Systematic Review Article

Early vs late orthodontic treatment of tooth crowding by first premolar extraction:

A systematic review

Hibernon Lopes Filho[a]; Lúcio H. Maia[a]; Thiago C. L. Lau[a]; Margareth M. G. de Souza[b]; Lucianne Cople Maia[b]

ABSTRACT

Objective: To investigate the body of evidence in the literature about the most favorable time for initiating orthodontic treatment in patients with severe crowding caused by tooth size arch length deficiency (TSALD).

Materials and Methods: Electronic databases (PubMed, Ovid Medline, Scopus, Virtual Health Library, and The Cochrane Library) were searched for articles published between 1900 and April 2014. Studies were included that evaluated treatment of patients with severe crowding caused TSALD, who were treated with first premolar extraction. The association between the stage of development of occlusion at which treatment was started, and the primary and/or secondary outcomes of early and late treatment were investigated.

Results: After application of the eligibility criteria and reading of the full texts, six articles were included in the final review. Of these six articles, all of which were retrospective, four showed that the primary outcome (correction of severe crowding) of the early and late groups was improved, but without statistically significant differences after treatment. Therefore, the findings of secondary outcomes in the literature (postretention crowding relapse, duration of total and active treatment [treatment with appliances], external apical root resorption, and soft tissue profile) were the target of this study. These studies presented low or moderate methodological quality and control of bias.

Conclusions: Both early and late extraction had a similar effect on correction of crowding. Early treatment had two favorable secondary outcomes (less relapse and reduced active treatment time) vs late treatment. However, the levels of evidence were not sufficient to assert which protocol was superior. (*Angle Orthod.* 2015;85:510–517.)

KEY WORDS: Tooth crowding; Serial extraction; Early treatment; Early and late treatment

INTRODUCTION

The appropriate therapy for dental crowding varies according to the magnitude of the problem. According to Little et al.,[1] this therapy may involve follow-up to develop and correct the occlusion. However, this is not always the case, and correction may occur spontaneously in patients with slight crowding (up to 2 mm); cases of severe crowding (>9 mm) may require more extensive therapy with tooth extractions.

Severe crowding caused by tooth size arch length deficiency (TSALD) may be treated at an early stage with serial tooth extractions in the early mixed dentition (first transitory period) or with late extraction of the premolars in the permanent dentition. The classic procedure of early treatment with the protocol of serial extractions has involved removal of the primary canines and finally; followed by later removal of the permanent the first premolars. Therefore, the goal of extraction in both time intervals is to create space to enable the correct alignment and leveling of the teeth in basal bone.[2–4]

[a] Postgraduate Student, Department of Pediatrics and Orthodontics, Universidade Federal do Rio de Janeiro Dental School, Rio de Janeiro, Brazil.

[b] Professor, Department of Pediatrics and Orthodontics, Universidade Federal do Rio de Janeiro Dental School, Rio de Janeiro, Brazil.

Corresponding author: Dr Lucianne Cople Maia, Dental School, Universidade Federal do Rio de Janeiro, UFRJ, Av. Professor Rodolpho Paulo Rocco, Ilha do Fundão, Rio de Janeiro, CEP 21941-590, Brazil
(e-mail: rorefa@terra.com.br)

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Table 1. Electronic Databases and Search Strategy Used

Database	Search Strategy	
	Key Words/MeSH	Refining Terms
PubMed www.ncbi.nlm.nih.gov/pubmed	Serial extraction [MeSH] OR "early versus late treatment of crowded" OR "early orthodontic treatment" OR "late premolar extraction" OR "first premolar extraction" OR "Serial extraction and late premolar extraction" AND "crowded" OR "tooth crowding"	Title, abstract; humans
OVID Medline www.ovidsp.tx.ovid.com	Serial extraction [MeSH] OR "early orthodontic treatment" OR "early versus late treatment of crowded" AND "crowded" OR "tooth crowding"	Humans
Scopus www.scopus.com/home.url	Serial extraction [MeSH] OR "early orthodontic treatment" OR "late premolar extraction" OR "premolar extraction" AND "crowded" OR "tooth crowding"	Title, abstract, key words; document, humans
Virtual Health Library (LILACS, IBECS, Medline, Scielo) www.regional.bvsalud.org/php/index.php	Serial extraction [MeSH] AND "tooth crowding" AND "premolar"	Humans
Cochrane Library www.thecochranelibrary.com/view/0/index.html	Serial extraction OR "early orthodontic treatment" AND "crowded" OR "tooth crowding"	-

