scott et al., 2008).

When preadjusted edgewise brackets are used, several important factors determine the rate of tooth alignment, including the bracket slot dimension, the associated interbracket span and the choice of archwire (Cobb et al., 1998; Evans et al., 1998). Frictional forces generated between bracket and archwire also have a significant effect on tooth movement (Scott et al., 2008). Friction is influenced by the method of attachment between archwire and bracket and by the physical characteristics of the archwire and bracket materials (Taylor & Ison, 1996). Conventional ligated edgewise brackets with elastomeric attachments between bracket and archwire have resulted in increased levels of frictional resistance (Michelberger et al., 2000). As a result, various self-ligating bracket (SB) systems have been developed to reduce unwanted friction. By avoiding the use of elastomeric attachments, self-ligation is associated with considerably reduced friction between the archwire and the bracket during orthodontic tooth movement, resulting in less damage to adjacent tissues, faster tooth alignment and space closure, and reduced overall treatment time (Henao & Kusy, 2004). In addition, it has been claimed that the advantages of SBs include reduced chairside assistance requirements, shorter adjustment appointments, increased patient comfort, improved oral hygiene and greater patient acceptance and satisfaction (Turnbull & Birnie, 2007). Although the use of SBs is convenient, this does not necessarily indicate that the SB system is superior to the conventional bracket (CB) system.

Conversely, numerous factors have been shown to affect the frictional resistance to tooth movement, including method of ligation, archwire size and material, bracket dimensions and material, angulation of wire to bracket, wet versus dry state, and masticatory forces (Proffit, 2012). Therefore, it is difficult to generalise laboratory findings that suggest SBs exert less friction on the archwire and require lower force to achieve tooth movement (O'Dywer et al., 2016).

The concept of the SB was introduced in 1935 as the Russel lock attachment (Stolzenberg, 1935). It is only recently that renewed interest in the use of SBs has arisen. Statistically, the use of SBs has increased over recent years: in 2002, 8.7% of American orthodontists used at least one self-ligating system; by 2008 the figure had increased to 42% (Keim et al., 2008).

Currently, SBs are divided into two main categories, active and passive, according to their mechanisms of closure. Active SBs have a spring clip that presses against the archwire, whereas passive SBs usually have a slide that can be closed without exerting force on the archwire (Chen et al., 2010; Fleming & O'Brien, 2013).

Based on treatment efficiency, previous studies have shown that the use of SBs can reduce treatment times by 4 to 6 months and by 4 to 7 visits when compared with CBs (Harradine, 2001; Eberting et al., 2001). Additionally, laboratory studies have suggested that friction is reduced, particularly with passive SBs (Franchi & Baccetti, 2006). However, some studies have found no difference in the rate of initial alignment between CBs and SBs. Studies investigating the rate of space closure have also reported no difference between SBs and CBs (Fleming et al., 2009; Ong et al., 2010).

During orthodontic treatment, pain or discomfort arises from transient pulpitis, compression of the periodontal ligament and mechanical trauma to the soft tissues (Scheurer et al., 1996). Many factors influence the level of pain experienced during orthodontic treatment. It has been claimed that SBs reduce friction on the teeth, resulting in lighter forces that should reduce pain originating from the pulp and periodontal ligament. However, the ability of self-ligating systems to reduce pain and discomfort during treatment remains controversial (Rahman et al., 2016). It is difficult to assess pain objectively, since it is influenced by multiple factors, including psychological, economic, sociocultural and environmental considerations (Lai et al., 2019).

Several studies have been conducted to evaluate the effects of orthodontic treatment on periodontal status. Brackets and ligatures create retention areas for plaque, which reduce the effectiveness of natural cleaning mechanisms by the tongue and lips and increase salivary viscosity (Lara-Carrillo et al., 2010; Babacan et al., 2011). Failure to ensure adequate oral hygiene during orthodontic treatment results in periodontal inflammation, hyperaemia, hyperplasia and dental demineralisation (Nalcaci et al., 2014). Because self-ligating brackets (SBs) lack ligature materials and have fewer retentive sites, they were expected to be associated with improved periodontal status (Lara-Carrillo et al., 2010). Conversely, some researchers have suggested that these advantages may not hold, as SBs include opening and closing mechanisms that could provide additional plaque-retentive areas (Pandis et al., 2008).

