Systematic Review

The effect of bracket slot size on the effectiveness of orthodontic treatment: *A systematic review*

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ABSTRACT

Objectives: To assess, by means of a systematic review, the scientific evidence of the influence of 0.018-inch or 0.022-inch bracket slots on treatment time, efficiency of space closure, efficiency of alignment, quality of orthodontic finishing, level of discomfort, and level of root resorption.

Materials and Methods: The PubMed, Bireme, Medline, Scopus, Web of Science, Open Grey, and Google Scholar databases were searched, with no date and language restrictions, for randomized clinical trials and controlled clinical trials, using controlled terms related to bracket slots. After the selection and removal of duplicate articles, the risk of bias was assessed, and the data from the included studies were extracted by two independent researchers.

Results: The search yielded 2640 studies. After applying the eligibility criteria, eight articles were fully read and four studies were selected for the qualitative systematic review. No randomized clinical trials assessed the duration of treatment in patients treated with 0.018-inch and 0.022-inch bracket slots. Due to heterogeneity of the data available, a meta-analysis could not be conducted.

Conclusions: While most studies indicated a shorter duration of treatment in patients with 0.018-inch bracket slots, no available data confirmed the higher efficiency of one system over the other. The biases in the studies did not allow for a reliable conclusion; therefore, new studies with a better methodologic design are needed. (*Angle Orthod.* 2018;88:100–106.)

KEY WORDS: Bracket slot size; Duration of treatment; Clinical outcomes

INTRODUCTION

In 1925, Edward Angle introduced the edgewise orthodontic appliance system and proposed the 0.022-inch by 0.028-inch bracket slot size, which allowed better control of crown and root position with the precious metal archwires available at that time.[1] With technologic breakthroughs, stainless steel alloys began to be used in orthodontics, making it possible to manufacture thinner wires with the same stiffness as that of gold archwires at a lower cost.[2,3] This permitted reducing bracket slot size to 0.018-inch. However, this did not preclude the continued use of 0.022-inch bracket slots in clinical practice.[4]

Some biomechanical advantages and disadvantages have been suggested for the use of 0.018-inch and 0.022-inch bracket slots. It is paramount that the wire fills the bracket slot in order to express angulation and inclination. The 0.018-inch bracket slot can be filled at the beginning of treatment to improve torque control of anterior teeth.[5] Moreover, the smaller and more flexible finishing archwires used with the 0.018-inch slot are more easily manipulated by the orthodontist.[6] On the other hand, the 0.022-inch bracket slot facilitates archwire insertion at the first visit, offers more size and wire composition options, and provides wires with greater freedom of movement during the initial alignment stage, thereby obtaining lighter forces.[7,8] Later in the treatment, the archwires with larger diameter used in the 0.022-inch bracket slot are stiffer and help

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control teeth in the vertical dimension during space closure and retraction mechanics.[5]

Preferences for each bracket slot size vary around the world, and the selection is often empirical, following the recommendations of a specific dental school. In several European countries, the 0.018-inch bracket slots are more commonly used, whereas in the United States, most orthodontists work with 0.022-inch slots.[3,5] There is scant evidence in the literature showing the advantages of one system over another; hence, orthodontists make this clinical decision with little scientific guidance.

Accordingly, the main objective of this systematic review was to determine whether the use of 0.018-inch or 0.022-inch bracket slots influences the duration of treatment, efficiency of space closure, efficiency of alignment, quality of orthodontic finishing, level of discomfort, and level of root resorption observed.

MATERIALS AND METHODS

Protocol and Registration

This systematic review was registered at PROSPERO under protocol CRD42015015916, which is available at http://www.crd.york.ac.uk/PROSPERO/register_new_review.asp?RecordID=15916&UserID=9696.