The ideal time for the beginning of orthodontic treatment has always been a subject of controversy; the factors that most frequently favor early treatment are that it is easy to perform, and its cost, duration, and stability are better vs late treatment.[5] This was also the opinion of 159 orthodontists of the American Board of Orthodontics, who said that treatment performed at an early stage enables improved control of growth; increases the patient's self-esteem and parents' satisfaction; presents better and more stable results; diminishes the extent of treatment needed for the permanent dentition, when necessary; and causes less damage to the periodontal tissues and tooth enamel.[6]

Many authors[7–12] have written about the subject expressing the same optimistic trend toward early treatment with regard to clinical efficacy, reduction in mechanotherapy, and increase in stability. However, their affirmations were based on professional experience and case reports only. Therefore, by means of a systematic review, the aim of this research was to answer the following focused question: For patients with severe crowding caused by TSALD, are the occlusal and secondary outcomes of treatment with early first premolar extraction equivalent to those obtained with late treatment?

MATERIALS AND METHODS

To answer the focused question, this systematic review was performed in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (www.prisma-statement.org)[13] and registered with the number CRD42014009006.

Study Selection Criteria

The following criteria were formulated to select articles for inclusion in this review. All randomized clinical trials (RCTs) and human clinical trials with a prospective or retrospective design that evaluated treatment of patients with severe crowding caused by TSALD of both genders and of different social and racial groups (Participants) were chosen. All patients were treated with first premolar extraction (Intervention). All studies must have evaluated the association between serial extraction and late premolar extraction (Comparison) and reported on the primary (occlusal) and/or secondary outcomes (Outcome). Any studies that evaluated the beginning stages of treatment and outcomes but did not compare them were excluded from this systematic review. Furthermore, case reports, pilot studies, editorials, letters, and literature reviews were also excluded from the sample.

The outcomes were divided into primary (related to correlation of severe crowding, alignment, and leveling of teeth in basal bone) and secondary (according to the findings in the literature).

Search Strategy and Screening of Articles

To identify relevant studies, irrespective of language, a detailed search was conducted in the following electronic databases for papers published between 1900 and the first week of April 2014: PubMed, Ovid, Scopus, Virtual Health Library, and The Cochrane Library. The key words and Medical Subject Headings (MeSH terms) were modified to conform to the rules of each database (Table 1).

Two independent authors evaluated the titles and abstracts of all articles separately. Disagreements between the authors were resolved by discussion to reach a consensus. In case of persistent disagreement, a third author was consulted to arrive at a consensus. If the abstract did not provide sufficient information for a decision on inclusion or exclusion, the

Table 2. Adapted Methodologic Checklist for Prognostic Studies Developed by the National Institute for Health and Clinical Excellence from United Kingdom[14]

