Systematic review of self-ligating brackets

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Introduction: Self-ligating brackets have been gaining popularity over the past several decades. Various advantages for these systems have been claimed. The purposes of this systematic review were to identify and review the orthodontic literature with regard to the efficiency, effectiveness, and stability of treatment with self-ligating brackets compared with conventional brackets. **Methods:** An electronic search in 4 data bases was performed from 1966 to 2009, with supplemental hand searching of the references of retrieved articles. Quality assessment of the included articles was performed. Data were extracted by using custom forms, and weighted mean differences were calculated. **Results:** Sixteen studies met the inclusion criteria, including 2 randomized controlled trials with low risk of bias, 10 cohort studies with moderate risk of bias, and 4 cross-sectional studies with moderate to high risk of bias. Self-ligation appears to have a significant advantage with regard to chair time, based on several cross-sectional studies. Analyses also showed a small, but statistically significant, difference in mandibular incisor proclination (1.5° less in self-ligating systems). No other differences in treatment time and occlusal characteristics after treatment were found between the 2 systems. No studies on long-term stability of treatment were identified. **Conclusions:** Despite claims about the advantages of self-ligating brackets, evidence is generally lacking. Shortened chair time and slightly less incisor proclination appear to be the only significant advantages of self-ligating systems over conventional systems that are supported by the current evidence. (Am J Orthod Dentofacial Orthop 2010;137:726.e1-726.e18)

Self-ligating brackets have been gaining popularity in recent years. However, self-ligation is not a new concept. The first self-ligating bracket, the Russell attachment, was introduced by Stolzenberg[1] in the early 1930s. Perhaps because of skepticism in the orthodontic society at that time, or the lack of promotion, it did not gain much popularity. During the past several decades, interest in self-ligating brackets has been rekindled, with the introduction of various types of new self-ligating systems. These self-ligating brackets have been touted to possess many advantages over conventional edgewise brackets.[2-4]

Self-ligating brackets can be divided into 2 main categories, active and passive, according to their mechanisms of closure. Active self-ligating brackets have a spring clip that stores energy to press against the archwire for rotation and torque control. In-Ovation (GAC International, Central Islip, NY), SPEED (Strite Industries, Cambridge, Ontario, Canada), and Time (Adenta, Gilching/Munich, Germany) are examples of active self-ligating brackets. On the other hand, passive self-ligating brackets usually have a slide that can be closed which does not encroach on the slot lumen, thus exerting no active force on the archwire. Damon (Ormco, Glendora, Calif) and SmartClip (3M Unitek, Monvoria, Calif) are 2 popular brands of passive design, although the SmartClip's appearance resembles conventional brackets and does not have a slide.

The claim of reduced friction with self-ligating brackets is often cited as a primary advantage over conventional brackets.[2,5-8] This occurs because the usual steel or elastomeric ligatures are not necessary, and it is claimed that passive designs generate even less friction than active ones.[8,9] With reduced friction and hence less force needed to produce tooth movement,[10] self-ligating brackets are proposed to have the potential advantages of producing more physiologically harmonious tooth movement by not overpowering the musculature and interrupting the periodontal vascular supply.[2] Therefore, more alveolar bone generation, greater amounts of expansion, less proclination of anterior teeth, and less need for extractions are claimed to be possible. Other claimed advantages include full and secure wire ligation,[11] better sliding mechanics and possible

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anchorage conservation,[3,4] decreased treatment time, longer treatment intervals with fewer appointments,[3,12,13] chair time savings, less chair-side assistance and improved ergonomics,[13-17] better infection control,[15] less patient discomfort,[3,4] and improved oral hygiene.[16-18]

However, self-ligating brackets have some disadvantages, including higher cost, possible breakage of the clip or the slide, higher profile because of the complicated mechanical design, potentially more occlusal interferences and lip discomfort, and difficulty in finishing due to incomplete expression of the archwires.

Many in-vitro studies have investigated parameters such as frictional resistance and torque expression in self-ligating systems.[19] Many have shown that less friction is generated with self-ligating brackets compared with conventional brackets in the laboratory,[5-8,16,20] and, therefore, less force is required to produce tooth movement.[21] However, the suitability of applying the results from in-vitro studies to clinical situations and the importance of friction in alignment, sliding mechanics, and total treatment time have not been fully addressed. Many case series, several cohort studies, and a few randomized controlled trials have addressed various parameters of self-ligating brackets. To date, no systematic review has synthesized evidence from these in-vivo clinical studies.

The a priori aim of this systematic review was to identify and review the orthodontic literature with regard to the efficiency (chair time, treatment time), effectiveness (occlusal indices, arch dimensions), and stability of treatment with self-ligating brackets compared with conventional brackets. If the data allowed, a meta-analysis would be performed.

MATERIALS AND METHODS

The following criteria were formulated a priori to select articles for inclusion in this review. The inclusion criteria were (1) clinical studies that compared self-ligating with conventional appliances regarding their efficiency, effectiveness, or stability; (2) all ages and sexes; and (3) all languages. The exclusion criteria were (1) in-vitro, ex-vivo, or animal studies; (2) studies with no comparison group; and (3) editorials, opinions, or philosophy articles with no subjects or analytical design.

Electronic data bases—PubMed, Web of Science, EMBASE, and Cochrane Library—from 1966 to the third week of May 2009 were searched with the assistance of a senior research librarian at the University of Washington Health Sciences Library. Search strategies and key words are shown in Appendix 1. Titles and abstracts of potential articles for inclusion were examined by at least 2 reviewers (S.S.-H.C., J.-E.K., C.L.S.); the articles were included based on consensus agreement on the above criteria. Abstracts of articles with uncertain inclusion characteristics were examined, with the full article retrieved if necessary. Grey literature was considered, but ultimately only published peer-reviewed articles were included.

After compiling the list of studies to be included, 2 investigators (S.S.-H.C., J.-E.K., C.L.S.) read the articles and abstracted the data onto custom data-abstraction forms, which had been piloted on 2 studies of each type (cohort study and randomized controlled trial). The reference lists of the retrieved full articles were also hand searched. Some authors of relevant studies were contacted for additional information. All search and data abstraction were independently performed by at least 2 investigators (C.L.S., J.-E.K., S.S.-H.C., G.M.G.). When 2 reviewers disagreed, a third investigator was called in, and consensus was reached.

