Evidence-based comparison of self-ligating and conventional brackets

Comparación de Brackets de Autoligado y Brackets Convencionales basada en la evidencia

Comparação baseada em evidências de colchetes autoligáveis e colchetes convencionais

Germán Hempel Souper[1] 0000-0002-5207-6977
María Ignacia Sat Yaber[1] 0000-0003-2956-9455
Valeria Vargas Aguilar[1] 0000-0003-1645-9839
Alejandro Díaz Muñoz[2] 0000-0002-0884-3411

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Abstract

Self-ligating brackets include a locking mechanism that holds the archwire in the bracket slot. They were created primarily to create a lower friction system, allowing for more efficient sliding mechanics and reducing treatment time.

Objective: This review aims to present all the information available on different self-ligating devices, whether active or passive, in a structured and organized way. This paper sets out to compare their qualities with each other and with conventional devices.

Method: A search was conducted in PubMed and Epistemonikos, regardless of language or year of publication.

Results: Comparisons were made of both active and passive self-ligating brackets and self-ligating brackets with conventional brackets in different clinical situations.

Conclusions No statistically significant difference was found in most clinical situations, except for torque expression, where conventional brackets have a more significant advantage.

Keywords: Orthodontic brackets, Self-ligating brackets, Conventional brackets.

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1 School of Dentistry, Universidad de Chile, Santiago, Chile. gahempel@uc.cl
2 Pediatrics and Dental and Maxillary Orthopedics Department. School of Dentistry, Universidad de Chile, Santiago, Chile

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Resumen

Los brackets de autoligado son aquellos que incorporan un mecanismo de cierre que mantiene el arco en el interior de la ranura del bracket. Fueron creados principalmente para crear un sistema de menor fricción, permitiendo una mecánica de deslizamiento más eficiente y disminuir el tiempo de tratamiento.

Objetivo: El objetivo de esta revisión es presentar de manera más estructurada y ordenada toda la información disponible respecto de los distintos aparatos de autoligado, ya sea activo o pasivo, comparando las cualidades entre sí y con los aparatos convencionales.

Método: Se realizó una búsqueda mediante PubMed y Epistemonikos, sin importar idioma o año de publicación.

Resultados: Se establecieron comparaciones tanto de brackets de autoligado activos con pasivos, como de brackets de autoligado con brackets convencionales en distintas situaciones clínicas.

Conclusiones: Para la gran mayoría de situaciones clínicas, no existe una diferencia estadísticamente significativa, a excepción de la expresión de torque, en donde los brackets convencionales tienen una mayor ventaja.

Palabras clave: Brackets de ortodoncia,Brackets de autoligado, Brackets convencionales.

Resumo

Os braquetes autoligáveis são aqueles que incorporam um mecanismo de fechamento que mantém o fio dentro da ranhura do braquete. Eles foram criados principalmente para criar um sistema de menor atrito, permitindo uma mecânica de deslizamento mais eficiente e reduzindo o tempo de tratamento.

Objetivo: O objetivo desta revisão é apresentar de forma mais estruturada e ordenada todas as informações disponíveis sobre os diferentes dispositivos autoligáveis, sejam eles ativos ou passivos, comparando as qualidades entre si e com os dispositivos convencionais.

Método: A busca foi realizada usando PubMed e Epistemonikos, independentemente do idioma ou ano de publicação.

Resultados: Foram comparadas braquetes autoligáveis ativos e passivos e braquetes autoligáveis convencionais em diferentes situações clínicas.

Conclusões: Para a grande maioria das situações clínicas, não há diferença estatisticamente significativa, exceto para a expressão do torque, onde os braquetes convencionais apresentam maior vantagem.

Palavras-chave: aparelho ortodôntico, aparelho autoligável, aparelho convencional.

Introduction

The term *self-ligating* refers to brackets that include a locking method, either a clip, cap, or gate mechanism that holds the archwire inside the bracket slot[1–3].They were designed to eliminate metallic and elastomeric ligatures, based on the concept that this system would create a lower friction environment, allowing for more efficient sliding mechanics that could reduce treatment time[4]. They can be classified into passive and active according to the locking mechanism in place[5,6]. In an active system, the ligation clip exerts pressure on the archwire, unlike the passive system, where the locking mechanism transforms the slot into a tube[5].

The concept of self-ligating brackets appeared in 1935, with the Russell appliance described by Dr. Stolzenberg[7], as an attempt to improve clinical efficiency by reducing ligation time[8,9].

