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Evaluation of the efficiency of passive self-ligating versus conventional brackets in the alignment of mandibular crowded teeth (A comparative study)

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Aim: Is to compare the efficiency of passive self-ligating versus conventional brackets in the alignment of crowded mandibular teeth.
Materials and methods: A randomized clinical trial with Fifty participants visiting the clinic of the Orthodontic Department and fulfilling the eligibility criteria were enrolled in the study. Patients were randomly allocated to group A (Conventional brackets) or group B (Damon Q metal passive self-ligating brackets). The amount of mandibular crowding was assessed by Little's irregularity index. Subjects in both groups were recalled for follow-up every four weeks till completion of alignment.
Results: There was no significant difference in baseline irregularity in both groups. The time needed in months to achieve zero Little irregularity index was insignificantly shorter in group B (5.04 ± 1.30) than in group A (5.05 ± 1.20) (P=0.99). Number of visits in group A (5.76± 1.30) was insignificantly lower than group B (5.87 ± 1.69) (P=0.86). Correlation between the initial little irregularity index and rate of improvement revealed a significant positive correlation between them in both groups. The rate of improvement was (0.96 ± 0.09) with little irregularity index 4 and increased to (1.17 ± 0.24) with little irregularity index 8.
Conclusions: There was no time difference between passive self-ligating brackets and conventional brackets in correcting mandibular crowding. Furthermore, no difference in the number of visits. The amount of initial irregularity and the timing were the factors that affected the rate of alignment.

Keywords: self-ligating brackets, conventional brackets, Damon brackets, alignment efficiency

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Introduction

A vast progress in the development of new appliances with new ligation features has occurred recently, one of them being self-ligating brackets. The bracket type became popular due to its convenience and clinical efficiency.[1,2]

Self-ligating brackets have several presumed advantages that include lower forces and moments and higher rates of tooth movement, this is due to the absence of binding of ligatures on the wire. The inbuilt metal labial face of the bracket system has full arch-wire engagement and low friction.[3] Other advantages include improved esthetics, fewer visits, shorter treatment time, and better oral hygiene.[4-6]

The debate is still present between self-ligating brackets and conventional brackets regarding the presence of actual comparative advantage, although improved treatment efficiency was found in retrospective studies that showed that self-ligating brackets can shorten treatment times by four to six months and reduce the number of appointments by four to seven visits. [7-10]

According to lab research, passive self-ligating brackets showed lower friction.[2,11] This was found only in conjunction with certain wires.[12,13] According to a review on frictional resistance, self-ligating brackets only reduce friction when used in conjunction with small round wires in an aligned arch free from tipping and malalignment. The conclusion was that there is insufficient data to support the idea that self-ligating brackets reduce friction when used with bigger wires or on tipped teeth.[14]

The claims about the clinical performance and superiority of different bracket types come from the manufacturers due to the lack of randomized clinical trials. These statements are often supported by marketing-oriented ideas rather than research data. Recent systematic reviews have drawn attention to the variability of data and suggested that further clinical trials are necessary to corroborate it.[15, 16]

In light of these details, we conducted this trial to determine the time to initial alignment for mandibular teeth while employing either passive self-ligating or conventional brackets.

Materials and methods

A prospective randomized clinical trial was conducted in the Orthodontic Department clinic, Faculty of Dentistry, Ain Shams University. The reference for sample size calculation is a study by Pandis et al.[17] The minimum acceptable sample size for each group was 18, given that the mean ± SD of treatment duration in 1st group was 114± 46 days. The estimated mean difference with the 2nd group was 45, the power was 80%, and the type I error probability was 0.05. To make up for the dropout, each group's sample size was raised to 25. To conduct the sample size calculation, the software (P.S. Power 3.6.9.) was used.

Fifty participants were enrolled in the trial. The inclusion criteria was: Patients with ages ranging from 18-40 years old, Patients with non-extraction treatment, Patients with permanent dentition with the exclusion of 3rd molars, and patients with Little's irregularity index[18] higher than 4 mm. While the exclusion criteria were: Patients with spacing arch, Poor oral hygiene, Patients with previous orthodontic intervention, Patients underwent orthognathic surgery.