Independent quality assessment of the included studies was performed according to a modified Newcastle-Ottawa scale by 2 investigators (G.J.H., S.S.-H.C). In areas of disagreement, a third investigator (G.M.G.) was consulted, and consensus was achieved after discussion.

For randomized controlled trials, 5 criteria were used for assessment: (1) randomization described, (2) allocation concealment reported, (3) intention-to-treat analysis performed, (4) blinded assessment stated, and (5) a priori power calculation performed.

For cohort and cross-sectional studies, these criteria were used: (1) representative sample of adequate size, (2) well-matched samples, (3) adjustment for confounders in analyses, (4) blinded assessment stated, and (5) dropouts reported (for prospective studies only).

One point was given to each criterion if fulfilled. Half a point was granted if part of the criterion was met. Studies with less than 2 points were considered to be at high risk for bias; from 2 to less than 4 points, the risk for bias was considered moderate; and for 4 points and above, the risk of bias was considered low. All quality ratings have limitations, and our intention was to provide a relative scale to judge the quality of the studies, by using the parameters stated above.

Meta-analysis

A meta-analysis was performed to combine comparable results in each category by using Review Manager (version 5.0, Copenhagen: Nordic Cochrane Centre, Cochrane Collaboration, 2008). Heterogeneity was assessed among the included studies. Results with less heterogeneity (I^2 statistics <75%) were presented with a fixed-

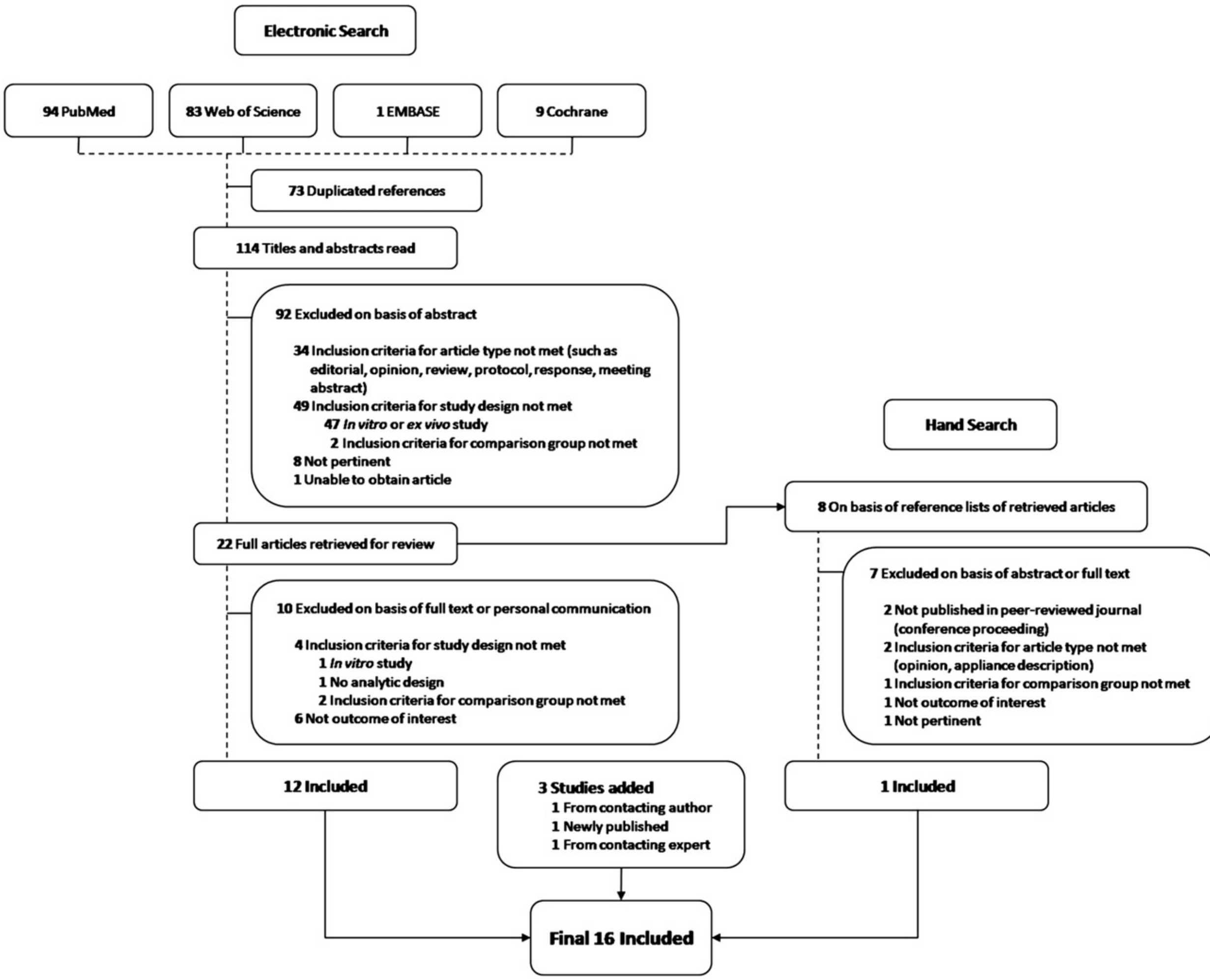


Fig 1. Flow diagram of literature search.

effects model, whereas results with $I^2 > 75\%$ utilized a random-effects model. Weighted mean differences were used to construct forest plots of treatment time, occlusal index scores, and other continuous data. Odds ratios were used for dichotomous data. Publication bias was assessed with funnel plots, if possible.

RESULTS

The electronic searches identified 114 titles and abstracts. From these, 22 full articles were retrieved for review. Ultimately, 16 articles met the inclusion criteria, including 1 article added from hand searching, 1 article added from contacting an author,[22] 1 article published during this review,[23] and another identified by contacting an expert in the field[17] (Fig 1). Characteristics of the excluded articles are listed in Appendix 2.

The 16 studies included 2 randomized controlled trials,[23,24] 10 cohort studies (7 prospective,[22,25-30] 3 retrospective[12,13,31]), and 4 cross-sectional studies.[14,15,17,32] All included articles were published in English, except for 1 in Chinese. Characteristics of the included studies are shown in the Table. Most samples comprised adolescent subjects.