Measure	Answer
1.1 The study sample represents the population of interest with regard to key characteristics, sufficient to limit potential bias in the results. *To minimize bias, the study population should be clearly defined and described and should represent the source population of interest. Points to consider include the following:* • *Is the source population or the population of interest adequately described with respect to key characteristics?* • *Are the sampling frame and recruitment adequately described, possibly including methods to identify the sample (number and type used; for example, referral patterns in health care), period of recruitment, and place of recruitment (setting and geographical location)?* • *Are inclusion and exclusion criteria adequately described (for example, including explicit diagnostic criteria or a description of participants at the start of the follow-up period)?* • *Is participation in the study by eligible individuals adequate?* • *Is the baseline study sample (that is, individuals entering the study) adequately described with respect to key characteristics?*	Yes No Unclear
1.2 The prognostic factor of interest is adequately measured in study participants, sufficient to limit potential bias. *To minimize bias, prognostic factors should have been defined and measured appropriately. Points to consider include the following:* • *Is a clear definition or description of the prognostic factor(s) measured provided (including dose, level, duration of exposure, and clear specification of the method of measurement)?* • *Are continuous variables reported or appropriate cut-off points (that is, not data-dependent) used?* • *Are the prognostic factor(s) measured and the method(s) of measurement valid and reliable enough to limit misclassification bias? (This may include relevant outside sources of information on measurement properties, as well as characteristics such as blinded measurement(s) and limited reliance on recall.)* • *Are complete data for prognostic factors available for an adequate proportion of the study sample?* • *Are the method and setting of measurement the same for all study participants?* • *Are appropriate methods employed if imputation is used for missing data on prognostic factors?*	Yes No Unclear
1.3 The outcome of interest is adequately measured in study participants, sufficient to limit bias. *To minimize bias, the outcome(s) of interest should be defined and measured appropriately. Points to consider include the following:* • *Is a clear definition of the outcome of interest provided, including duration of follow-up?* • *Are the outcome(s) that was(were) measured and the method(s) of measurement valid and sufficiently reliable to limit misclassification bias? (This may include relevant outside sources of information on measurement properties, as well as characteristics such as blind measurement and limited reliance on recall.)* • *Are the method and setting of measurement the same for all study participants?*	Yes No Unclear
1.4 Important potential confounders (postretention follow-up, extraction or nonextraction treatment) are appropriately accounted for, limiting potential bias with respect to the prognostic factor of interest. *To minimize bias, important confounders should be defined and measured and confounding should be accounted for in the design or analysis. Points to consider include the following:* • *Are all important confounders, including treatments (key variables in the conceptual model), measured? Are clear definitions of the important confounders measured (including dose, level, and duration of exposures) provided?* • *Is measurement of all important confounders valid and reliable? (This may include relevant outside sources of information on measurement properties, as well as characteristics such as blind measurement and limited reliance on recall.)* • *Are the method and setting of measurement of confounders the same for all study participants?* • *Are appropriate methods employed if imputation is used for missing data on confounders?* • *Are important potential confounders accounted for in the study design (for example, matching for key variables, stratification or initial assembly of comparable groups)?* • *Are important potential confounders accounted for in the analysis (that is, appropriate adjustment)?*	Yes No Unclear
1.5 The statistical analysis is appropriate for the design of the study, limiting potential for the presentation of invalid results. In studies where the outcome of interest was not the primary outcome, consider the presence of descriptive analysis of the measures of interest. *To minimize bias, the statistical analysis undertaken should be clearly described and appropriate for the design of the study. Points to consider include the following:* • *Is the presentation of data sufficient to assess the adequacy of the analysis?* • *Where several prognostic factors are investigated, is the strategy for model building (that is, the inclusion of variables) appropriate and based on a conceptual framework or model?* • *Is the selected model adequate for the design of the study?* • *Is there any selective reporting of results?* • *Are only prespecified hypotheses investigated in the analyses?*	Yes No Unclear

[a] This checklist was used to perform the quality assessment and determine possible bias in the included studies.