Although SBs were expected to afford faster correction of malocclusion, potential adverse effects must be considered. For instance, root resorption is a major concern for orthodontists (Sherrard, 2010). Orthodontic tooth movement is considered a principal cause of root resorption. There is a correlation between the severity of malocclusion and the degree of consequent root resorption. Hence, the initiation and progression of root resorption during orthodontic treatment may be related to several factors, such as treatment duration, pre-existing idiopathic root resorption and the type of movement, e.g., torque, intrusion or bodily movement (Hartsfield et al., 2004; Gonzales et al., 2008). In addition, bracket type, the mechanics employed, and the type and magnitude of applied forces are also relevant to this complication (Leite et al., 2012).

However, controversy and limited evidence remain regarding the benefits of SBs; it is essential to evaluate the viability of these brackets through evidence-based studies to clarify their advantages. Therefore, the aim of this study is to compare the clinical outcomes of self-ligating versus conventional brackets in human patients, drawing on high-quality clinical studies to assess differences in overall treatment time, alignment efficiency, periodontal status, external apical root resorption and patient-reported pain and discomfort.

2 Methods

The search strategy was developed following formulation of the PICOS (patient, intervention, comparison, outcome and study design) questions to ensure comprehensive retrieval of pertinent literature. The population comprised patients treated with fixed orthodontic appliances, the intervention comprised treatment with self-ligating brackets, the comparator comprised treatment with conventional brackets, the outcomes of interest were root resorption rate, pain, periodontal status and treatment efficiency, and the study designs sought were randomised clinical trials and prospective or retrospective cohort studies.

An electronic search of MEDLINE (National Library of Medicine) via PubMed was performed to identify English-language articles published between January 2003 and March 2023 that addressed the predefined research questions.

Keywords were organised by outcome: for root resorption the terms "root resorption", "conventional bracket" and "self-ligating bracket" were combined; for pain the terms "pain", "conventional bracket" and "self-ligating bracket" were combined; for periodontal status the terms "periodontal", "conventional bracket" and "self-ligating bracket" were combined; and for treatment efficiency the terms "treatment efficiency", "conventional bracket" and "self-ligating bracket" were combined.

In addition to the electronic search, manual screening of relevant journal issues and the reference lists of retrieved articles was undertaken to identify further pertinent studies.

Eligible studies comprised randomised controlled trials, controlled clinical trials and prospective or retrospective cohort investigations. Participants were required to be healthy individuals undergoing fixed orthodontic treatment in the permanent dentition with either self-ligating or conventional brackets, and no restrictions were imposed with respect to sample size, age or sex.

Excluded from consideration were single-case reports, case series and other descriptive or non-empirical publications such as review articles, opinion pieces and conference abstracts, as well as studies conducted in animals or performed in vitro.

A total of 157 studies were identified through electronic searching (**Figure 1**). Articles were excluded if the title or abstract was not related to the thesis topic. When no abstract was available but the title appeared relevant, the full text was retrieved and assessed; the article was included if relevant. In the first selection step, animal and in vitro studies, as well as reviews, were excluded, and 57 articles were retained for full-text analysis. After full-text review, case reports were excluded and duplicates removed. Following application of the predefined inclusion criteria, 26 studies were identified for analysis. Additionally, a further 10 studies were identified by manually searching the reference lists of the 26 retrieved articles. Consequently, a total of 36 studies were retained for analysis in this review.

2.1 Statistics

Descriptive statistics, frequency analysis, and content analysis were employed as part of the qualitative methodology to systematically analyze the textual content of the included studies. It is important to note that, given the narrative nature of this study, regression analysis and meta-analysis techniques were not deemed suitable for the analytical framework.

3 Results

3.1 Treatment efficiency

The findings summarised in supplementary **Table S1** indicate the results of studies that investigated and compared the treatment efficiency of conventional and self-ligating brackets. Many of these studies reported treatment duration, number of visits and rate of alignment. Only a few reported data for specific treatment phases, such as crowding alleviation or space closure.