Of the 16 studies, 4 were judged to have a low risk of bias, 8 were categorized as having moderate risk, and 4 were considered to have high risk (Table; Appendix 3). The 4 studies with low risk of bias were the 2 randomized controlled trials[23,24] and the 2 prospective cohort studies.[22,30] Most other cohort studies were judged to have moderate risk of bias, and those with high risk of bias were mainly cross-sectional studies.[14,15,17]

The studies were further divided into 3 categories based on the aspects of self-ligating brackets that were investigated: efficiency, effectiveness, and stability.

Table. Characteristics of included studies (detailed quality information in Appendix 3)

Author	*Year*	*Design*	*Self-ligating group (number of patients)*	*Conventional group (number of patients)*	*Pretreatment mean age (y)*	*Authors' conclusions*	*Risk of bias*
Berger and Byloff[14]	2001	Cross-sectional	SPEED (20) (Strite Industries) Damon SL (20) (Ormco/"A" Company) Time (20) (Adenta) Twinlock (20) (Ormco/"A" Company)	Mini-twin (40) (Ormco/"A" Company)	Not reported	Total opening and closing time was significantly less for each of the 4 SL designs compared with conventional brackets; SPEED took the least average time and Damon SL the most.	High
Eberting et al[12]	2001	Retrospective cohort	Damon SL (108) (SDS Ormco)	Type not specified (107)	Not reported	Patients treated with Damon SL had significantly lower treatment times, required significantly fewer appointments, and had significantly higher American Board of Orthodontics scores than those treated with conventionally ligated edgewise brackets.	Moderate
Fleming et al[23]	2009	Randomized controlled trial	SmartClip (32) (3M Unitek)	Victory (33) (3M Unitek)	SmartClip: 15.9 Victory: 16.6	In nonextraction patients with mild mandibular incisor crowding, the SL system used was no more effective at relieving irregularity. Enhanced resolution of irregularity was positively correlated with pretreatment irregularity.	Low
Hamilton et al[31]	2008	Retrospective cohort	In-Ovation (379) (GAC International)	Victory (383) (3M Unitek)	Not reported	Active SL brackets appear to offer no measurable advantages in treatment time, number of visits, and time spent in initial alignment over conventional preadjusted orthodontic brackets. The number of debonded brackets and other emergency visits were significantly higher in patients treated with active SL brackets.	Moderate
Harradine[13]	2001	Retrospective cohort	Damon SL (30) (SDS Ormco) (study on speed of ligation: n = 50) (study on bracket complications: n = 25)	Type not specified (30) (study on speed of ligation: n = 50) (study on bracket complications: n = 25)	Not reported	Treatment times were 4 months shorter and required 4 fewer visits on average in the Damon group. Slide opening and closure were significantly faster than with conventional ligation. Both types of brackets produced good and equivalent reductions in occlusal irregularity.	Moderate

Table. Continued

Author	Year	Design	Self-ligating group (number of patients)	Conventional group (number of patients)	Pretreatment mean age (y)	Authors' conclusions	Risk of bias
Jiang and Fu[25]	2008	Prospective cohort	Damon3 (13) (SDS Ormco) (mandibular incisor torque: –1°)	Conventional metal preadjusted brackets (13) (Shinya, China) (mandibular incisor torque: –1°)	Damon3: 14.5 Conventional: 15.3	In patients with crowding treated without extractions, there were overall increases in the proclination of the mandibular incisors and arch widths in both groups. Patients treated with Damon3 had greater intermolar width increases than those treated with conventional appliances.	High
Maijer and Smith[15]	1990	Cross-sectional	Activa (14) ("A" Company)	Straight-wire brackets (14) ("A" Company)	Not reported	Reduced chair time was a significant advantage of SL brackets. The operator's training made little difference in speed, at least with anterior brackets.	High
Miles[26]	2005	Prospective cohort	SmartClip (29) (3M Unitek)	Victory MBT (29) (3M Unitek)	17.1	SmartClip was no more effective at reducing irregularity during the initial stage of treatment than a conventional twin bracket.	Moderate
Miles et al[28]	2006	Prospective cohort (Split-mouth design)	Damon2 (58) (SDS Ormco)	Victory MBT (58) (3M Unitek)	16.3	The Damon2 was no better during initial alignment than a conventional bracket. Damon2 had a higher bracket failure rate.	Moderate
Miles[27]	2007	Prospective cohort (split-mouth design)	SmartClip (14) (3M Unitek)	Conventional MBT twin (14) (3M Unitek)	13.1 (median)	No significant difference in the rate of en-masse space closure between SmartClip brackets and conventional twin brackets tied with stainless steel ligatures was found.	Moderate
Paduano et al[17]	2008	Cross-sectional	SmartClip (10) (3M Unitek) In-Ovation (10) (GAC International) Time2 (10) (American Orthodontics)	GAC Ovation with stainless steel ligatures (10) GAC Ovation with elastic ligatures (10) (GAC International)	Not reported (age range, 12-30 y)	SL systems showed quicker and more efficient wire removal and placement for late orthodontic treatment phases. The ligation time in the mandibular arch was affected by the type of SL appliance used.	High
Pandis et al[29]	2006	Prospective cohort	Damon2 (43) (SDS Ormco)	Microarch (19) (GAC International)	14	No significant difference in failure incidence was noted between SL and edgewise brackets bonded with either conventional acid etching or self-etching primer in either arch.	Moderate