Eligibility Criteria

This systematic review utilized the PICO (Population-Intervention-Comparison-Results) strategy for the research conducted. Prospective and retrospective clinical studies with patients whose fixed orthodontic appliances utilized 0.018-inch or 0.022-inch bracket slots were selected. As outcomes, the results of the eligible studies should have assessed the quality of orthodontic finishing, duration of treatment, efficiency of alignment, pain experience, efficiency of orthodontic space closure, and/or root resorption. Laboratory reports, editorials, clinical cases, and studies that did not compare the 0.018-inch and 0.022-inch bracket slots were not included.

Search

Several electronic databases (PubMed, Medline, Bireme, Scopus, Web of Science, Google Scholar, and Open Grey) were searched. Manual searches were also performed using the references of the selected articles.

No language or date restrictions were applied to the searches, and the following terms, adapted to each syntax rule, were used: “fixed orthodontic appliance” or “fixed appliance” or “orthodontic treatment” or “orthodontic patient” or “orthodontic brackets” or “orthodontic appliance design” or “orthodontic appliance” and “bracket size” or “bracket slot” or “bracket dimension” or “slot dimension” or “bracket slot height” or “bracket slot size” or “slot size” or “slot bracket system” and “0.018 inch slot” or “.018 inch” or “0.018 inch” and “0.022 inch slot” or “.022 inch” or “0.022 inch.” Additionally, the authors included MeSH synonyms, related terms, and free terms. The searches were made until the date of May 20, 2017. All the relevant titles were saved in a reference manager (EndNote, version X5.0.1, Thomson Reuters (Scientific) LLC, New York, NY/USA) and duplicate articles were removed.

The electronic databases were searched independently by two researchers (B.S.D.W. and E.P.V.) to identify the relevant studies. All titles/abstracts were read, and those that met the eligibility criteria were selected for later access to the full articles.

Data Extraction

The data on the studies included in this review were extracted by two independent researchers, and their results were then compared. When lack of agreement could not be solved, a third researcher (L.F.P.) was consulted. The following data were collected from the selected articles: authors, year of publication, sample size, age of participants, bracket slot size, alignment efficiency, space closure efficiency, overall duration of treatment, quality of orthodontic finishing, type of bracket, and conclusions.

The critical assessment of medical articles, developed by Fowkes and Fulton,[9] which consists of a qualification scale for methodologic quality, was used to determine the risk of bias in the included studies. This protocol allowed for the identification of important elements of the methodologic design. This guideline’s checklist includes questions on study design, study sample, characteristics of the control group, quality of measurements and outcomes, completeness, and distorting influences. Each item was classified as a major problem (++), minor problem (+), no problem (0), or not applicable (NA) and included one or more aspects of bias or applicability. However, this type of analysis of bias did not give any overall quantitative grade.

The selection criteria and the presence or absence of a reference pattern for diagnosis and researcher blinding were used to assess the risk of partiality and the quality of each primary study. Each criterion was analyzed independently by two researchers (B.S.D.W. and E.P.V.), and when there was lack of agreement between them, a third reviewer (L.F.P.) was consulted.

Risk of Bias in the Studies

Once a detailed appraisal of the methods and results was performed, the studies were analyzed to deter-

