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Expansion of maxillary arches with crossbite: a systematic review of RCTs in the last 12 years

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SUMMARY The aim of this study was to review recent randomized clinical trials (RCTs) dealing with the effectiveness of various modalities of orthopaedic/orthodontic expansion of maxillary arches with crossbite and the associated 6 month post retention stability. The study selection criteria included RCTs involving subjects with maxillary deficiency with crossbite, with no limits of age. The authors searched the following electronic databases from 1999 to January 2011: the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, LILACS, and WEB of SCIENCE. The search strategy resulted in 12 articles meeting the inclusion criteria. Most of the studies did not meet major methodological requirements; some studies were not relevant because of small sample size, possible bias and unaccounted for confounding variables, lack of blinding in measurements, and deficient statistical methods. Treatment outcomes were different depending on the appliance used, tooth tissue-borne/tooth-borne expanders, bonded semi-rapid maxillary expansion (SRME), or rapid maxillary expansion (RME); in any case, methodological flaws prevent any sound conclusion. Stable results have been measured at the 6 month follow-up after removal of the retention plate in the treated groups in the maxillary intermolar and intercanine distances. Long-term stability results should be assessed. The Consolidated Standards of Reporting Trials (CONSORT) Statement could be helpful in improving the reporting of RCTs.

Introduction

Maxillary expansion is a common orthodontic treatment used for the correction of posterior crossbite resulting from reduced maxillary width; several treatment modalities are employed with similar objectives.

Randomized clinical trials (RCTs) are considered the gold standard for comparing the effectiveness of interventions because of their ability to minimize or avoid bias (Zuccati Clauser *et al.*, 2009). Systematic reviews (SRs) and meta-analysis are also evidence-based tools that use systematic literature searches to summarize data for a particular treatment effect about specific topics.

An exhaustive SR considering only RCTs up to 1999 reported quantitative data on the outcomes of crossbite correction. Harrison and Ashby (2001) concluded that trials before 1999 were small and inadequately powered: further studies, with appropriate sample sizes, would be required to assess the relative effectiveness of the interventions.

An SR including even RCTs, concerning stability of treatment of unilateral posterior crossbite, was conducted by Petrén *et al.* (2003) covering the period from January 1966 to October 2002.

Other SRs, through a careful evaluation of the methodological quality of the selected articles of non-randomized trials, provided weak indirect evidence on long-term stability of maxillary expansion with either fixed or removable expansion appliances. The authors concluded that most of the studies were seriously lacking in power because of small sample size, bias and confounding variables, lack of method error analysis, lack of blinding in measurements, and questionable or non-statistical methods (Lagravère *et al.*, 2005a,b,c, 2006; Schiffman and Tuncay, 2001).

Therefore, a new SR based exclusively on the RCTs of the last 12 years dealing with orthopaedic/orthodontic expansion of maxillary arches with crossbite in terms of maxillary arch expansion was undertaken to answer the following questions:

1. Which expansion treatment modality is the most effective in correcting crossbite and in increasing the width between the maxillary molars and/or canines?
2. Which treatment yields most stable results 6 months post retention or later?

Materials and methods

A search was carried out of RCTs of orthodontic treatments aimed at correcting posterior crossbite according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2009 checklist (Moher *et al.*, 2009). To identify all eligible RCTs, a literature survey was carried out with the following inclusion criteria.

Population

Studies were considered if the samples consisted of patients with posterior crossbite, without the limits of age.

Craniofacial anomalies associated with transversal deficiency were excluded.

Interventions

Non-surgical orthodontic/orthopaedic expansion treatments with removable or fixed appliances were included if they had been used to correct posterior crossbites. If active expansion had been carried out simultaneously with other orthopaedic therapies in the maxillary arch, the articles were excluded.

Comparisons

Controls were people extracted from the same sample by a random procedure, who did not have any orthodontic treatment or underwent an alternative orthodontic treatment. The only difference between the groups should be the treatment. Control groups with normal occlusion were considered invalid.