Several new self-ligating appliances have been developed in recent decades. Their creators claim that they are more efficient than traditional methods. Other existing appliances have been modified to adapt to the requirements of clinicians and patients[10].

Many properties have been proposed for any ligation system. Harradine states that a ligation system should be secure and firm, ensure full bracket engagement of the archwire, show low friction between bracket and archwire, allow for high friction when required, demand little clinical time, allow easy attachment of auxiliary elements, help maintain good oral hygiene, and finally, be comfortable for the patient[11].

The main advantage of self-ligating brackets is the low friction during tooth movement, allowing teeth to slide more easily over the archwire and clinicians to use lower forces[11].

A review of the literature reveals a large number and diversity of studies with contradictory results. This creates confusion among orthodontists as to the actual usefulness of this type of bracket in clinical practice.

This review aims to present all the information available on different self-ligating devices, whether active or passive, in a structured and organized way. This paper sets out to compare their qualities with each other and with conventional devices. The most relevant clinical considerations will also be discussed.

Methodology

The literature review was conducted in PubMed MEDLINE and Epistemonikos. The term *self-ligating brackets* has been used in 518 papers. An additional 30 studies identified through other sources were added. Clinical trials, meta-analyses, randomized clinical trials, and systematic reviews comparing self-ligating brackets with each other or with conventional brackets in different clinical situations were included. The papers were not filtered according to the year of publication. Narrative reviews were not considered, nor were papers without a full text. We also did not consider papers that combined self-ligating brackets with other types of appliances, nor studies of lingual self-ligating brackets. Studies that appered in both search sources and studies unrelated to the topic were also eliminated. In the end, 96 studies were included.

The results are divided into two areas to organize the information collected. First, different passive and active self-ligating brackets at different stages of treatment are compared. Then, different clinical aspects of self-ligating and conventional brackets are compared. In each area, both clinical and in vitro studies will be presented first, followed by a reference to the systematic reviews that have studied the same clinical aspects.

Development

Passive vs. active self-ligating brackets

The results were organized into the following treatment elements:

Friction

In vitro studies have shown that passive self-ligating brackets have less friction than active self-ligating brackets; therefore, sliding mechanics improve with passive brackets. However, bracket design must also be considered[12,13].

Alignment and leveling

One study compared the time required to align moderate maxillary anterior crowding and found no difference when correcting the initial crowding[14]. A systematic review with meta-analysis concludes that active self-ligating brackets appear to be more efficient for initial alignment[6].

Torque expression

Active self-ligating brackets would be more effective in torque expression than passive self-li-

gating brackets[15]. Other studies conclude, however, that the influence of the ligature or the active or passive closure mechanism is minimal and that the size of the slot is much more important for torque expression[5]. Systematic reviews in this regard show a slight difference in torque expression between active and passive self-ligating brackets[16].

Self-ligating vs. conventional brackets

The differences between active and passive self-ligating brackets and conventional brackets will also be expressed according to the following clinical elements.

Friction

Studies, mainly experimental, show various results, ranging from significantly lower friction to a significant increase in friction[17,18]. Henao and Robert's in vitro study compares both types of self-ligating brackets with conventional brackets. Using three different archwires, they detected a significantly lower difference regarding friction in passive self-ligating brackets with 0.014-inch archwires[19]. In a similar study, Burrow concludes that friction and reversible elastic wire deformation (binding) was higher in conventional brackets when using elastomeric ligatures. Sliding resistance was lower in passive self-ligating brackets[20]. Costa et al. obtained similar results: they observed a reduction in friction in passive self-ligating brackets[21]. A systematic review concludes that passive and active self-ligating brackets only produce less friction when low diameter round archwires are used on previously aligned dental arches. However, in severe malocclusions, there is insufficient evidence to ensure that there is less friction when using rectangular archwires[22].

Alignment and leveling

Some studies, mainly laboratory studies, show that self-ligating systems produce significantly greater tooth movement at this stage due to their low friction[23]. However, other studies show that similar results can be obtained by using conventional brackets with moderate-strength metal ligatures[24]. Conversely, other studies conclude that neither self-ligating system is more efficient in reducing crowding[25,26].Ong et al. obtained similar results when comparing passive self-ligating brackets with conventional brackets. They added that the ligation method is only one factor that can influence this stage of treatment[27]. In contrast, Scott et al. and Abdul et al. report that conventional brackets would be more efficient in the first four months when compared to passive self-ligating brackets[28,29]. Pandis et al. studied the behavior of passive self-ligating brackets with conventional brackets according to the degree of crowding: greater or less than 5 mm. They found no significant difference in severe crowding, but passive self-ligating brackets were more efficient in moderate crowding[30]. Conventional brackets proved to be the most efficient in controlling and correcting rotations, followed by active self-ligating brackets and passive self-ligating brackets[31]. Systematic reviews[32,33] point out a controversy regarding initial alignment in extraction orthodontics. However, in non-extraction cases, the values and duration of the alignment phase and the changes in incisor position and inclination were almost identical in patients treated with both systems[32]. The efficiency of orthodontic alignment has shown little difference between the different types of fixed appliances[33].