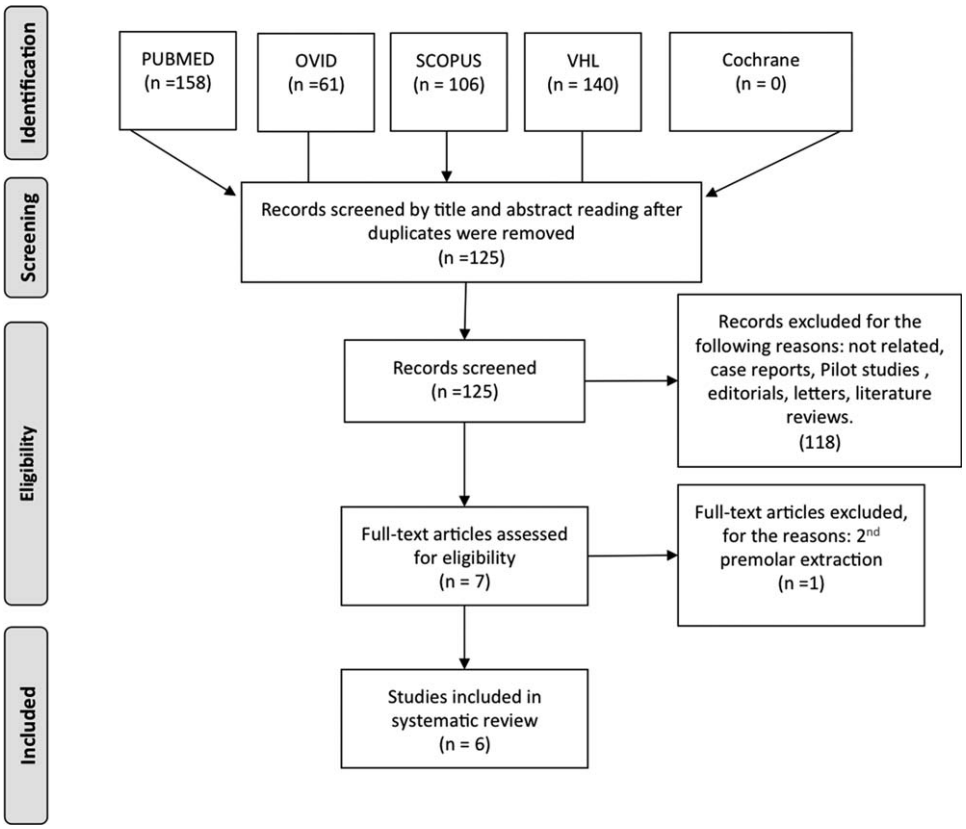

Figure 1. PRISMA flow diagram of the search results from the databases.

Table 3. Ranking of Articles According to the Quality Assessment and Control of Bias[14]

	Little et al.[17]	Haruki and Little[18]	Wilson et al.[19]	Wagner and Berg[20]	Brin and Bollen[21]	O'Shaughnessy et al.[22]
Study sample representative of the population of interest with regard to key characteristics, sufficient to limit potential bias in the results	Yes	Yes	Yes	No	No	Yes
Prognostic factor of interest adequately measured in study participants, sufficient to limit potential bias (early versus late treatment)	Unclear	Yes	Unclear	Yes	Yes	Yes
Outcome of interest adequately measured in study participants, sufficient to limit bias (outcome: the treatment for tooth crowding and/or secondary outcomes)	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear
Important potential confounders appropriately accounted for, limiting potential bias with respect to the prognostic factor of interest (eg, correlation Irregularity index or PAR between groups before treatment)	Unclear	Unclear	No	Unclear	No	Unclear
Statistical analysis appropriate for the design of the study, limiting potential for the presentation of invalid results	Yes	Yes	Yes	Yes	Yes	Yes
Category and situation of the article	2 "Yes" = low methodologic quality; included	3 "Yes" = moderate methodologic quality; included	2 "Yes" = low methodologic quality; included	2 "Yes" = low methodologic quality; included	2 "Yes" = low methodologic quality; included	3 "Yes" = moderate methodologic quality; included

Table 4. Summarized Data of the Six Included Studies[17–22] Concerning Early vs Late Treatment of Crowding