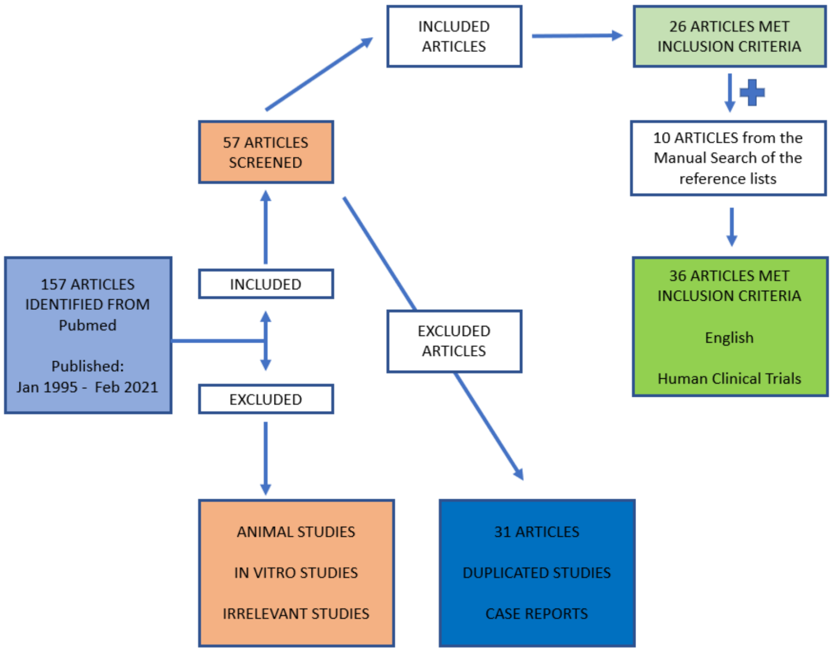

Figure 1. Flowchart of search strategy and selection process.

Four out of nine studies (Pandis et al., 2007; Scott et al., 2008; Songra et al., 2014; Wahab et al., 2014) reported treatment duration specifically for the initial alignment period. Required alignment time for the self-ligating bracket groups ranged from 91.03 days (Pandis et al., 2007) to 422 days (passive SB in Songra et al., 2014), whereas for the conventional bracket groups the period ranged from 114.5 days (Pandis et al., 2007) to 253 days (Scott et al., 2008).

Only one of these studies found significantly faster alignment, specifically for the second time interval (T1–T2), which represented the changes between the first and second month (Wahab et al., 2014). For the other time periods, a similar trend of higher movement rates was observed in the conventional bracket group, but these differences were not significant. Interestingly, in Wahab et al. (2014) crowding alleviation was achieved in a higher percentage of patients in the conventional bracket group (98%) compared with the self-ligating bracket group (67%).

The other five studies (Fleming et al., 2010; DiBiase et al., 2011; Johansson and Lundstrom, 2012; O'Dywer et al., 2016; Jung, 2021) reported only total treatment time. No significant differences in total treatment time were observed between the two study groups in any of these five studies. There was no clear tendency: in three studies a slightly longer treatment was observed in the self-ligating bracket groups (Fleming et al., 2010; DiBiase et al., 2011; Johansson and Lundstrom, 2012), whereas in the other two studies treatment was longer for the conventional bracket groups (O'Dywer et al., 2016; Jung, 2021).

A subset of studies also reported number of visits. Fleming et al. (2010), DiBiase et al. (2011) and Johansson and Lundstrom (2012) all found no significant difference in the number of visits between self-ligating and conventional brackets.

Data on occlusal outcome or space closure were presented by a minority of studies (DiBiase et al., 2011; Songra et al., 2014; Wahab et al., 2014). Similarly, no significant differences were reported for these parameters with respect to bracket type.

Across the studies included in this review, the outcomes are consistent: there were no significant differences between groups using self-ligating brackets and groups using conventional brackets in terms of treatment efficiency, although most of the data showed slightly more favourable results for the self-ligating bracket systems.

3.2 Adverse effects

Root resorption. Out of the 36 selected studies, only eight reported data on root resorption (**Table S2**). Four were randomised controlled trials and four were controlled clinical trials. The mean age of included patients ranged from 12.4 to 20.6 years across studies.

Root resorption was assessed by a variety of methods, including periapical radiography, orthopantomography and cone-beam computed tomography. The specific parameters used to quantify root resorption varied markedly. Some studies reported absolute changes (Scott et al., 2008; Pandis et al., 2008; Leite et al., 2012; Chen et al., 2015; Handem et al., 2016; Qin & Zhou, 2019), others reported relative changes, and others reported volumetric changes (Jacobs et al., 2014; Aras et al., 2018). Consequently, comparability among studies is limited.