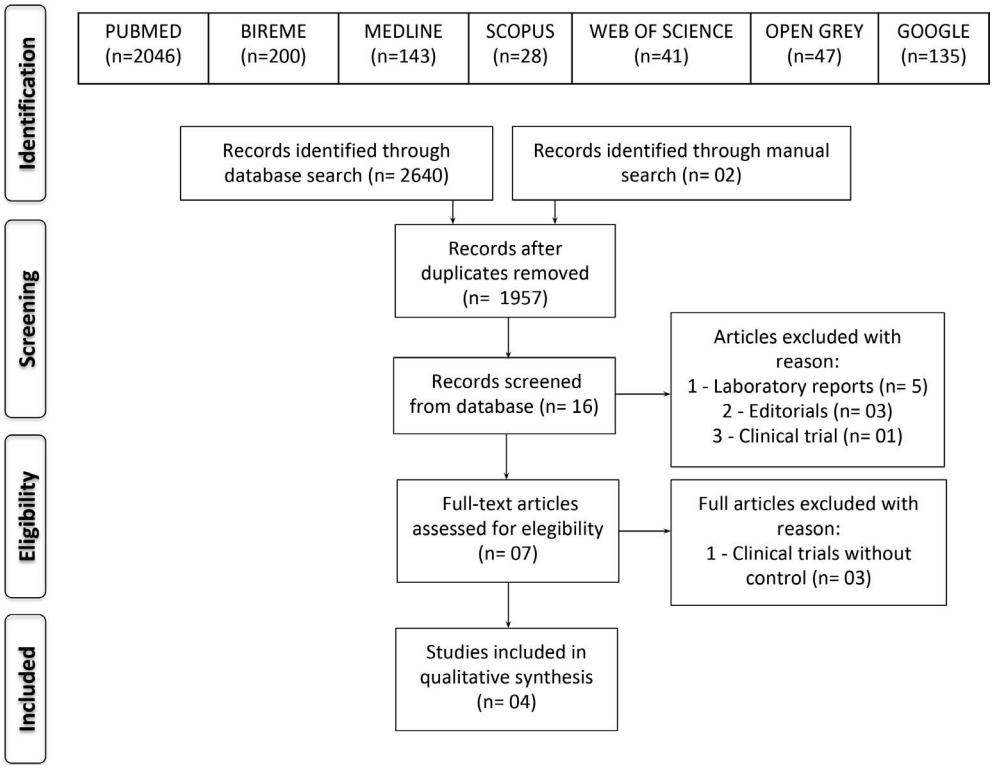

Figure 1. Flowchart showing the results of manual and database searches.

mine the possibility of biased results, serious confounders, and occurrence of chance.[9] Finally, to determine the value of the study, three questions were posed: (1) Are the results erroneously biased in a certain direction? (2) Are there any serious confounding or other distorting influences? and (3) Is it likely that the results occurred by chance? If these three summary questions were answered with no, then there was a high probability that the research presented low risk of bias.

RESULTS

Selection of the Studies

The search yielded 2640 studies: 2046 from PubMed, 200 from Bireme, 143 from Medline, 135 from Google Scholar, 47 from Open Grey, 41 from Web of Science, and 28 from Scopus. After all duplicate articles were removed, a total of 1957 remained.

After applying the eligibility criteria, eight articles were fully read, of which four were excluded for not meeting all of the eligibility criteria. Finally, four studies (references 10–13) were selected for the qualitative systematic review (Figure 1).

Characteristics of the Studies

Table 1 provides a detailed description of the studies included in the systematic review.

Two articles[10,11] had as their major aim the comparison of 0.018-inch and 0.022-inch bracket slots. One study investigated factors that could affect the duration of orthodontic treatment.[12] The other study compared alignment efficiency using three different types of archwires associated with the use of 0.018-inch and 0.022-inch bracket slots.[13]

In two studies,[10,11] participants' ages ranged from 14 to 16 years. In one study,[12] the age range at the start of treatment was 9 to 55.4 years, with an average age of 16.3 years. The last study was conducted with individuals age 10 to 30 years.[13]

Among the four selected studies, only two evaluated quality of orthodontic finishing with bracket slot size.[11,12] No articles assessed level of discomfort and level of root resorption with bracket slot size.

Risk of Bias in the Studies

No randomized clinical trials assessed the duration of treatment in patients treated with 0.018-inch and 0.022-inch bracket slots. The randomized clinical trial that compared the alignment efficiency of the two types of bracket slots was considered to be slightly biased.[13] The other three articles included in this review were moderately to heavily biased.[10–12] The risk of bias of the selected studies is shown in Table 2.