Patients who fulfilled the eligibility criteria were randomized to either Group A or Group B. Group A: 25 patients underwent fixed appliance therapy using conventional brackets. Group B: 25 patients underwent fixed appliance therapy using passive self-ligating brackets.

A colleague not involved in the clinical trial, generated randomization sequences using the Microsoft Excel software (Microsoft, Redmond,

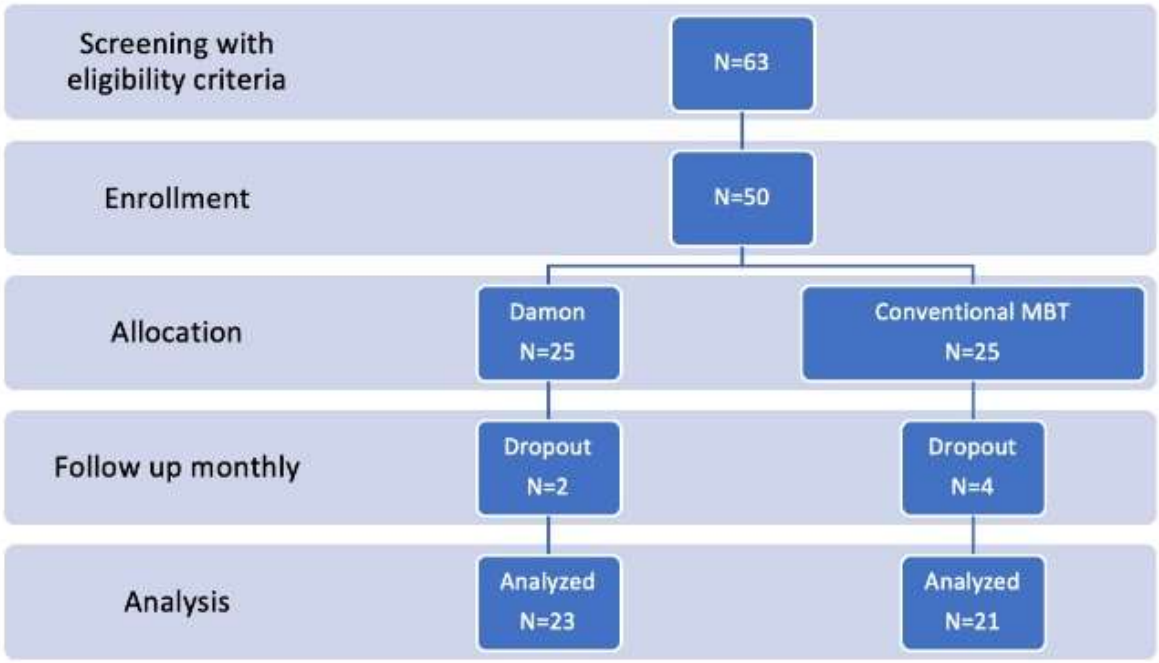

Figure (1): CONSORT flow chart.

Washington, USA). Each subject was given a number in the order in which he/she showed up for diagnosis. Allocation of the subjects into either group A or B was performed by matching that number with the generated sequence. The principal investigator was blinded to patient allocation. CONSORT flow chart (Figure 1).

After examining the study protocol, the ethical committee of Ain Shams University's Faculty of Dentistry accepted the study design. Approval (FDASU-RecIM011964). After educating the participants about the therapies and any potential side effects, written consent forms were collected.

Comprehensive patient diagnosis was performed using the orthodontic department standard evaluation sheet. All patients underwent clinical examination that included Extraoral examination and Intraoral examination. Diagnostic records included Photographs, Radiographic records, and Orthodontic study models.

The degree of mandibular crowding was assessed by Little's irregularity index. This was done by measuring the linear displacement of the anatomic contact points of each mandibular incisor from the adjacent tooth anatomic point, the sum of these five displacements representing the relative degree of anterior irregularity.