Article	Sample Size (ET, LT)[a]	Previous Estimate of Sample Size[a]	Average Age (SDs) Crowding-II/PAR (SDs)	Methods/ Measurements	Primary Outcome (Early × Late) Posttreatment of Crowding
Little et al., 1990[17]	Sufficient (30, 30)	No/unknown	ET: 11 y 3 mo(6.4); II 4.13 mm (2.02) LT: 12 y 6 mo(5.2); II 5.4 mm (3.0)	Plaster models and cephalograms	No statistically significant difference: ET: II 1.80 mm (0.91)
Haruki and Little, 1998[18]	Sufficient (36, 46)	No/unknown	ET: 11 y 3 mo(11.7); II 7.97 mm (3.31) LT: 13 y 4 mo(25.0); II 8.34 mm (3.71)	Study casts	No statistically significant difference: ET: II 1.55 mm (1.39) LT: II 1.39 mm (0.84)
Wilson et al., 1999[19]	Sufficient (28, 30, 30)	No/unknown	ET: 9 y 9 mo/9 y 6 mo; LT: 12 y 6 mo	Cephalometric radiographs	Not analyzed
Wagner and Berg, 2000[20]	Insufficient (20, 20)	No/unknown	ET: 8 y 2 mo(1.15); PAR 28.8 (9.9) LT: 11 y 6 mo(1.9); PAR 24.4 (7.1)	Plaster models and cephalograms	No statistically significant difference: ET: PAR 2.8 (3.7) LT: PAR 5.4 (3.9)
Brin and Bollen, 2011[21]	Insufficient (24, 24)	59 patients SE	ET: 12 y 4 mo (1.5); LT: 12 y 8 mo (1.5)	Lateral cephalograms	Not analyzed
O'Shaughnessy et al., 2011[22]	Sufficient (51, 49)	No/unknown	ET: 7 y 9 mo (0.92); PAR 18.24 (10.09) LT: 13 y 4 mo (2.0); PAR 31.27 (11.68)	Summary records	No statistically significant difference: ET: PAR 2.61 (20.5) LT: PAR 3.08 (2.18)

[a] ET indicates early treatment; LT, late treatment; SE, serial extractions; LE, late extractions; II, irregularity index; PAR, peer assessment rating; and EARR, external apical root resorption.

complete article was obtained and reviewed before a final decision was made.

Data Extraction

The methodologic checklist for prognostic studies[14] developed by the National Institute for Health and Clinical Excellence of the United Kingdom in 2009 was adapted by the authors to evaluate the quality of included studies and control of bias (Table 2). For adaptation, the exclusion of item 1.2 (about the loss of follow-up), was proposed, because all included studies were retrospective and therefore this item was not applicable. The items of the checklist are written in such a manner that the answer ''yes'' always indicates that the study was conceived and conducted to minimize the risk of bias for this item. An answer of ''unclear'' to a question could arise when the answer to an item is not related or is not related in a clear manner. Studies were classified as being of high methodologic quality and low risk of bias if all five parameters received an answer of ''yes,'' moderate methodologic quality if at least three of the parameters received a reply of ''yes,'' or low methodologic quality if two or fewer parameters received an answer of ''yes.''

According to the recommendations of Petrén et al.,[15] the data were collected by two authors on the following items: (1) authors and year of publication, (2) sample size, (3) previous estimate of sample, (4) variation in age and crowding, (5) methods of measurement, (6) evaluation of primary outcome (correction of crowding), (7) secondary outcomes with regard to time of treatment (early and late), and (8) authors' conclusions. When necessary, the authors of the selected studies were contacted by e-mail to obtain the additional information necessary about the data that were not specified in the article, or in case of doubts about studies conducted by the same author(s). In case of studies conducted by the same author and with patients who overlapped, the study with the larger sample or longer postretention time was included. The others were excluded.

RESULTS

The search strategy resulted in 588 articles: 158 from PubMed, 61 from OVID, 106 from SCOPUS, 140 from the Virtual Health Library, and 0 from the Cochrane Library (Figure 1). After all duplicates, books, annals, web pages, case reports, and com-