Anchorage loss

Anchorage loss in conventional and passive self-ligating brackets was compared. The authors found no difference in anchorage loss between the two groups[34]. Similar results were obtained in several studies comparing self-ligating brackets with conventional brackets[35–39]. Systematic reviews conclude that both conventional and self-ligating brackets showed the same anchorage loss[40] and that no evidence suggests a significant difference between conventional and self-ligating brackets[41].

Space closure

Studies show that self-ligating brackets exhibit no advantages in this phase[24], and the same rate of canine retraction is observed when comparing both self-ligating systems with conventional brackets[35–38]. We compared passive self-ligating brackets with conventional brackets with metal ligatures. Regarding the range of mass space closure, there were no significant differences in the number of millimeters by which spaces closed per month[42,43,44]. Burrow obtained different results when comparing a passive self-ligating bracket with a conventional bracket, as conventional brackets achieved better space closure[45]. Systematic reviews[32,33,46] on this subject show no significant difference. Regarding en-masse retraction of incisors and canines, it is concluded that the use of self-ligating brackets does not improve space closure compared with conventional braces[32]. Space closure rate efficiency has shown little difference between the different types of fixed appliances[33]. Therefore, self-ligating brackets are not clinically superior to conventional brackets[46].

Torque expression

Conventional brackets show better torque control than self-ligating brackets as the latter cannot press the archwire into the slot fully[47]. However, another study comparing conventional brackets with passive self-ligating brackets concluded that the latter appear to be equally effective in applying torque to the upper incisors compared to conventional brackets in extraction or non-extraction cases[48]. Systematic reviews on this topic conclude that conventional brackets express torque better than self-ligating brackets[16].

Transversal changes

It has been proposed that self-ligating brackets have a more significant effect on transversal changes than conventional brackets[49,50]. However, studies found no differences in the dimensional changes of the maxillary arch or changes in the inclination of incisors and molars in any type of bracket when using transversely wider archwires[49,50]. Buccal bone modeling using passive or active self-ligating brackets could not be confirmed either[51]. Other studies comparing conventional brackets with passive self-ligating brackets found no significant differences in the transversal dimension in the maxillary arch or in any periodontal clinical parameters[52,53,54]. The only significant difference was that passive self-ligating brackets showed a greater buccal inclination of the upper molars than conventional brackets[52]. Other types of studies have found different results when comparing passive self-ligating brackets with conventional brackets: the most significant transversal movement occurs in the premolar area in both techniques and is significantly greater with passive self-ligating brackets[55,56]. In the same study, inter-canine distance increased significantly with conventional braces compared to self-ligating brackets[55]. In similar studies, the passive self-ligation group showed a greater increase in intermolar and inter-canine width[56,57,58].
Systematic reviews show no evidence of self-ligating brackets being more efficient than conventional brackets in transversal expansion[46]. The dimensional arch changes observed with self-ligating and conventional brackets appear to be similar, with comparable levels of inter-canine expansion[33].

Root resorption

In vitro studies have shown a reduction in the force exerted by active self-ligating brackets compared with conventional brackets with metal and elastomeric ligatures, concluding that this may reduce adverse effects such as root resorption associated with high force levels[59]. However, randomized clinical trials show that root resorption does not depend on the brackets used[28,60,61]. A systematic review suggests that self-ligating brackets do not outperform conventional brackets in reducing external apical root resorption in upper lateral incisors

and mandibular central and lateral incisors[62]. However, self-ligating brackets may have an advantage in protecting the upper central incisor, which has yet to be confirmed by higher-quality studies[62]. Another review mentions inconclusive results in the clinical management of root resorption[63].

Clinical time

Studies comparing the time required to position and remove ligatures in conventional metal and ceramic brackets, and in active and passive self-ligating brackets have shown that an average of 8 minutes per arch is required for metal ligatures. For elastic ligatures, this takes 2.3 minutes, and for self-ligating brackets, only 0.7 minutes[64]. Other studies conclude that passive self-ligating appliances provide a faster and more efficient system of archwire replacement, reporting clinical time savings of approximately 1.5 minutes per patient[65]. In contrast, Harradine found that this time reduction in a passive self-ligating system was small and of little clinical relevance[66]. A review concludes that both types of self-ligating brackets appear to have a significant advantage regarding clinical time[67].