All studies reported some degree of root resorption for both conventional and self-ligating brackets; however, none of the eight studies demonstrated significant differences between the two bracket types. In most studies, evaluations were performed at treatment baseline and immediately after treatment, with two exceptions. Leite et al. (2012) evaluated absolute external apical root resorption (EARR) at baseline and six months after treatment initiation. Aras et al. (2018) measured EARR at baseline and nine months after treatment initiation.

Absolute root resorption for self-ligating bracket systems ranged from as low as 0.2 mm for maxillary lateral incisors (Chen et al., 2015) to 2.26 mm (Scott et al., 2008). For conventional brackets, values ranged from 0.3 mm (Chen et al., 2015) to 1.21 mm (Scott et al., 2008).

Across all eight studies, no significant differences were observed between bracket types, irrespective of whether the measurement was reported as absolute, relative or volumetric change. In most studies the between-group differences were small and no consistent trends were identified. The only study reporting larger absolute differences in group means also exhibited high interpatient variability (Chen et al., 2015).

Pain. There are eleven studies reporting data on pain experienced by patients treated with self-ligating versus conventional bracket systems (**Table S3**). Most were randomised controlled trials, while two employed controlled clinical trials in a split-mouth design. Seven studies used visual analogue scales; the remainder used verbal or numeric rating scales.

There was considerable variability in the follow-up periods used to evaluate pain. Four studies (Scott et al., 2008; Fleming et al., 2009; Miles & Weyant, 2010; Lai et al., 2019) reported pain at 4 hours, 24 hours, 3 days and 1 week following archwire placement. Two further studies (Pringle et al., 2009; González-Sáez et al., 2021) evaluated pain daily for seven days after bracket bonding, whereas two other studies (Tecco et al., 2009; Atik & Ciger, 2014) had longer follow-up periods of up to 1 and 3 months, respectively.

Across these studies, outcomes were similar: pain was higher during the first and second days in the conventional-bracket groups. In the self-ligating groups, pain was reported to be greater mainly during archwire engagement and disengagement. Three studies (Miles et al., 2006; Tecco et al., 2009; González-Sáez et al., 2021) reported a statistically significant difference indicating that the conventional bracket system was more painful during the initial stage than the self-ligating system. In contrast, six other studies (Scott et al., 2008; Fleming et al., 2009; Miles & Weyant, 2010; Atik & Ciger, 2014; Rahman et al., 2016; Lai et al., 2019) found no difference between bracket systems in pain levels within the first week after bracket placement.

Four studies (Miles et al., 2006; Fleming et al., 2009; Bertl et al., 2013; Rahman et al., 2016) compared pain during archwire engagement (tying) and disengagement (untying) between self-ligating and conventional brackets. Three of these reported a significantly greater pain during archwire engagement in patients treated with self-ligating brackets.

Periodontal health. Among the 36 selected studies, eight reported data on periodontal health related to the application of self-ligating versus conventional brackets (**Table S4**). Five were conducted as randomised controlled trials and three as controlled clinical trials. The ages of participants included in the studies ranged from 12–30 years.

Four periodontal indices were used for comparison: the plaque index (PI), the gingival index (GI), probing depth (PD) and bleeding on probing (BOP). Only one study (Kaygisiz et al., 2015) included all four outcomes; the remaining studies reported three indices.

In nearly all studies, no significant differences were observed between the two bracket groups for any of the four periodontal indices. Most studies found neither significant differences nor consistent trends between groups. Only one study (Uzuner et al., 2014) reported significant differences in gingival index and probing depth scores in the self-ligating group.

4 Discussion

This review evaluated whether self-ligating brackets confer advantages in orthodontic treatment compared with conventional brackets. Data on treatment efficiency, root resorption, pain and periodontal health were used for the comparison. Data were selected from 36 included studies, comprising randomized clinical trials or controlled clinical trials conducted on patients.