Perfect alignment from the mesial aspect of the left canine to the mesial aspect of the right canine would theoretically have a score of 0, with increased crowding represented by greater displacement and, therefore, a higher index score.

Intervention For Group A: In this group, conventional MBT pre-adjusted brackets (0.022-inch slot) were used. Each bracket was placed to its corresponding tooth using a bracket holder and heights were measured using a bracket positioning gauge. Cementation was done using a 3M Transbond transparent orthodontic composite. The composite was light-cured

for 30 seconds at a distance of 3 mm and an angle of 45° to the surface.[19]

First, an alignment was performed using a 0.013-inch round Copper NiTi Archwire (Ormco, California, USA); on the second appointment, a 0.014-inch Cu NiTi wire was utilized. Then a Cu NiTi wire measuring 0.016 inches at the third visit, a Cu NiTi wire measuring 0.018 inches at the fourth visit, and a Cu NiTi wire measuring 0.014 inches by 0.025 inches at the last visit.

For Group B: The same steps were performed for Group B the difference was in bracket type. In this group, Damon Q metal passive self-ligating brackets were used. Bracket positioning is based on Andrews' principles where the slot point coincides with the FA point with the lower cuspid's bracket slightly mesial to the height of the contour. An equal amount of enamel should be present above the occlusal border of the incisor bracket pad. To open and close the brackets, we used the Damon Key (Figure 2).

Figure (2): The Damon Key was used to open and close the brackets.

Alginate impressions were taken for patients and poured. The stone casts were measured using a digital caliper. A 3-shape R-750 scanner was used to scan the stone casts (3shape A/S. Copenhagen, Denmark). The digital models were analyzed and there was no difference in measurement between the digital caliper and scanned casts.[20] The Little's irregularity index was remeasured till completion of alignment was obtained.

The bonding date was recorded. The follow-up appointments were every four weeks till the completion of alignment. The number of follow-up visits was recorded**.** Complete alignment was judged clinically by re-measuring the irregularity index. The time to alignment was calculated in months.

Statistical analysis was performed with SPSS 20®, Graph Pad Prism®, and Microsoft Excel 2016. All quantitative data were presented as minimum, maximum, means, and standard deviation (SD) values. In Quantitative data: In non-parametric data. Accordingly, a comparison between the 2 groups was performed by using Mann Whiteny`s test. While in normal data (age) comparison between both groups was performed by using an independent t test. In Qualitative data: All comparisons were performed by using Chi-square test. The correlation between rate of improvement and age and initial little irregularity index was evaluated using Pearsons's correlation coefficient.

Results

Gender distribution was insignificant (P=0.77) as male was (14.3%) and (17.4%), while female was (85.7%) and (82.6%) regarding groups A and B respectively.

Comparison between groups regarding age revealed insignificant differences between them (P=0.47), a group A (20.33 ± 1.65) was insignificantly lower than group B (20.70 ± 1.64) with (0.36 ± 0.5) mean difference. The irregularity index was (5.52 ± 1.29) and (5.74 ± 1.57) for group A and group B respectively, the difference was statistically insignificant (P=0.77).

Table 1: Minimum, maximum, mean and standard deviation of time needed in months to achieve zero LII among group A and B and comparison between them using Mann Whiteny`s test:

	Time needed in months				MD	SED	95% CI		P value
	Min	Max	M	SD			L	U	
Group A	3	8	5.05	1.20	0.01	0.38	-0.76	0.77	0.99
Group B	3	8	5.04	1.30					

M: mean, SD: standard deviation, md: mean difference SED: standard error difference, CI: confidence interval, L: lower arm, U: upper arm, P value: statistically significant <0.05

Table 2: Minimum, maximum, mean and standard deviation of number of visits among group A and B and comparison between them using Mann Whiteny`s test:

	Number of visits				MD	SED	95% CI		P value
	Min	Max	M	SD			L	U	
Group A	4	9	5.76	1.30	0.11	0.46	-1.03	0.82	0.86
Group B	3	10	5.87	1.69					

M: mean, SD: standard deviation, md: mean difference SED: standard error difference, CI: confidence interval, L: lower arm, U: upper arm, P value: statistically significant <0.05

The time needed in months in groups A &B was presented in Table (1). The time needed was shorter in group B (5.04 ± 1.30) than in group A (5.05 ± 1.20) with a (0.01 ± 0.38) mean difference. However, it was statistically insignificant (P=0.99).