Table 1. Data on the Studies Included in the Review

Author(s), Year	Design	Sample Size	Age, Y	Alignment Efficiency
Cobb *et* al., 1998	Randomized clinical trial	G. 0.018 inch: 85 arches G. 0.022 inch: 70 arches	Not assessed	One-month difference in favor of 0.022-inch bracket slot in mandibular arch ($P < .05$)
Amditis and Smith, 2000	Retrospective clinical trial	G. 0.018 inch: 32 patients G. 0.022 inch: 32 patients	G. 0.018 inch: 15.6 G. 0.022 inch: 14.9	Not assessed
Vu et al., 2008	Retrospective clinical trial	G. 0.018 inch: 364 patients G. 0.022-inch: 91 patients	Not assessed	Not assessed
Detterline et al., 2010	Retrospective clinical trial	G. 0.018-inch: 613 patients G. 0.022 inch: 215 patients	G. 0.018 inch: 16.5 G. 0.022 inch: 17.7	0.4-month difference in favor of 0.018-inch slot ($P < .05$)

G. = Group

Results of Individual Studies

The randomized clinical trial that compared dental alignment in three types of archwires and two widely used simple and double edgewise bracket slot sizes (0.018-inch and 0.022-inch) showed that the time and rate necessary for alignment were very similar in both bracket slot sizes for the maxillary arch, but alignment was significantly faster for the 0.022-inch slot in the mandibular arch ($P > .05$): 1 month on average.[13]

One of the retrospective studies assessed in this review compared the duration of orthodontic treatment in two groups of patients with edgewise bracket slots (0.018-inch and 0.022-inch). The mean duration of treatment was 20.2 months for the group treated with 0.018-inch bracket slots and 21.7 months for the 0.022-inch group ($P < .05$). When the patients were split into subgroups according to the patient's molar relationship and tooth extraction for orthodontic purposes, there was a larger difference in the duration of treatment in favor of the 0.018-inch bracket slot in patients with Class I malocclusion and in those who required tooth extraction.[10]

Another study assessed the duration of orthodontic treatment and revealed that treatment with 0.022-inch bracket slots was, on average, 9.5 months longer than treatment with 0.018-inch bracket slots. This retrospective study sought to identify and quantify the factors that affected the duration of orthodontic treatment and concluded that the 0.022-inch bracket slot was associated with a longer treatment time. Bracket slot sizes did not influence the quality of orthodontic finishing.[12]

The fourth study included in this review investigated whether there was a significant difference in the clinical results of patients treated with 0.018-inch or 0.022-inch bracket slots and revealed a significantly shorter average duration of treatment for 0.018-inch bracket slots ($P < .001$; difference of 3.9 months). The ABO-OGS (American Board of Orthodontics and Objective Grading System) score assessed the quality of orthodontic finishing, showing a 2.7-point difference for the 0.018-inch bracket slots ($P < .05$). In addition, patients treated with 0.018-inch bracket slots had the best scores in the alignment/rotations assessment.[11]

Summary of Results

Owing to the heterogeneous data, a meta-analysis could not be conducted. There were large differences regarding the selection and size of the samples: difference in the type of bracket used (ie, single, twin, ceramic, edgewise, metal, self-ligating), inclusion or not of surgical patients, and functional devices used in the treatment (ie, extraoral headgear, Herbst, Forsus), in addition to the fact that some articles excluded, while others included, patients with tooth extraction for orthodontic purposes and traction of embedded teeth. It is also important to mention that there were different methods for describing the final quality of orthodontic treatment. With respect to sample size, the articles assessed between 64 and 828 participants.

DISCUSSION

To date, some questions still remain about the effects of bracket slot size on the efficiency of orthodontic treatment. The choices seem to be made by clinicians despite the lack of scientific evidence.