Table. Continued

Author	*Year*	*Design*	*Self-ligating group (number of patients)*	*Conventional group (number of patients)*	*Pretreatment mean age (y)*	*Authors' conclusions*	*Risk of bias*
Pandis et al[30]	2007	Prospective cohort	Damon2 (27) (SDS Ormco) (mandibular incisor torque: –6°)	Microarch (27) (GAC International) (mandibular incisor torque: –1°)	Damon2: 13.5 Microarch: 13.9	No significant difference in the time required to correct mandibular crowding was found between the 2 groups. However, for an irregularity index value <5, self-ligating had 2.7 times faster correction. There were overall increases in mandibular incisor proclination and intercanine width for both groups after alignment, with no significant difference between the groups. The self-ligating group had a statistically greater intermolar width increase.	Low
Pandis et al[22]	2009	Prospective cohort (completion of part of 2007 study)	Damon2 (27) (SDS Ormco) (mandibular incisor torque: –6°)	Microarch (27) (GAC International) (mandibular incisor torque: –1°)	Damon2: 13.6 Microarch: 13.9	There were overall increases in mandibular incisor proclination and intercanine width for both groups after treatment, with no significant difference between the groups. The self-ligating group had a statistically greater intermolar width increase after treatment.	Low
Scott et al[24]	2008	Randomized controlled trial	Damon3 (32) (SDS Ormco) (mandibular incisor torque: –1°)	Synthesis (28) (SDS Ormco) (mandibular incisor torque: –1°)	Damon3: 16.2 Synthesis: 16.4	Damon3 was no more efficient than conventional ligated preadjusted brackets in initial or overall rate of mandibular incisor alignment. Alignment was associated with increased intercanine width, maintenance of intermolar width, some reduction of arch length, and proclination of mandibular incisors for both appliances, but the differences were not significant.	Low
Turnbull and Birnie[32]	2007	Cross-sectional	Damon2 (140) (SDS Ormco)	Orthos (122) (SDS Ormco)	Damon2: 13.7 Orthos: 14.4	Damon2 had a significantly shorter mean archwire ligation time for both removing and placing wires.	Moderate

SL, Self-ligating.

Eleven studies had results that could be used for meta-analyses.[12,13,22,24-26,28-32]

Eleven studies investigating the efficiency of self-ligating brackets compared with conventional brackets were identified,[12-15,17,26-29,31,32] and 7 reported results that could be pooled for analysis. The outcomes studied included total treatment time, rate of mandibular incisor alignment, rate of en-masse space closure, number of visits, chair time, and bracket failure rate. Figure 2 (comparisons 1.1-1.7) shows the results of the meta-analysis from 7 eligible studies. Among all the outcomes, only chair time required for opening the slides of the self-ligating brackets or removing the conventional ligatures showed a significant difference between the 2 groups (P <0.00001). It took 20 seconds less to open the self-ligating brackets per arch than removing the ligatures in the conventional group.

Seven studies investigating the effectiveness of self-ligating brackets compared with conventional brackets were identified.[12,13,22,24,25,30,31] The outcomes that had been studied included occlusal indices, arch dimensions, and mandibular incisor inclinations after incisor alignment or at the end of treatment. Figure 3 (comparisons 2.1-2.4) shows the results of the meta-analysis from these 7 studies. No statistically significant difference was observed between the 2 groups in any outcome category, except for change in mandibular incisor proclination. The self-ligating bracket systems resulted in 1.5° less incisor proclination than the conventional bracket systems.

At this time, no studies comparing the stability of treatment result with self-ligating brackets to conventional brackets were identified.

We intended to assess publication bias, but the small number of studies for each outcome of interest were too few to derive meaning from funnel plots.

DISCUSSION

Quality of the studies in this review

We identified 4 pertinent studies with low risk of bias, 8 with moderate risk of bias, and 4 with high risk of bias. Three poor-quality studies were not included in the meta-analysis because of lack of results with proper statistics or methods that were too different to combine. Therefore, the quality of most of the evidence in the meta-analyses is moderate to good. The amount of evidence for each outcome of interest was sparse, with no analysis combining data from more than 3 studies.

Total treatment time and occlusal indices

Three retrospective cohort studies with moderate risk of bias compared total treatment times. Eberting et al[12] and Harradine[13] found significantly decreased treatment times of 4 to 6 months and 4 to 7 fewer visits with self-ligating brackets, whereas Hamilton et al[31] found no significant difference between the 2 groups. However, the mean treatment times varied in the 3 studies, and the decision regarding when treatment goals had been attained might have differed among the investigators. Standardized mean differences were used to minimize methodologic differences among the trials (in this case, to account for considerable differences in total treatment times between the studies), and the synthesized result showed no significant difference.

The same 3 studies also compared the occlusal outcome after treatment. Eberting et al[12] used American Board of Orthodontics scores, Hamilton et al[31] used the index of complexity, outcome, and need, and Harradine[13] used the peer assessment rating. Interestingly, an almost identical pattern was observed in the 2 forest plots. The 2 smaller studies with passive self-ligating brackets (Damon, Ormco) favored self-ligation,[12,13] whereas the larger study with active self-ligating brackets (In-Ovation, GAC) found no significant difference.[31] The difference in treatment efficiency between passive and active self-ligating brackets requires further investigation. To synthesize the 3 different scores (all were deductions from the full score), standardized mean differences were calculated. The results in occlusal quality showed no significant difference at the end of treatment. Caution should be used regarding these results, since the heterogeneity was high and the 3 studies might have been susceptible to bias from their retrospective designs.

Studies with randomized or consecutive assignment are needed to provide further information. A standardized stopping rule and a blinded assessor for completion of treatment would result in more valid comparisons of treatment durations.

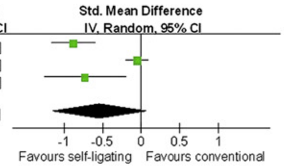
Rate of alignment and space closure

Five studies with low to moderate risk of bias, including 2 randomized controlled trials and 3 prospective cohort studies, investigated the rate of mandibular incisor alignment. All self-ligating brackets were the passive type (Damon, Ormco; SmartClip, 3M Unitek). Pandis et al[22,30] and Scott et al[24] reported days needed for alignment but used different end points: visual inspection of correction of proximal contacts and changing to 0.019 × 0.025-in stainless steel archwire. Pandis et al[22,30] enrolled nonextraction patients, whereas Scott et al enrolled extraction patients. Miles[26] and Fleming et al[23] reported reduction of irregularity at various times of alignment. A standardized mean difference was calculated, and no significant difference in efficiency of alignment in the mandibular

Comparison 1.1. Total treatment time (in month), presented in standardized mean difference