The number of visits in groups A &B is presented in Table (2). Comparison between groups revealed insignificant differences between them (P=0.86), Number of visits in group A (5.76± 1.30) was insignificantly lower than in group B (5.87 ± 1.69) with (0.11 ± 0.496) mean difference.

The rate of little irregularity index improvement per month in groups A &B revealed insignificant differences between them (P=0.59), in group A (1.11± 0.21) was insignificantly lower than in group B (1.14 ± 0.15) with (0.03 ± 0.05) mean difference.

Factors affecting the rate of little irregularity index improvement included: The Initial little irregularity index as the rate of little irregularity index improvement in both groups in correlation with the initial little irregularity index was presented in Table (3). The correlation between initial LII and rate of improvement was evaluated using Pearson`s correlation coefficient which revealed a significant positive correlation between them in both groups. The rate of improvement was (0.96 ± 0.09) with LII 4 and increased to (1.17 ± 0.24) with LII 8.

The other factor is the percentage of improvement of little irregularity index per month: The rate of little irregularity index improvement percentage in groups A &B were presented in Table (4). The table shows higher rates of improvement in the initial treatment months with a deceleration of improvement rates as the months progress. The improvement percentage was 53% in the first month which decreased to 0.3% in the seventh month. Comparison between groups A & B revealed insignificant differences between them in all months.

Discussion

"When do I get my braces off" is one of the first questions the orthodontic patients ask. For many reasons, a more thorough comprehension of the variables influencing therapy duration may be beneficial. Shorter treatment periods have an influence on lifestyle from the standpoint of the patient and from the perspective of the orthodontist, patients are less susceptible to side effects and compliance "burnout." [21]

Fixed appliance orthodontic treatment is usually finished in 15 to 24 months. The movement of teeth is based on the slow turnover of bone and the adaptation of the periodontal tissues to the applied stresses. Treatment duration is influenced by many factors, including patient compliance, occlusal characteristics (as impacted teeth and Class II molar relationships), and treatment procedure itself as treatments that involve extractions and molar relationship correction typically take longer to complete.[22]

Although the idea that a bracket system may affect how long a patient receives therapy has been proposed, it has not yet been supported by prospective research. However, by lowering related biological hazards and time requirements, the potential creation of such an upgrade would benefit the patient as well as the practitioner.[23]

Self-ligating brackets, and the Damon system in particular, have garnered a lot of interest and have seen a significant rise in use in recent years.[24] Numerous benefits have been mentioned, such as less

friction, decreased forces and moments produced, less pain, improved tooth movement and sliding mechanics, increased arch expansion, continuous arch-wire engagement, decreased biostability, and shorter chair-side times. While bracket advancements have attracted scientific and commercial attention, there is still insufficient clinical proof. [25]

This study aimed to compare the efficiency of passive self-ligating versus conventional brackets in the alignment of crowded mandibular teeth.

When comparing Damon self-ligating brackets to conventional brackets, in the current study there was no reduction in time needed for initial irregularity relief. The time needed was less in the Damon group (5.04 ± 1.30) than in the conventional bracket group (5.05 ± 1.20), but the difference was not statistically significant (P=0.99).

These results agree with a study conducted by Ribeiro et al.[26] The relief of mandibular crowding during the first alignment phase did not provide statistically significant differences between self-ligating and traditional bracket systems, according to the authors. However, following 600 days of therapy, the difference in mandibular crowding correction became statistically significant.