Outcomes

1. Correction of the posterior crossbite.
2. Expansion of the upper jaw/teeth measured as linear and/or angular changes in the width between the molars and/or canines; the reference points could be measured on casts, on radiographs, computed tomography, or cone-beam computed tomography. Measurements could be performed with different instruments: callipers, ultrasonic instruments, laser scanning, or other.
3. Stability of the results measured as differences between the results at the end of treatment and at 6 months post retention or later.

Studies

Only RCTs were included. Articles were examined if patient's randomization was declared in the 'Materials and methods', irrespective to the methods carried out; articles not declaring the randomization in this section were excluded; articles reporting randomization on previously collected records were excluded. Articles without an English abstract were excluded.

The following procedures were used (Figure 1):

1. Articles were searched from 1999 to January 2011: the earlier articles were examined in the Intervention Review: Harrison and Ashby (2001).
2. Search of the Cochrane Central Register of Controlled Trials (CENTRAL), via the Cochrane Library using the search strategy 'palatal expansion' OR 'maxillary expansion' http://onlinelibrary.wiley.com/o/cochrane/cochrane_clcentral_articles_fs.html.

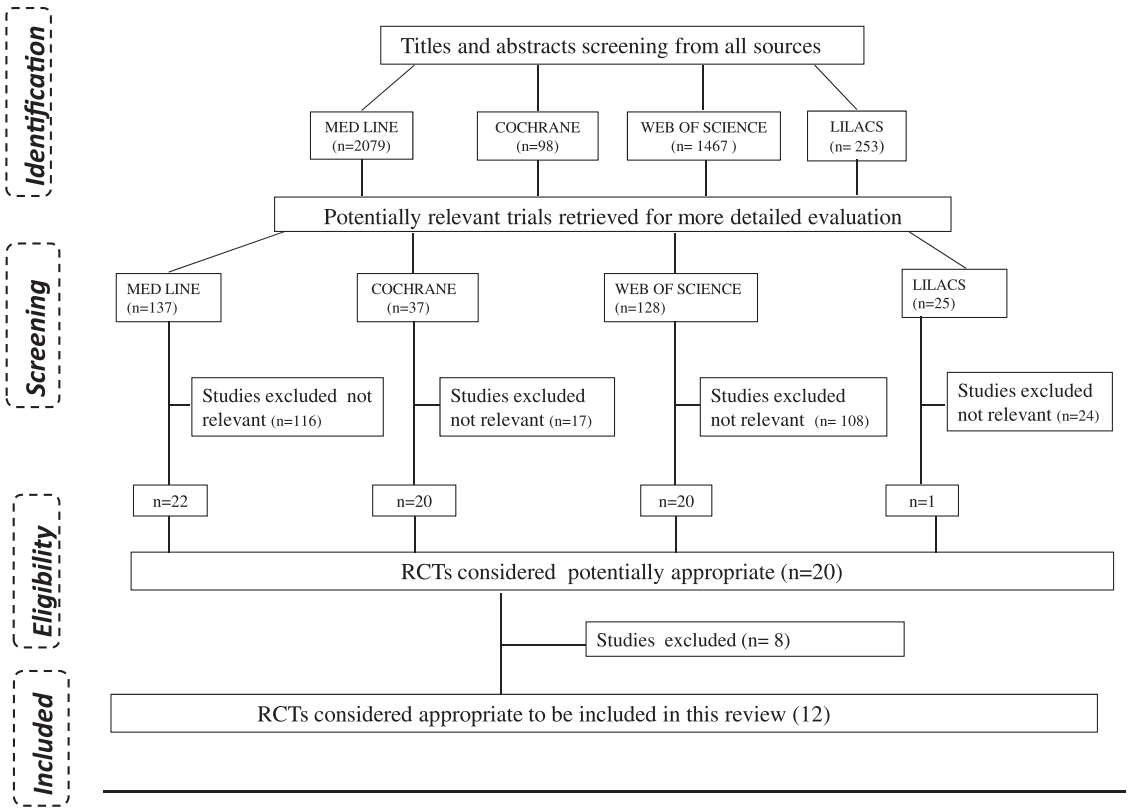

Figure 1 Flow chart adopted from Moher *et al.* (2009).