Study or Subgroup	Self-ligating Mean	SD	Total	Conventional Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Eberting 2001	24.5	6.5	108	30.9	7.9	107	34.4%	-0.88 [-1.16, -0.60]
Hamilton 2008	15.6	5.2	379	15.9	6.1	383	36.2%	-0.05 [-0.19, 0.09]
Harradine 2001	19.4	5.9	30	23.5	5.2	30	29.4%	-0.73 [-1.25, -0.20]
Total (95% CI)			**517**			**520**	**100.0%**	**-0.54 [-1.17, 0.09]**

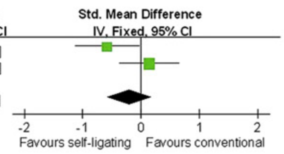
Heterogeneity: $Tau^2 = 0.28$; $Chi^2 = 30.13$, df = 2 ($P < 0.00001$); $I^2 = 93\%$
Test for overall effect: Z = 1.67 (P = 0.10)



Comparison 1.2. Rate of mandibular incisor alignment (days needed), presented in standardized mean difference

Study or Subgroup	Self-ligating Mean	SD	Total	Conventional Mean	SD	Total	Weight	Std. Mean Difference IV, Fixed, 95% CI
Pandis 2007	91	31.9	27	114.5	46.4	27	46.4%	-0.58 [-1.13, -0.04]
Scott 2008	253	63.6	32	243	82.5	28	53.6%	0.14 [-0.37, 0.64]
Total (95% CI)			**59**			**55**	**100.0%**	**-0.20 [-0.57, 0.17]**

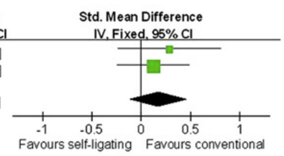
Heterogeneity: $Chi^2 = 3.55$, df = 1 ($P = 0.06$); $I^2 = 72\%$
Test for overall effect: Z = 1.04 (P = 0.30)



Comparison 1.3. Rate of mandibular incisor alignment (change of irregularity index at 10 weeks of alignment), presented in standardized mean difference

Study or Subgroup	Self-ligating Mean	SD	Total	Conventional Mean	SD	Total	Weight	Std. Mean Difference IV, Fixed, 95% CI
Miles 2005	-3.4	2.5	29	-4.2	3	29	33.1%	0.29 [-0.23, 0.80]
Miles 2006	-1.2	1.5	58	-1.4	1.7	58	66.9%	0.12 [-0.24, 0.49]
Total (95% CI)			**87**			**87**	**100.0%**	**0.18 [-0.12, 0.48]**

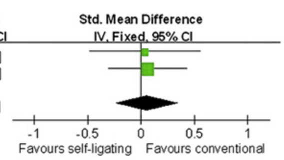
Heterogeneity: $Chi^2 = 0.25$, df = 1 ($P = 0.62$); $I^2 = 0\%$
Test for overall effect: Z = 1.17 (P = 0.24)



Comparison 1.4. Rate of mandibular incisor alignment (change of irregularity index at 20 weeks of alignment), presented in standardized mean difference

Study or Subgroup	Self-ligating Mean	SD	Total	Conventional Mean	SD	Total	Weight	Std. Mean Difference IV, Fixed, 95% CI
Miles 2005	-4.3	2.7	29	-4.4	2.9	29	33.3%	0.04 [-0.48, 0.55]
Miles 2006	-1.4	1.5	58	-1.5	1.8	58	66.7%	0.06 [-0.30, 0.42]
Total (95% CI)			**87**			**87**	**100.0%**	**0.05 [-0.25, 0.35]**

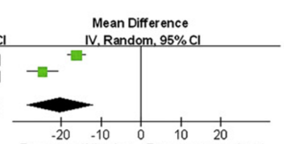
Heterogeneity: $Chi^2 = 0.01$, df = 1 ($P = 0.94$); $I^2 = 0\%$
Test for overall effect: Z = 0.34 (P = 0.73)



Comparison 1.5. Time required for opening slides of self-ligating brackets or removing conventional ligatures (second/arch)

Study or Subgroup	Self-ligating Mean	SD	Total	Conventional Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Harradine 2001	15.4	3.9	100	31.6	11.1	100	51.7%	-16.20 [-18.51, -13.89]
Turnbull 2007	39.8	13	140	64.5	18	122	48.3%	-24.70 [-28.55, -20.85]
Total (95% CI)			**240**			**222**	**100.0%**	**-20.30 [-28.63, -11.98]**

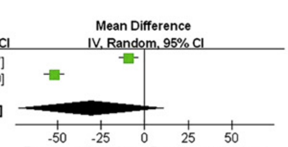
Heterogeneity: $Tau^2 = 33.50$; $Chi^2 = 13.77$, df = 1 ($P = 0.0002$); $I^2 = 93\%$
Test for overall effect: Z = 4.78 (P < 0.00001)



Comparison 1.6. Time required for closing slides of self-ligating brackets or replacing conventional ligatures (second/arch)

Study or Subgroup	Self-ligating Mean	SD	Total	Conventional Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Harradine 2001	59.4	24.7	100	68.8	11.4	100	50.0%	-9.40 [-14.73, -4.07]
Turnbull 2007	46.3	22	140	98.4	24	122	50.0%	-52.10 [-57.71, -46.49]
Total (95% CI)			**240**			**222**	**100.0%**	**-30.74 [-72.59, 11.10]**

Heterogeneity: $Tau^2 = 903.86$; $Chi^2 = 117.04$, df = 1 ($P < 0.00001$); $I^2 = 99\%$
Test for overall effect: Z = 1.44 (P = 0.15)



Comparison 1.7. Bracket failure rate

Study or Subgroup	Self-ligating Events	Total	Conventional Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
Miles 2006	26	283	5	278	48.8%	5.52 [2.09, 14.60]
Pandis 2006	19	849	11	371	51.2%	0.75 [0.35, 1.59]
Total (95% CI)		**1132**		**649**	**100.0%**	**1.99 [0.27, 14.46]**
Total events	45		16			

Heterogeneity: $Tau^2 = 1.86$; $Chi^2 = 10.44$, df = 1 ($P = 0.001$); $I^2 = 90\%$
Test for overall effect: Z = 0.68 (P = 0.50)

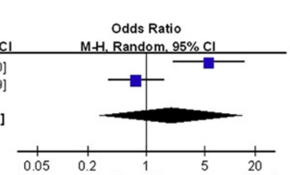
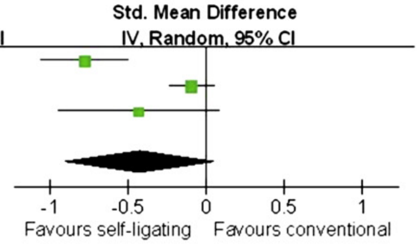


Fig 2. Comparison of efficiency: self-ligating vs conventional brackets.