In a split-mouth study by Miles et al.[27] to evaluate the effectiveness of Damon2 brackets vs traditional twin brackets for mandibular teeth alignment. The traditional twin bracket system had a lower irregularity index score than the Damon2 bracket by 0.2 mm at both 10 and 20 weeks following the commencement of therapy, a difference that was clinically insignificant. The authors concluded that in terms of alignment efficiency during the early phases of orthodontic treatment, there was no discernible difference between the Damon2 and conventional bracket systems.

The self-ligating bracket (Smart clip) did not outperform a traditional bracket (with stainless steel ligatures or elastomeric modules) during the first phases of therapy in another trial by Miles and colleagues using a similar design.[28] Moreover, no significant difference was seen in early mandibular alignment for Damon3 self-ligating brackets and Synthesis conventionally ligated counterparts in a trial conducted by Scott et al.[29]

Pandis et al.[30] chose to estimate the time required to correct the lower anterior teeth rather than comparing the initial relief in irregularity. They enrolled 54 patients who required non-extraction therapy and had a mandibular irregularity index of >2 and allocated them to two groups: Damon2 self-ligating brackets and traditional edgewise appliance (Micro-arch).

They concluded that during the first alignment stage, there was no time difference in mandibular crowding relief between Damon2 and traditional brackets. However, a 2.7 times quicker correction was shown with the Damon2 bracket system for moderate mandibular crowding. Regardless of the kind of bracket, the treatment duration rose by an extra 20% for each irregularity index in cases where there was higher crowding (LII>5 mm).[30]

The findings might be explained by the possibility that excessive arch-wire bending prevents self-ligating appliances from fully closing the sliding cap in situations of severe dental crowding and rotations. In severe cases, the failure of full arch-wire engagement prevents the arch-wire from freely moving within the bracket slot, potentially reducing the velocity of tooth movement.

In comparison to conventional brackets, earlier research by Eberting[8], Harradine[7], and their colleagues showed much shorter treatments (4–6 months) and fewer visits when employing Damon brackets. However, there is a chance for bias due to the retrospective designs of these studies. Moreover, it appears that treatment time reductions using SLBs may occur in later phases of the course of therapy.

Extraction and non-extraction cases (40% extraction in Harradine et al.[7] trial) were both included in the retrospective studies previously addressed, which represents a more complicated set of cases. Furthermore, these trials did not address the arch-wire sequence or the matching procedure utilized to place patients in study groups. This clarifies the discrepancy between our findings because we employed the identical arch-wire sequence in both groups and did not utilize any extraction cases.

The majority of earlier clinical studies on the effectiveness of self-ligating brackets during the alignment phase exclusively focused on lower dental irregularities. In a research by Jahanbin et al.,[31] the authors discovered that throughout the initial alignment stage, the self-ligating Damon3 MX system corrected upper dental crowding noticeably more quickly than MBT pre-adjusted brackets.

Nonetheless, this difference could not be established in rates of improvement in mandibular irregularity throughout the 4-month period. The variation in the study's correction rate for upper and lower dental crowding may be attributed to the maxillary alveolar bone's reduced trabecular density, which promotes orthodontic tooth movement.[31]

When evaluating the length of therapy, the number of appointments is relevant. According to our research, there was no statistically significant difference in the number of appointments between the groups while using Damon self-ligating brackets versus traditional brackets (P=0.86).

Using self-ligating brackets systems, Fortini et al. [32] and Eberting et al. [8] reported four and seven visits less, respectively. Patients treated with self-ligating brackets had longer appointment intervals than those treated with conventional brackets, according to observational data. [33]

Two studies indicate more appointments with self-ligating brackets than with conventional brackets, whereas one research indicates more appointments with conventional brackets, according to a meta-analysis by Alessandra et al. [34]. Therefore, they concluded that the difference was not significant.

Extended appointment intervals must be planned with the greater fracture risk of NiTi arch-wires in mind. Less frequent visits are often appreciated by patients, but the unintended result is ineffective monitoring of the effects, side effects, dental hygiene, and complications. If patients are not given instructions on how to deal with their bracket or arch-wire fails, treatment time may be lost.[35]

In research by Songra et al.[36], conventional brackets took less time to align the teeth than active and passive self-ligating brackets. Nevertheless, this might be more a result of other variables than the bracket ligation technique, such as the variation in the intervals between follow-up visits.