Table 4. Extended

Secondary Outcomes (Early × Late)				
Relapse Postretention	Duration of Treatment: Total/Active	EARR (mm)[a] (mean and SD)	Soft Tissue Profile	Authors' Conclusions
No statistically significant difference: ET: II 4.39 mm (1.64)	ET: ?/1 y LT: ?/2 y	Not analyzed	Not analyzed	No difference in long-term stability between ET and LT
Statistically significant difference: ET: II 3.09 mm (1.35) LT: II 4.15 mm (1.94)	Not analyzed	Not analyzed	Not analyzed	The LT group had greater mandibular anterior irregularity and deviation of the midline
Not analyzed	Not analyzed	Not analyzed	No statistically significant difference	The gender differences that were found to exist were most likely results of normal maturational changes, not of the treatment itself
Not analyzed	ET: 6 y/1.4 y LT: 3.6 y/2.3 y	Not analyzed	Not analyzed	The ET group had a markedly shorter period with fixed appliances, but the overall duration of treatment was significantly longer and the number of appointments significantly higher
Not analyzed	Not analyzed	No statistically significant difference: ET: 1.8 (1.1) LT: 2.1 (1.4)	Not analyzed	Spontaneous unraveling of incisor crowding with SE treatment does not prevent the common EARR seen in patients treated with LE when the patients are treated by mechanotherapy after the SE
Not analyzed	Similar: ET: 82.9 (19.7)/ 20.6 (4.4) LT: 31.8 (13.1)/ 24.6 (4.9)	Not analyzed	Not analyzed	SEs might reduce active treatment time, but significant observation time precedes active treatment

mentaries were removed, 125 articles remained. One additional article was found in the manual search. From the articles initially found (n = 126), after application of the eligibility criteria, seven articles[16–22] were selected. All seven articles were read in full, and one that presented doubts (Intervention) with respect to inclusion was discarded,[16] resulting in the inclusion of six[17–22] articles in the final review (Table 3).

Of these six articles, four[17,18,20,22] presented the primary outcome (correction of severe crowding). The Peer Assessment Rating (PAR) or irregularity index of the early and late groups was improved, without statistically significant differences, on completion of the treatment (Table 4). Therefore, we made the secondary outcomes the target of this study, as a means of discovering evidence of the best time for treatment (Table 4).

Of the six articles included in the analysis, two studies[17,18] evaluated the postretention relapse after 10 years of severe crowding treated early and late. Three studies[17,20,22] evaluated the total and active duration of the treatment (treatment with appliances). One study[21] evaluated external apical root resorption (EARR) post–orthodontic treatment with serial extractions followed by mechanotherapy. One study[19] compared the soft tissue profiles of patients treated after serial extraction with and without subsequent orthodontic treatment with the soft tissue profiles of patients who were treated with late extraction (Table 4).

DISCUSSION

Effectiveness and Long-Term Effects of Early Treatment of Tooth Crowding

In this systematic review, the goal of the bibliographic survey was to select all the RCTs, controlled clinical studies, retrospective and prospective observational studies with control groups, and observational studies that compared the prognosis of early and late treatment of severe dental crowding. No RCTs were found. Six controlled clinical studies[17–22] with consistent results were found.

Of the two studies that evaluated postretention relapse, in the first,[17] in which early treatment was performed with serial extractions and a period of physiological movement before corrective orthodontic treatment was begun, all 30 patients demonstrated satisfactory clinical results at the end of active treatment. However, 22 of the 30 patients (73%) showed unsatisfactory anteroinferior alignment in the postretention stage. The intercanine width and arch length diminished in 29 of the 30 cases during the postretention stage. There was no difference between the experimental sample (serial extraction) and the

control group (extraction and treatment of the complete permanent dentition) (Table 4).

In the second study,[18] active orthodontic treatment began during the mixed dentition immediately after extraction of the first premolars. The cases involving serial extractions, which had a period of physiological migration after the extractions, were excluded. There were no significant differences in the pretreatment and posttreatment stages between these groups. There was a significant difference between these groups with respect to the PAR index of irregularity of the mandibular dental arch in the postretention stage. The group with late treatment presented greater irregularity of the mandibular anterior teeth and greater deviation from the midline in the postretention stage (Table 4).