Comparison 2.1. Occlusal indices at the end of treatment (deductions from full score), presented in standardized mean difference

Study or Subgroup	Self-ligating Mean	SD	Total	Conventional Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Eberting 2001	30	8.9	108	38	11.4	107	34.7%	-0.78 [-1.06, -0.50]
Hamilton 2008	48	20.4	379	49.9	19.6	383	37.7%	-0.09 [-0.24, 0.05]
Harradine 2001	5.6	3.2	30	7	3.2	30	27.6%	-0.43 [-0.94, 0.08]
Total (95% CI)			**517**			**520**	**100.0%**	**-0.43 [-0.93, 0.07]**

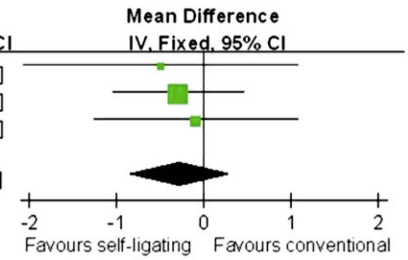
Heterogeneity: Tau² = 0.17; Chi² = 19.07, df = 2 (P < 0.0001); I² = 90%
Test for overall effect: Z = 1.67 (P = 0.09)



Comparison 2.2. Change of intercanine width, positive mean means expansion

Study or Subgroup	Self-ligating Mean	SD	Total	Conventional Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Jiang 2008	0.6	1.6	13	1.1	2.4	13	13.9%	-0.50 [-2.07, 1.07]
Pandis 2009	1.6	1.3	27	1.9	1.5	27	61.0%	-0.30 [-1.05, 0.45]
Scott 2008	2.6	2.3	32	2.7	2.3	28	25.1%	-0.10 [-1.27, 1.07]
Total (95% CI)			**72**			**68**	**100.0%**	**-0.28 [-0.86, 0.31]**

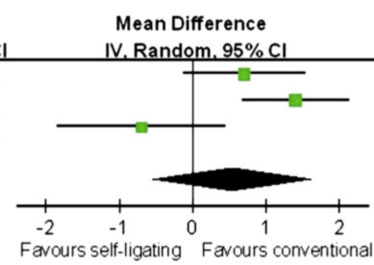
Heterogeneity: Chi² = 0.17, df = 2 (P = 0.92); I² = 0%
Test for overall effect: Z = 0.93 (P = 0.35)



Comparison 2.3. Change of intermolar width, positive mean means expansion

Study or Subgroup	Self-ligating Mean	SD	Total	Conventional Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Jiang 2008	1.4	0.8	13	0.7	1.3	13	34.5%	0.70 [-0.13, 1.53]
Pandis 2009	2.4	1.5	27	1	1.2	27	36.1%	1.40 [0.68, 2.12]
Scott 2008	-0.1	2.4	32	0.6	2.1	28	29.4%	-0.70 [-1.84, 0.44]
Total (95% CI)			**72**			**68**	**100.0%**	**0.54 [-0.56, 1.64]**

Heterogeneity: Tau² = 0.74; Chi² = 9.33, df = 2 (P = 0.009); I² = 79%
Test for overall effect: Z = 0.96 (P = 0.33)



Comparison 2.4. Change of Incisor inclination (L1-MP), positive mean means proclination

Study or Subgroup	Self-ligating Mean	SD	Total	Conventional Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Jiang 2008	9.9	5.4	13	9.2	9	13	5.5%	0.70 [-5.01, 6.41]
Pandis 2009	3.1	2.8	27	5.6	4.2	27	49.0%	-2.50 [-4.40, -0.60]
Scott 2008	1.7	4.1	32	2.3	3.7	28	45.6%	-0.60 [-2.57, 1.37]
Total (95% CI)			**72**			**68**	**100.0%**	**-1.46 [-2.79, -0.13]**

Heterogeneity: Chi² = 2.43, df = 2 (P = 0.30); I² = 18%
Test for overall effect: Z = 2.15 (P = 0.03)

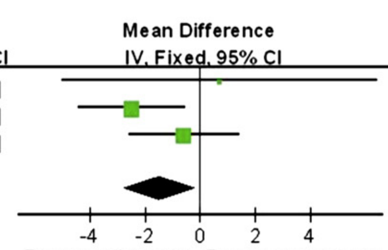


Fig 3. Comparison of effectiveness: self-ligating vs conventional brackets.

arch was found. The efficiency of alignment was found to be associated with initial irregularity only. The study of Fleming et al[23] was not included in the meta-analysis because of the 3-dimensional analysis that they used. However, they also concluded that, for nonextraction patients with mild mandibular incisor crowding, self-ligating brackets were no more effective at relieving irregularity.

The other study by Miles[27] addressed the efficiency of space closure. This was a prospective cohort study with a split-mouth design with moderate risk of bias. It concluded that there was no significant difference in the rate of en-masse space closure between SmartClip brackets and conventional brackets tied with stainless steel ligatures. However, the sample size was small, and the possibility that any true difference could be obscured in a split-mouth design should be considered.

Existing evidence does not support the claim that lower friction in a self-ligating system permits faster alignment or space closure in a clinical setting.

Chair time

Five cross-sectional studies comparing chair time were identified. Only 2 studies had similar methods and adequate statistics to allow pooling of the data for meta-analysis.[13,23] The results showed a mean savings of 20 seconds per arch for opening the slides of Damon brackets compared with removing the ligatures of conventional brackets. However, there was no significant difference between the time needed for closing the slides of Damon brackets and replacing the ligatures of conventional brackets. The other studies not included in the meta-analysis suggested decreased chair time with self-ligating brackets.[14,15,17]

Arch dimension and lower incisor inclination

Three studies investigated arch dimensions and mandibular incisor inclinations. Jiang and Fu[25] and Pandis et al[22] reported the changes after treatment in their prospective studies, and Scott et al[24] reported the change after progressing to 0.019 × 0.025-in stainless steel archwires in a randomized controlled trial. All 3 studies used Damon brackets in the self-ligating group. For intercanine and intermolar widths, there was no significant difference between the 2 groups. For incisor proclination, the meta-analysis indicated that self-ligating brackets resulted in slightly less incisor proclination (1.5°).