Checkup frequency

The locking mechanism of self-ligating brackets is not subject to biological degradation, as with elastomeric ligatures. Therefore, it would be possible to increase the time between checkups[64]. Regarding the number of appointments needed to complete the treatment, some studies indicate that patients passive self-ligating brackets required between four and seven fewer appointments than those with conventional braces[4,66]. In contrast, other studies comparing active or passive self-ligating brackets with conventional brackets found that self-ligating systems do not reduce the number of checkups[68,69,70]. One review shows no reduction in the number of appointments compared to conventional brackets[32]. Another states that no relevant conclusions can be drawn given the few studies included[71].

Total treatment time

Some authors report that cases treated with passive self-ligating appliances ended, on average, between 4 and 6 months earlier than conventional ones[4,66]. Other studies comparing active self-ligating brackets with conventional brackets show that treatment was completed, on average, 5.7 months earlier than cases treated with conventional braces[72]. However, the decrease in months of treatment is not statistically significant[34]. However, other studies show that active or passive self-ligating appliances do not reduce treatment time compared to conventional appliances[68,70]. One review shows no decrease in total treatment time compared with conventional braces[31]. At the same time, another indicates that it is impossible to draw conclusions on the differences between the two types of brackets given the limited number of studies included[71].

Patient comfort

When evaluating patient discomfort with passive self-ligating brackets and conventional brackets, no differences were found in the seven days after inserting the 0.014-inch Cu Nitti archwire[73]. Rahman et al. reached the same conclusion, as they found no significant differences in pain[74].

When comparing the pain experience in patients treated with an active self-ligating system with conventional appliances, no differences were found between the two groups with an initial 0.016-inch NiTi archwire. However, when evaluating the pain associated with removing NiTi 0.019x0.025-inch archwires and inserting SS 0.019x0.025-inch archwires, the self-ligating group reported more significant perceived pain[75]. Similar results were obtained when comparing passive self-ligating brackets with conventional brackets when inserting or removing rectangular archwires: patients with

self-ligating brackets experienced more pain[76]. Another study reports differences when comparing passive self-ligating brackets with conventional brackets in initial stages with a 0.014-inch NiTiCu archwire. The authors found less pain in the group treated with self-ligating brackets[77,78], as did Pringle et al.[79].However, when the archwire diameter was increased to 0.016x0.025 inch, the pain increased with self-ligating appliances[77,78]. Other studies found no evidence of a difference in pain intensity when comparing self-ligating brackets with conventional brackets when evaluated after 4 hours, 24 hours, 3 days, 1 week and 1 month[80].

Regarding bracket appearance, patients preferred conventional brackets[77]. Regarding the contact between the brackets and the lips, the patients with self-ligating brackets reported greater discomfort[77].

Systematic reviews report greater discomfort with self-ligating brackets, although the differences are neither statistically nor clinically significant[32,33,81]. Other reviews do not reach conclusions on this issue due to the few studies included[71].

Hygiene and halitosis

Some studies have shown that self-ligating appliances had a higher accumulation of periodontal pathogens[21,82,83]. However, other studies show no differences, so bracket design does not seem to have a major influence on biofilm accumulation or the presence of periodontal pathogens in subgingival plaque or gingival inflammation[84,85,86,87,88]. Therefore, self-ligating brackets do not differ regarding *Streptococcus mutans* or *Lactobacillus* colonization compared to conventional braces[88,89,90] and would have no advantage over conventional brackets regarding periodontal status and halitosis[91]. In contrast, a study indicates that self-ligating brackets exhibit less biofilm retention, better periodontal parameters, and less halitosis compared with brackets with elastomeric ligatures[92,93].

Some systematic reviews conclude that self-ligating metal brackets accumulate less *Streptococcus mutans* biofilm than conventional metal brackets. However, they suggest that these findings should be interpreted jointly with individual patient characteristics, such as hygiene and eating habits[94]. Other results show that self-ligating brackets do not outperform conventional brackets in promoting better oral health[81] and others show that there is no evidence of a potential influence of bracket design (conventional or self-ligating) on colony formation and adhesion of *Streptococcus mutans*[1,95]. Regarding halitosis, reviews found that selfligating brackets controlled malodor better than conventional brackets[96].