They planned the study as the manufacturer instructed, with appointments at twelve weeks for self-ligating brackets and six weeks for conventional brackets. This allowed faster progression in the arch-wire sequence with the conventional bracket and had an impact on both active space closure and initial alignment.

In 12 weeks appointments progression in the arch-wire sequence would have been delayed despite the occurrence of full teeth alignment and the arch-wire became passive after six or seven weeks. This clarifies why we employed 4-week follow-up intervals in the current study and how the number of visits might impact the length of therapy. These days, a lot of self-ligating bracket makers advise between 6 and 10 weeks.

Prettyman and colleagues[37] conducted a poll to find out how orthodontists feel about self-ligating brackets in comparison to traditional braces. The majority of practitioners stated that they either used a high or low percentage of patients with self-ligating

brackets. 33% of respondents said they had used self-ligating brackets on the majority of patients (70%–100%), whereas 52% of respondents said they had used them on less than 30% of patients.

Overall, the number of cases the practitioners took to get used to self-ligating brackets had a substantial impact on bracket choice. Treatment factors, such as better oral hygiene, faster progress, and overall shorter treatment, were more likely to be reported by practitioners who used longer appointment intervals with self-ligating brackets.[37]

Anand and colleagues [25] conducted intriguing research whereby they examined two clinicians who employed both traditional and self-ligating brackets in their operations. There were no changes in the total number of visits or overall treatment time between groups under the first doctor. However, the second clinician's treatment plan differed significantly as the self-ligation group was shorter by 11 months and had 7 fewer appointments. The frequency of appointments for the two bracket systems was the same.

The data analysis was followed by an interview with the second doctor. It appears that a dentist who referred patients to him asked for self-ligating brackets for his patients since they were frequently stationed at a nearby military post and required prompt treatment due to potential transfer or deployment. This illustrates how treatment time can be influenced by practitioner expertise as well as patient-related factors.

The degree of initial irregularity was the primary component in this study that affected the pace of alignment; a strong positive association was found between the initial little irregularity score and the rate of improvement in both groups. With a little irregularity index of 4, the rate of improvement was 0.96 ± 0.09, and it rose to 1.17 ± 0.24 with an index of little irregularity of 8.

These results are consistent with research by Scott and colleagues [29], who revealed no rate difference between Damon3 self-ligated bracket systems and traditional ligated bracket systems in mandibular alignment. The degree of initial irregularity was the only factor that affected the rate of teeth alignment.

They came to the conclusion that teeth that are initially more displaced tend to align faster. Another explanation is the unusually low load deflection rate of the Cu NiTi wires, this might be related to their mechanical characteristics.

In this study, timing also had an impact on the pace of teeth alignment; there were greater rates of improvement during the first few months of therapy, but these rates decreased as the months went on. In both groups, the improvement percentage dropped from 53% in the first month to 0.3% in the seventh.

This study was not without limitations, despite the fact that it was carefully planned to exclude confounding factors in previously published investigations. For instance, because the doctors treating the patients could not be blinded to the bracket allocation, there may have been some performance bias.

Bracket breakage or debonding is another factor to consider. Previous studies have reported Damon bracket failures, which may be related to the inexperience of the clinicians and the force applied on bracket slides when opening or closing.[28] The rate of bracket breaking was not noted in the current investigation.

With these limitations aside, we believe that our findings apply to other clinical contexts. Further trials with bigger sample sizes and longer durations are recommended to confirm our results.

Conclusions:

1. The advantages of self-ligating brackets were not substantiated in the current study. The bracket type selection did not influence initial irregularity relief.
2. Moreover, the number of visits did not differ between bracket types.

3. The rate of alignment was affected by the degree of initial irregularity and the timing; as higher improvement rates were observed in the earlier months of treatment.