Subjects in the studies of Jiang et al[25] and Pandis et al[22] were all treated without extractions, while Scott et al[24] reported on extraction patients with greater incisor irregularity at the beginning of the treatment. Scott et al reported greater increases in intercanine width, probably because the canines were retracted to a wider part of the arch. Intermolar width was not increased with self-ligating brackets in that study, and, according to the authors, it was probably related to forward sliding of the molars into a narrower part of the arch in the extraction patients.[24] In addition, different archwire sequences were used for the 2 groups in the studies of Jiang and Fu[25] and Pandis et al,[22] whereas Scott et al[24] used the same archwires for both groups. These results suggest that self-ligating and conventional appliances resolve crowding with a similar mechanism, since the only statistically significant finding was the 1.5° difference in incisor proclination. The claims that self-ligating brackets facilitate greater and more physiologic arch expansion and, therefore, allow more nonextraction treatment require more evidence.

Bracket failure rate

Four studies investigating bracket failures were identified.[13,28,29,31] Only Miles et al[28] and Pandis et al[29] reported the percentages of failed brackets and had results that could be pooled. These 2 studies were both prospective with moderate risks of bias. The meta-analysis showed no significant differences in the bracket failures rates between the 2 groups. However, heterogeneity was high, and the 2 studies suggested conflicting results, with Pandis et al[29] favoring self-ligating brackets, and Miles et al[28] favoring conventional brackets. Pandis et al included first-time failures only. Also, the durations were different between the 2 studies. The study of Hamilton et al[31] was not included in the meta-analysis but also showed a higher percentage of patients experiencing bracket failures and more mean failures per person with self-ligating brackets. Self-ligating brackets usually have a smaller base and a thicker profile than do conventional brackets. Therefore, it was postulated that the increased failure rate with self-ligating brackets might have been due to the smaller base and the higher profile, especially in the mandibular posterior teeth.[33] However, no significant difference was found from the meta-analysis.

Stability

Some claim that lower forces produced by self-ligating bracket systems might result in more physiologic tooth movement and more stable treatment results. However, studies on stability after treatment with self-ligating brackets are lacking at this time.

CONCLUSIONS

Despite claims regarding the clinical superiority of self-ligating brackets, evidence is generally lacking.

Self-ligation does appear to have a significant advantage with regard to chair time, based on several cross-sectional studies. Analyses also showed a small, but statistically significant, difference in mandibular incisor proclination (1.5° less proclination with self-ligating brackets compared with conventional brackets). No other significant differences in treatment time or occlusal characteristics after treatment were found. No studies on long-term stability of treatment met our inclusion criteria. Well-matched or randomized subjects, protocols for identifying the end of treatment, and blinded assessors for outcome measurements are important factors for future studies to minimize potential biases.

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APPENDIX 1

Database searching strategies

PubMed: ("Orthodontic Appliances"[Mesh] OR bracket* OR brace OR braces) AND (self-ligat* OR self ligat*).

Web of Science and Cochrane Library: (brace* OR bracket*) AND (self-ligat* OR self ligat*).

Embase: (1) [exp Orthodontics/ or exp Orthodontic Device/ or brackets.mp; (2) self-ligating.mp; (3) 2 or self-ligat*.mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer name]; (4) 1 and 3; (5) from 4 keep 1.

APPENDIX 2

Characteristics of excluded studies

Study	*Reason for exclusion*
Agarwal et al,[34] 2008	Inclusion criteria for article type not met
Baccetti and Franchi,[35] 2006	In vitro study
Badawi et al,[19] 2008	In vitro study
Baek et al,[36] 2008	Inclusion criteria for comparison group not met
Baek,[37] 2008	Response
Bednar et al,[38] 1993	In vitro study
Bednar et al,[39] 1991	In vitro study
Berger,[40] 1999	Inclusion criteria for article type not met
Berger,[41] 1994	Inclusion criteria for article type not met
Berger,[10] 1990	In vitro study
Blake et al,[42] 1995	Not outcome of interest
Bortoly et al,[43] 2008	In vitro study
Breuning,[44] 2008	Not pertinent
Budd et al,[9] 2008	In vitro study
Cacciafesta et al,[45] 2003	In vitro study
Chalgren et al,[46] 2007	In vitro study
Champagne et al,[47] 2007	Inclusion criteria for article type not met
Damon,[2] 1998	Inclusion criteria for article type not met
Damon,[3] 1998	Inclusion criteria for article type not met
Deguchi et al,[48] 2007	Not pertinent
Elayyan et al,[49] 2008	Ex vivo study
Elekdag-Turk et al,[50] 2008	Inclusion criteria for comparison group not met
Eliades,[51] 2008	Response
Eliades,[52] 2006	Response
Eliades and Bourauel,[53] 2005	Inclusion criteria for article type not met
Ellis,[54] 2008	Inclusion criteria for article type not met
Fleming et al,[55] 2009	Not outcome of interest
Fleming et al,[56] 2008	Inclusion criteria for article type not met
Franchi et al,[57] 2008	In vitro study
Gandini et al,[58] 2008	In vitro study
Garino and Garino,[59] 2004	Inclusion criteria for comparison group not met
Garino and Favero,[60] 2003	Inclusion criteria for comparison group not met
Giancotti and Greco,[61] 2008	Inclusion criteria for article type not met
Giancotti and Greco,[62] 2008	Inclusion criteria for article type not met
Goldbecher et al,[63] 2005	Unable to obtain article
Gottlieb et al,[64] 1972	Inclusion criteria for article type not met
Griffiths et al,[5] 2005	In vitro study
Hain et al,[65] 2006	In vitro study
Hain et al,[66] 2003	In vitro study