Discussion

This review shows a wide variety of results and conclusions regarding passive and active self-ligating brackets, and conventional brackets. Therefore, it is important to organize all the available information for clinical decision-making based on current evidence.

Regarding the studies of self-ligating brackets, their validity seems questionable. Several elements must be considered when reading these types of articles. As Rinchuse et al. point out, many of these studies are performed in vitro, so they fail to simulate the patient's biological response, and others focus on only part of the treatment. In addition, tooth movement range is much greater than clinical movement[8]. Additionally, brackets have many different sizes, making it difficult to compare them with conventional brackets[8]. Many of these studies focus on different size archwires, so it is difficult to draw clear conclusions by unifying all the criteria.

Clinical studies show contradictory results when evaluating the differences between passive and active self-ligating brackets concerning alignment and leveling. The only systematic review consulted concludes that active self-li-

gating brackets would be more efficient in the alignment stage. However, the authors add that more studies are required to confirm these results since their review considered only three studies, and the differences found were not statistically significant[6,14]. Regarding friction, they conclude that passive self-ligating brackets would have certain advantages. However, these are in vitro studies, so results must be analyzed cautiously and considering the comments above[12,13]. The same applies when comparing these studies in terms of torque expression. One systematic review shows a small silght in torque expression[5,15,16].

When grouping the data between active and passive self-ligating brackets with conventional brackets, we detected contradictory results when comparing various clinical studies at different treatment stages and with clinical considerations. Regarding friction, a single systematic review concludes that self-ligating brackets would produce less friction with round archwires of smaller caliber in an ideally aligned dental arch. However, this clinical situation occurs in very few cases[17-22].

Regarding orthodontic treatment stages, there are no significant differences in alignment and leveling between the different types of fixed appliances[23-33]. When evaluating anchorage loss and space closure, no significant evidence showed any difference between the different types of brackets[24,32-46]. Regarding torque expression, conventional brackets have better results than self-ligating brackets[16,47,48]. Finally, when analyzing transversal expansion, there is no evidence of the superiority of self-ligating brackets[33,46,49-57].

Further contradictory results appear in the various clinical studies evaluating other clinical considerations of self-ligating and conventional brackets. Regarding root resorption, only one in vitro study indicates the possible root protective effect of self-ligating appliances due to the amount of force exerted in relation to their conventional counterpart. However, clinical studies show similar results regarding root volume loss in both types of brackets, and systematic reviews conclude that a system cannot be considered superior to the other[28,59-63].

Only one study found a reduction in clinical activity time with self-ligation brackets, which would be of little clinical relevance. Finally, the systematic reviews mention that self-ligating appliances seem to have a significant advantage regarding chair time. However, it remains to be seen whether this difference is clinically relevant[64-67].

As the self-ligating systems have the advantage that the locking mechanism is free of biological degradation, the checkup interval can be increased. However, when reviewing the literature on checkup frequency, the results are mixed, and the systematic reviews generally show no reduction in the number of appointments compared to conventional brackets[4,32,64,66,68-71].

Regarding total treatment time, some authors report a decrease in the cases treated with self-ligating brackets; others say that this reduction is not significant. One study even reports a longer time for self-ligating brackets[4,31,33,60,62-64]. However, systematic reviews show no decrease in total treatment time compared with conventional devices[4,32,34,66,68-72].

As for comfort, patients experience greater discomfort with self-ligating brackets, but this is not statistically significant[32,33,71,73-81]. Finally, reviews and clinical studies are also contradictory when analyzing hygiene levels. Some find no differences, and others state that self-ligating brackets accumulate less *Streptococcus mutans* biofilm, so the issue is far from clear [1,21,81-96].

Conclusions

After reviewing the available literature on self-ligating brackets, we can draw the following conclusions:

- Regarding alignment, leveling, friction, space closure, anchorage loss, transversal changes, root resorption, checkup frequency, duration

of treatment, patient comfort, and hygiene, and halitosis, the results show no significant differences between self-ligating or conventional brackets, and further studies are required to support their clinical relevance.
- As for chair time, there is no evidence suggesting that self-ligating brackets significantly decrease clinical time compared to conventional brackets.
- The main disadvantage of the self-ligating system compared with conventional brackets is that torque expression is more problematic.
- Many external factors related to tooth movement cannot be controlled, but they can affect the comparison between self-ligating and conventional brackets.
- In vitro studies show different results than clinical studies.

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Authorship contribution
1. Conception and design of study
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6. Approval of the final version of the manuscript.

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MISY participated in 1, 2, 3, 4, 5 and 6.
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