Declarations

Competing interests

No conflict of interest

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References

1- Drescher D, Bourauel C, Schumacher HA. Frictional forces between bracket and arch wire. Am J Orthod Dentofac Ortho 1989; 96:397–404.

2- Thorstenson GA, Kusy RP. Comparison of resistance to sliding between different self-ligating brackets with second-order angulation in the dry and saliva states. Am J Orthod Dentofacial Orthop 2002; 121:472-82.

3- Matarese G, Nucera R, Militi A, Mazza M, Portelli M, Festa F, Cordasco G. Evaluation of frictional forces during dental alignment: an experimental model with 3 nonleveled brackets. Am J Orthod Dentofac Ortho 2008; 133:708–715.

4- Stolzenberg J. The efficiency of the Russell attachment. Am J Orthod Oral Surg 1946; 32:572-82.

5- Maijer R, Smith DC. Time savings with self-ligating brackets. J Clin Orthod 1990;24:29-31.

6- Turnbull NR, Birnie DJ. Treatment efficiency of conventional vs self-ligating brackets: effects of archwire size and material. Am J Orthod Dentofacial Orthop 2007;131:395-9.

7- Harradine NW. Self-ligating brackets and treatment efficiency. Clin Orthod Res 2001;4:220-7.

8- Eberting JJ, Straja SR, Tuncay OC. Treatment time, outcome and patient satisfaction comparisons of Damon and conventional brackets. Clin Orthod Res 2001;4:228-34.

9- Fleming PS, DiBiase AT, Sarri G, Lee RT. Efficiency of mandibular arch alignment with 2 preadjusted edgewise appliances. Am J Orthod Dentofacial Orthop 2009;135:597-602.

10- Ong E, McCallum H, Griffin MP, Ho C. Efficiency of self-ligating vs conventionally ligated brackets during initial alignment. Am J Orthod Dentofacial Orthop 2010;138:138.e1-e7.

11- Franchi L, Baccetti T. Forces released during alignment with a preadjusted appliance with different types of elastomeric ligatures. Am J Orthod Dentofacial Orthop 2006; 129:687-90.

12- Redlich M, Mayer Y, Harari D, Lewinstein I. In vitro study of frictional forces during sliding mechanics of ‘‘reduced-friction’’ brackets. Am J Orthod Dentofacial Orthop. 2003; 124:69–73.

13- Reicheneder CA, Gedrange T, Berrisch S, Proff P, Baumert U, Faltermeier A, Muessig D. Conventionally ligated versus self- ligating metal brackets—a comparative study. Eur J Orthod. 2008; 30:654–660.

14- Ehsani S, Mandich MA, El-Bialy TH, Flores-Mir C. Frictional resistance in self-ligating orthodontic brackets and conventionally ligated brackets: a systematic review. Angle Orthod. 2009; 79:592–601.

15- Chen SS, Greenlee GM, Kim JE, Smith CL, Huang GJ. Systematic review of self-ligating brackets. Am J Orthod Dentofacial Orthop 2010; 137:726.e1-e18.

16- Fleming PS, Johal A. Self-ligating brackets in orthodontics. A systematic review. Angle Orthod 2010;80:575-84.

17- Pandis N, Polychronopoulou A, Eliades T. Self-ligatingvs conventional brackets in the treatment of mandibular crowding: a prospective clinical trial of treatment duration and dental effects,” *American Journal of Orthodontics and Dentofacial Orthopedics*, 2007; 132(2): 208–215.

18- Little RM. The irregularity index: a quantitative score of mandibular anterior alignment. *American Journal of Orthodon tics*, 1975; 68(5): 554–563.

19- Vandewalle KS, Roberts HW, Andrus JL, Dunn WJ. Effect of light dispersion of LED curing lights on resin composite polymerization. J Esthet Restor Dent; 17(4):244-54.

20- Camardella LT, Breuning H, Vilella OV. Are there differences between comparison methods used to evaluate the accuracy and reliability of digital models? Dental Press J Orthod. 2017; 22(1):65-74.