Table 1. Extended

Space Closure Efficiency	Overall Duration of Treatment, Mo	Quality of Orthodontic Finishing	Bracket Type	Author(s) Conclusions
Not assessed	Not assessed	Not assessed	Edgewise (mix of single wing and twin brackets)	Alignment was, on average, 1 month faster in the mandibular arch with the 0.022-inch bracket slot
The 0.018-inch bracket slot seemed to be more efficient. Patients with tooth extraction were faster ($P < .05$)	G. 0.018 inch: 20.2 G. 0.022 inch: 21.7	Not assessed	Edgewise	Mean duration of treatment with the 0.018-inch slot was shorter by 1.5 months ($P < .05$)
Not assessed	G. 0.018 inch: 27.14 G. 0.022-inch: 36.68	No correlation between bracket slot size and quality of orthodontic finishing	Ceramic, self-ligating and metal	Mean duration of treatment with the 0.018-inch slot was shorter by 9.5 months ($P < .05$)
Not assessed	G. 0.018 inch: 30.2 G. 0.022 inch: 34.1	In the ABO-OGS scoring system, there was a 2.7 difference ($P < .05$) in favor of the 0.018-inch slot	Not specified	Mean duration of treatment with 0.018-inch slot was shorter by 3.8 months ($P < .05$)

Among the studies included in this review, only two investigated whether bracket slot sizes have some influence on the duration of orthodontic treatment.[10,11]

The articles that associated duration of treatment with bracket slot size revealed longer treatment times when 0.022-inch rather than 0.018-inch bracket slot sizes were used.[10–12] However, there was a stark difference in duration of treatment between these studies: orthodontic treatment was 9.5 months longer in patients with 0.022-inch bracket slots,[12] and that study assessed 455 patients, suggesting that the difference could be explained by a sampling bias related to the small number of cases treated with 0.022-inch bracket slots, which was less than 20% of the sample. In addition, the authors described important clinical differences before treatment: there were surgical patients and patients treated with the Tweed technique in the 0.022-inch group.[12]

In another study,[11] the patients treated with 0.022-inch bracket slots demonstrated an average increase in the duration of treatment of 3.8 months ($P < .05$). The difference in treatment duration between the studies can be explained by the exclusion of orthognathic surgery cases in the study undertaken by Detterline et al.,[11] since Vu et al.[12] reported an average duration of treatment of 7.4 more months for cases including orthognathic surgery regardless of the type of bracket used.

A study[10] compared 64 patients with both bracket slot sizes treated consecutively by the same orthodontist at a private practice and detected a small, but statistically significant, clinical difference of 1.5 months in the duration of treatment in favor of 0.018-inch bracket slots. Those authors suggested that space closure by means of sliding mechanics may have been more efficiently achieved with the use of the 0.018-inch bracket slot, as the mean duration of treatment between the groups with tooth extraction (n = 26, 0.018-inch bracket slot; n = 25, 0.022-inch bracket slot) and without extraction (n = 6, 0.018-inch bracket slot; n = 7, 0.022-inch bracket slot) was different in this study. In the patients without tooth extraction, the mean duration of treatment using the two bracket slots was almost identical. By contrast, in the patients with tooth extraction, the mean difference between the two groups was significant—in favor of the 0.018-inch bracket slot by a mean of 2.1 months.

The studies concluded that the mean duration of treatment for patients with Class I malocclusion was shorter than for patients with Class II or III malocclusion[10,12] treated with 0.018-inch or 0.022-inch bracket slots. Moreover, the findings of Vu et al.[12] indicated higher quality of orthodontic finishing for patients with Class I malocclusion. In that study, there was no correlation between bracket slot size and quality of orthodontic finishing. The patients treated with 0.018-inch and 0.022-inch bracket slots showed similar quality of orthodontic finishing.