With respect to the duration of treatment, in three studies[17,20,22] it was seen that the time of active treatment (with fixed appliances) of the serial extraction group was significantly shorter than that of the group with late premolar extraction. Nevertheless, the total treatment time was significantly longer in the serial extraction group. Thus, the orthodontic follow-up of patients under treatment with serial extraction lasted twice as long as that of the patients who underwent late treatment, and the cost could probably be greater. However, these patients had fixed appliances for less time, and the esthetic aspects of their smile were corrected much earlier, so that they had a more pleasant social relationship and a better cost benefit (Table 4).

With respect to EARR, in one study[21] the spontaneous development of incisor crowding treated with serial extraction did not prevent the EARR that is commonly seen in patients treated with late premolar extraction, even when patients were treated with mechanotherapy after serial extractions (Table 4).

With regard to the soft tissue profile,[19] in the patients who were treated with late premolar extraction, the most vestibular point of the mandibular incisor was situated in a more posterior position from pretreatment to posttreatment than in the group treated with serial extraction (Table 4). However, no significant differences were found in the soft tissue profiles of these three groups of patients.

It is known that periodontal health is one of the main objectives of orthodontic treatment, together with esthetics, function, and stability. However, no studies evaluated posttreatment periodontal conditions, eg, dehiscences, fenestrations and their consequences, periodontal recession, and sensitivity. Periodontal health was most favorable with early treatment, as early treatment promotes eruption of the canines in the center of the alveolar ridge. However, controlled clinical studies are necessary to evaluate periodontal conditions and postorthodontic treatment effects.

Quality of the Studies

RCTs are rarely used in orthodontics, and investigations about the early treatment of severe crowding are no exception. The results show that only retrospective studies were available, probably because of the difficulty in selecting many patients with the same type of occlusion. Moreover, various items demanded to ensure the quality of the review[14] were clearly not applicable, for example, blinding of patients or observers to treatment. Furthermore, as in previous reviews about orthodontic problems,[15] one item of the classic scale[14] (item 1.2) could not be used, as all the studies found were retrospective and this item was not applicable (Table 2).

Although the primary outcomes were similar in four studies[17,18,20,22] and two of the four secondary outcomes (root resorption and soft tissue profile) showed no statistically significant differences[20,21] between early and late treatment of severe crowding, the other two secondary outcomes (relapse and active treatment time) were favorable to early intervention. However, in the two studies of each outcome, one of each had a moderate[18,22] level of evidence and other displayed a low[17,20] level of evidence (Table 3).

There were serious deficiencies in these studies, such as small sample sizes[20,21]; no previous estimate of sample size[17–20,22]; no discussion about the probability of error; and problems of bias and confounding variables (eg, no correlation Irregularity Index/PAR performed between groups before treatment[17–22]). The absence of information on method error analysis and blind measurements were other examples of failures that may have affected the results across studies.[17–22] Withdrawals (desistances) were very clear in only one of the six studies.[21] Therefore, the evaluation of quality and control of bias classified four article as having a low level of evidence[17,19–21] and only two with a moderate level of evidence[18,22] (Table 3).

A serious limitation in the majority of the studies was the lack of an adequate untreated control group, that is, a group of individuals with the same type and severity of malocclusion who did not undergo treatment. However, the late group, in which the same type and severity of malocclusion was present, was used as a control and treated afterward, thereby enabling a better evaluation to be made. If a longitudinal study had been done, there would be greater difficulty because of ethical reasons and the difficulty of assembling patients with the same malocclusion, but the results would be more precise.

An RCT is our most powerful tool for evaluating therapies, and the quality of the trial significantly affects the validity of the conclusions.[14] Nevertheless, in this

review the studies had valid methods and correct statistics, but no study presented the use of masking prior to measurements and analyses, and this continues to be a great deficiency in the area of orthodontics.

CONCLUSIONS

Although there was limited evidence in the studies, it was observed that:

- Early and late treatment presented similar primary outcomes for relief of crowding.
- Early treatment had two favorable secondary outcomes—less relapse and reduced active treatment times (treatment with appliances)—but the levels of evidence were not sufficiently strong to assert the best indication.
- Controlled studies and RCTs are needed to clarify the best treatment time for severe TSALD.

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