Although most differences were not statistically significant, self-ligating brackets consistently demonstrated slightly better outcomes than conventional brackets. With larger sample sizes in individual studies or by conducting a meta-analysis of a sufficient number of selected studies, these trends could attain statistical significance. Consequently, it may be advantageous to use self-ligating brackets; the benefit is likely small, but efficacy is not reduced compared with conventional brackets. Patient cooperation, extractions and malocclusion severity can have a significant impact on treatment duration and rate of alignment and should therefore be considered. Moreover, duration is most likely influenced by the skill, experience and objectives of the treating orthodontist, in addition to the severity of the patient's malocclusion. Therefore, bracket type is not the sole determinant of improved orthodontic outcomes, and associated factors should be measured concurrently.

The literature indicates that the extent of root resorption is broadly similar between the two bracket types. Concerning bracket type, no statistically significant difference was found between conventional and self-ligating systems, although a trend towards greater root resorption with conventional brackets was evident. Among the eight included studies, Jacobs et al. (2014) included the largest patient cohort and reported a higher rate of root resorption in the conventional bracket group; however, the difference was not statistically significant. In a separate publication, treatment duration and orthodontic force were positively associated with the amount of root resorption and were attributed to persistent bone turnover associated with extended tooth movement (Chen et al., 2015). According to the included studies, both bracket groups had similar treatment durations. Therefore, contributory factors include not only treatment duration but also the forces generated by the bracket system. Self-ligating brackets tend to produce lower forces for a given tooth displacement, which may reduce the magnitude of root resorption, as observed in most studies. In addition, lighter forces have long been recommended to reduce adverse tissue reactions such as root resorption (Reitan, 1974; King & Fischlschweiger, 1982).

Eleven studies examined differences in pain between self-ligating and conventional brackets. The overall assessment with respect to this parameter remains inconclusive: nearly half of the studies reported no clinically significant difference between bracket types, while the remaining studies reported some significant findings. The evidence suggests that, regardless of bracket type, pain is greatest during the first two or three days after archwire placement. During this early period, patients treated with self-ligating brackets generally reported lower pain scores than those treated with conventional brackets, suggesting that the lower friction associated with self-ligating systems may facilitate tooth movement with less discomfort.

All studies that assessed pain during ligation and deligation reported greater pain associated with the ligation and deligation process for self-ligating brackets. Pain during these procedures was influenced by archwire type. Most studies reported that self-ligating brackets did not cause additional pain during initial alignment; however, the use of rectangular stainless-steel archwires was rated as more painful. Furthermore, most self-ligating systems require pressure to engage the archwire; as archwire dimension and rigidity increase, the greater engagement pressure can produce higher pain levels.

Pain is a subjective experience and varies considerably between individuals. Therefore, bracket type alone cannot fully explain pain during orthodontic treatment. In summary, conventional brackets may cause greater pain at the beginning of treatment, whereas self-ligating brackets may be associated with slightly higher pain during engagement and disengagement of larger rectangular archwires, typically toward the end of treatment.

From this review, there is no evidence of a differential periodontal response to orthodontic treatment according to bracket type when individuals with self-ligating and conventional brackets were compared. It has been suggested that self-ligating brackets facilitate improved oral hygiene because they lack elastomeric modules, which are thought to retain and accumulate plaque. Conventional brackets ligated with stainless-steel ligatures exhibited similar changes in periodontal health compared with self-ligating brackets. Moreover, most participants had received instruction in oral hygiene prior to orthodontic treatment, which may partly explain the absence of significant differences.

The review demonstrated a slight tendency favouring self-ligating brackets over conventional brackets with respect to treatment efficacy and root resorption. Although most outcomes were not statistically significant, a greater number of authors expressed a preference for the self-ligating system. This study may provide clinicians with further insight into the respective advantages and disadvantages of self-ligating and conventional brackets.

Conclusions

There is insufficient evidence to conclude whether orthodontic treatment is more or less efficient with self-ligating brackets. However, given the magnitude of changes reported in the studies included in this review, no substantial benefit is anticipated from the use of self-ligating brackets. Consequently, other factors such as cost, availability and ease of use (chair time) should be taken into consideration.

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Ethical approval

No ethical approval was required for this study as it did not involve human participants, animal subjects, or sensitive data. This study falls under the category of data collection without participant identification.

Consent for publication

Not applicable.

Authors' contributions

The author(s) declare that all the criteria for authorship designated by the International Committee of Medical Journal Editors have been met. More specifically, these are: (a) Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND (b) Drafting the work or revising it critically for important intellectual content; AND (c) Final approval of the version to be published; AND (d) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Competing interests

The author(s) declare that there are no competing interests related to this work.

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