Detterline et al.[11] found a statistically significant difference of 2.7 points in the ABO-OGS overall score in quality of orthodontic finishing in favor of the 0.018-inch bracket slot. In that study, the 0.018-inch bracket slot was better in terms of duration of treatment and quality of orthodontic finishing. However, when the categories were evaluated separately, only the alignment/rotations category proved to be significantly different. The largest difference in quality of orthodontic finishing in any of the categories did not exceed 0.5 points. The large sample size of that study led to

Table 2. Quality Assessment According to Fowkes and Fulton[9,a]

Guideline	Checklist		Cobb et al.[13]	Amditis and Smith[10]	Vu et al.[12]	Detterline et al.[11]
	Objective	Common Design				
Study design appropriate to objective?	Prevalence	Cross-sectional	NA	NA	NA	NA
	Prognosis	Cohort	NA	0	0	0
	Treatment	Controlled trial	0	NA	NA	NA
	Cause	Cohort, case-control, cross-sectional	NA	NA	NA	NA
Study sample representative?	Source of sample		0	+	+	+
	Sampling method		0	+	+	+
	Sample size		0	+	++	++
	Entry criteria/exclusions		0	0	0	0
	Nonrespondents		0	0	0	0
Control group acceptable?	Definition of controls		0	0	0	0
	Source of controls		0	0	0	0
	Matching/randomization		0	+	+	+
	Comparable characteristics		0	0	0	0
Quality of measurements and outcomes?	Validity		0	0	0	0
	Reproducibility		+	+	+	+
	Blindness		NA	NA	NA	NA
	Quality control		0	0	0	0
Completeness?	Compliance		0	0	0	0
	Dropouts		0	0	0	0
	Deaths		NA	NA	NA	NA
	Missing data		+	+	+	+
Distorting influences?	Extraneous treatments		+	0	+	0
	Contamination		NA	NA	NA	NA
	Changes over time		0	0	0	0
	Confounding factors		+	0	+	+
	Distortion reduced by analysis		0	0	+	0
Summary questions	Bias: Are the results erroneously biased in a certain direction?		No	No	Yes	Yes
	Confounding: Are there any serious confounding or other distorting influences?		Yes	Yes	Yes	Yes
	Chance: Is it likely that the results occurred by chance?		No	Yes	No	No

[a] ++: major problem; +: minor problem; 0: no problem; NA: not applicable.

statistically significant differences that are clinically questionable.

The efficiency of treatment in terms of dental alignment between patients treated with 0.018-inch and 0.022-inch brackets was assessed by Cobb et al.[13] According to that study, the only statistically significant difference was the quicker alignment of the mandibular arch with 0.022-inch bracket slots. Nevertheless, the study did not standardize the types of brackets used. Bracket design seems to have affected the results more than did bracket size, as in that study, twin and single-wing brackets were used in the mandibular arch with the 0.018-inch slot, whereas twin brackets were used with the 0.022-inch slot. The orthodontic wires used in the study were randomly selected. Bracket slot size could not be randomized as each orthodontist worked with only one bracket slot size.

A randomized clinical study compared the efficiency of 0.018-inch and 0.022-inch in orthodontic treatment,[3] but the results have not been published yet. No studies have associated bracket slot size with level of discomfort of orthodontic treatment and level of root resorption.[14]

The actual slot size and shape of an orthodontic bracket are likely to vary, that is, they may be larger or smaller than the advertised nominal value within a bracket series. Manufacturing anomalies may occur in a single bracket, throughout the sets of specific tooth brackets, or generally throughout an entire bracket series.[15] These manufacturing irregularities hamper efforts to evaluate how bracket slot size may affect the outcomes of orthodontic treatment.

There is insufficient scientific evidence from currently available studies to recommend a specific bracket slot size for better treatment efficiency. This review indicates the need for randomized clinical trials to make more reliable clinical recommendations about which bracket slot size is more efficient.

CONCLUSIONS

- Three of the four studies included in this systematic review showed greater efficiency of the 0.018-inch bracket slot size than the 0.022-inch counterpart.
- However, there are no data that confirm the higher efficiency of one system over the other, given that the risk of bias inherent to the design of the analyzed studies did not allow for a reliable conclusion.
- Randomized and controlled clinical trials should be conducted to gather reliable evidence on the use of 0.018-inch or 0.022-inch bracket slot sizes and their impact on the efficiency of orthodontic treatment.

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