APPENDIX 2. Continued

Study	*Reason for exclusion*
Harradine,[11] 2003	Inclusion criteria for article type not met
Harradine and Birnie,[33] 1996	Inclusion criteria for article type not met
Hayashi et al,[67] 2007	Not pertinent
He et al,[68] 2009	Protocol
Hemingway et al,[69] 2001	In vitro study
Henao and Kusy,[6] 2005	In vitro study
Henao and Kusy,[70] 2004	In vitro study
Janson et al,[71] 2000	Not pertinent
Kao,[72] 2007	No analytic design
Katsaros and Dijkman,[73] 2003	Inclusion criteria for article type not met
Khambay et al,[7] 2004	In vitro study
Kim et al,[8] 2008	In vitro study
Kusy,[74] 2004	In vitro study
Lin and Xu,[75] 2008	Inclusion criteria for article type not met
Loftus and Årtun,[76] 2001	In vitro study
Loftus et al,[77] 1999	In vitro study
Loh,[78] 2007	Inclusion criteria for comparison group not met
Macchi et al,[79] 2002	Inclusion criteria for article type not met
Maijer and Lamark,[80] 2004	Inclusion criteria for article type not met
Mallory et al,[81] 2004	In vitro study
Matarese et al,[82] 2008	In vitro study
Menendez et al,[83] 2005	Study not published or peer-reviewed (conference proceeding)
Miles,[84] 2008	Response
Montgomery,[85] 2007	Inclusion criteria for article type not met
Morina et al,[86] 2008	In vitro study
Northrup et al,[87] 2007	In vitro study
Pandis et al,[88] 2008	In vitro study
Pandis et al,[89] 2008	In vitro study
Pandis et al,[90] 2008	Not outcome of interest
Pandis et al,[91] 2008	Not outcome of interest
Pandis et al,[92] 2006	Not outcome of interest
Pandis et al,[93] 2007	In vitro study
Park et al,[94] 2004	Not pertinent
Parkin,[95] 2005	Inclusion criteria for article type not met
Pellan,[96] 2006	Inclusion criteria for article type not met
Pizzoni et al,[20] 1998	In vitro study
Prososki et al,[97] 1991	In vitro study
Razavi,[98] 2008	Inclusion criteria for article type not met
Read-Ward et al,[99] 1997	Ex vivo study
Redlich et al,[100] 2008	Not pertinent
Redlich et al,[101] 2003	In vitro study
Reicheneder et al,[102] 2008	In vitro study
Reicheneder et al,[103] 2007	In vitro study
Rinchuse et al,[104] 2008	Response

APPENDIX 2. Continued

Study	*Reason for exclusion*
Rinchuse and Miles,[105] 2007	Inclusion criteria for article type not met
Rinchuse et al,[106] 2007	Inclusion criteria for article type not met
Sakima et al,[107] 2006	Not pertinent
Scott et al,[108] 2008	Not outcome of interest
Shivapuja and Berger,[16] 1994	In vitro study
Sims et al,[109] 1994	Ex vivo study
Sims et al,[21] 1993	In vitro study
Sivakumar et al,[110] 2006	Inclusion criteria for article type not met
Smith et al,[111] 2008	Protocol
Southard et al,[112] 2007	Inclusion criteria for article type not met
Tecco et al,[113] 2007	In vitro study
Tecco et al,[114] 2005	In vitro study
Thermac et al,[115] 2008	In vitro study
Thomas et al,[116] 1998	In vitro study
Thorstenson and Kusy,[117] 2002	In vitro study
Thorstenson and Kusy,[118] 2002	In vitro study
Thorstenson and Kusy,[119] 2001	In vitro study
Thorstenson and Kusy,[120] 2000	Meeting abstract
Torres et al,[121] 2005	Study not published or peer-reviewed (conference proceeding)
van Aken et al,[122] 2008	Not pertinent
Wilkinson et al,[123] 2002	Not pertinent
Yeh et al,[124] 2007	In vitro study
Yu and Qian,[125] 2007	Inclusion criteria for article type not met
Zachrisson,[126] 2006	Inclusion criteria for article type not met
Zhu et al,[127] 2007	In vitro study
Ziuchkovski et al,[128] 2008	Not outcome of interest

APPENDIX 3

Quality assessment of the included studies

Randomized clinical trials

Study	Randomization described	Allocation concealment reported	Intent to treat analysis performed	Blinded assessment stated	A priori power calculation performed	Total points	Risk of bias
Fleming et al,[23] 2009	1	1	1	0.5	1	4.5	Low
Scott et al,[24] 2008	1	0	1	1	1	4	Low

Cohort studies

Study	Representative sample of adequate size (∼30 in each group)	Well-matched sample	Adjusting for confounders	Blinded assessment stated	Reporting drop-outs	Total points	Risk of bias
Eberting et al,[12] 2001	1	0.5	1	0	NA	2.5	Moderate
Hamilton et al,[31] 2008	1	1	1	0	NA	3	Moderate
Harradine,[13] 2001	1	1	0	1	NA	3	Moderate
Jiang and Fu,[25] 2008	0	0.5	0.5	0	0.5	1.5	High
Miles,[26] 2005	1	0.5	0	0	1	2.5	Moderate
Miles et al,[28] 2006	1	1	NA	0	1	3	Moderate
Miles,[27] 2007	0	1	NA	0	1	2	Moderate
Pandis et al,[29] 2006	0.5	0.5	1	0	0	2	Moderate
Pandis et al,[30] 2007	1	1	1	0	1	4	Low
Pandis et al,[22] 2009 (in press)	1	1	1	0	1	4	Low

Cross-sectional studies

Study	Representative sample of adequate size (∼30 in each group)	Well-matched sample	Adjusting for confounders	Blinded assessment stated	Reporting drop-outs	Total points	Risk of bias
Berger and Byloff,[14] 2001	0.5	0	0	0	NA	0.5	High
Maijer and Smith,[15] 1990	0	0	0	0	NA	0	High
Paduano et al,[17] 2008	0.5	0	0	0	NA	0.5	High
Turnbull and Birnie,[32] 2007	1	1	0.5	0	NA	2.5	Moderate

Quality assessment was based on a modified Newcastle-Ottawa scale: *1,* criterion met; *0.5,* criterion partially met; *0,* criterion not met or not stated. *NA,* Not applicable.
Risk of bias: *low,* >4 points; *moderate,* 2-3.5 points; *high,* <2 points.