21- Beckwith FR, Ackerman RJ Jr, Cobb CM, Tira DE. An evaluation of factors affecting duration of orthodontic treatment. Am J Orthod Dentofacial Orthop 1999; 115(4):439-47.

22- Skidmore KJ, Brook KJ, Thomson WM, Harding WJ. Factors in- fluencing treatment time in orthodontic patients. Am J Orthod Dentofa- cial Orthop 2006; 129(2):230-8.

23- Fleming PS, DiBiase AT, Lee RT. Randomized clinical trial of orthodontic treatment efficiency with self-ligating and conventional fixed orthodontic appliances. Am J Orthod Dentofacial Orthop 2010; 137(6):738-42.

24- Dehbi H, Azaroual MF, Zaoui F, Halimi A Benyahia H. Therapeutic efficacy of self-ligating brackets: a systematic review. Int Orthod 2017; 15(3):297-311.

25- Anand M, Turpin DL, Jumani KS, Spiekerman CF, Huang GJ. Retrospective investigation of the effects and efficiency of self-ligating and conventional brackets. Am J Orthod Dentofacial Orthop 2015; 148(1):67-75.

26- Gaspar Ribeiro DA, deAlmeida MR, Conti AC, Navarro R, Oltramari-Navarro P, et al. Efficiency of mandibular arch alignment with self-ligating and conventional edgewise appliances: A dental cast study. Dentistry 2012; 2:128.

27- Miles PG, Weyant RJ, Rustveld L. A clinical trial of Damon 2 vs. conventional twin brackets during initial alignment. Angle Orthod. 2006;76:480-5.

28- Miles PG. Smart Clip versus conventional twin brackets for initial alignment: Is there a difference. Aust Orthod J. 2005;21:123-7.

29- Scott P, DiBiase AT, Sherriff M, Cobourne M. Alignment efficiency of Damon3 self-ligating and conventional orthodontic bracket systems: A randomized clinical trial. Am J Orthod Dentofacial Orthop. 2008;134;470.e1-8.

30- Pandis N, Polychronopoulou A, Eliades T. Self-ligating vs. conventional brackets in the treatment of mandibular crowding: A prospective clinical trial of treatment duration and dental effects. Am J Orthod Dentofacial Orthop. 2007;132:208-15.

31- Jahanbin A, Hasanzadeh N, Khaki S, Shafaee H. Comparison of self-ligating Damon3 and conventional MBT brackets regarding alignment efficiency and pain experience: A randomized clinical trial. J Dent Res Dent Clin Dent Prospects. 2019 Fall;13(4):281-288.

32- Fortini A, Lupoli M, Cacciafesta V. A new low-friction ligation system. J Clin Orthod 2005;39:464-71.

33- Kai LM. A comparison of treatment time and number of appointments in active self-ligating brackets and conventionally ligated twin edgewise brackets. Master thesis, University of Southern California, 2010.

34- Alessandra Impellizzeri, Alessandra Putrino, Chiara Zangrillo, Ersilia Barbato, Gabriella Galluccio. Efficiency of self-ligating vs conventional braces: systematic review and meta-analysis, Dental Cadmos 2019; 87(6): 347-356.

35- Bourauel C, Scharold W, Jager A, Eliades T. Fatigue failure of as received and retrieved NiTi orthodontic archwires. Dental Materials 2008;24:1095-101.

36- Songra G, Clover M, Atack NE, Ewings P, Sherriff M, Sandy JR, Anthony J. Ireland, Comparative assessment of alignment efficiency and space closure of active and passive self-ligating vs conventional appliances in adolescents: A single-center randomized controlled trial, American Journal of Orthodontics and Dentofacial Orthopedics, Volume 145, Issue 5,2014,Pages 569-578,ISSN 0889-5406,

37- Prettyman C, Best AM, Lindauer SJ, Tufekci E. Self-ligating vs conventional brackets as perceived by orthodontists. Angle Orthod. 2012; 82(6):106.