3. A MEDLINE search (via PubMed; http:www.ncbi.nlm.nih.gov/pubmed) from 1999 to 2011 using key words 'expan*' AND ('palat*' OR 'maxill*').
4. LILACS searches from 1999 to 2011 using key words 'expan$' AND 'palat$'; 'expan$' AND 'maxill$' (http://bases.bireme.br/cgi-bin/wxislind.exe/iah/online/?IsisScript=iah/iah.xis&base=LILACS&lang=i&form=F).
5. A (ISI) WEB of SCIENCE search (via Isiknowledge) from 1999 to 2011 using key words 'expan*' AND ('palat*' OR 'maxill*'; http://apps.isiknowledge.com/WOS_GeneralSearch_input.do).

We assessed the titles to identify potential RCTs; we made a preliminary selection of abstracts potentially meeting our inclusion criteria. Then, we read the abstracts selected and we also retrieved the full text whenever the study design described in the abstract appeared to fulfil the inclusion criteria. Finally, we selected the eligible articles.

Two authors conducted this work independently and then checked the results together. Any discrepancies between researchers in inclusion of articles were solved through discussion and consensus without blinding to the authors. Data analysis was checked by one author using the Consolidated Standards of Reporting Trials (CONSORT) guidelines checklist (Higgins and Green, 2009; Moher *et al.*, 2010).

The two reviewers evaluated the methodological quality of the trials included in this review by assessing 'five possible sources of biased effect size estimate' (method of randomization, allocation concealment, blinding of outcome assessors, completeness of follow-up, and selective outcome reporting) (Table 1) and 'other possible sources of imprecision' (sample size calculation, baseline similarity of the groups, reporting of eligibility criteria, and error measurement) according to the Cochrane Collaboration, tool for assessing bias (accessed October 2011) http://onlinelibrary.wiley.com/o/cochrane/cochrane_clcentral_articles_fs.html.

Selective outcome reporting was not examined because the primary outcome of the review did not necessarily coincide with the author choice (Table 4).

Results

The electronic and hand searches retrieved 2079 articles from MEDLINE, 98 articles from Cochrane, 1467 articles from PubMed, and 253 articles from LILACS, which were entered into a PRISMA flow chart (Figure 1) to illustrate the path for selecting the final trials (Moher *et al.*, 2009).

After evaluating titles and abstracts, 137, 37, 128, and 25 articles were obtained, respectively.

After evaluating the full texts, we determined that 20 articles fulfilled the inclusion criteria. Six articles were excluded because no measurements of the molars and/or canines expansion were reported (Alcan and Ceylanoğlu, 2006; Garib *et al.*, 2006; Tecco *et al.*, 2007; Guilleminault *et al.*, 2008; Lippold *et al.*, 2008; Coelho *et al.*, 2009). The article of Thilander and Lennartsson (2002) was excluded because the randomization was not valid for the reported investigation even if a valid randomization had been carried out in a previous study (Thilander *et al.*, 1984), already included in the research of Harrison and Ashby (2001). Only one article of Garib *et al.* (2005) was analysed in this review.

Methodological quality

1. The method of randomization was considered adequate for 6 of the 12 trials. In the article of Petrén *et al.* (2011), most of the crossbite patients were recruited from the previous RCT sample (Petrén and Bondemark, 2008).
2. Allocation concealment was considered adequate only in one study (Petrén *et al.*, 2011), inadequate or unclear for the remaining articles.
3. Blinding for outcome evaluation was reported in three trials.
4. The reporting and analysis of dropouts were considered adequate in 4 of 12 trials. Three studies were assessed to have low risk of bias (Petrén and Bondemark, 2008; Godoy *et al.*, 2011; Petrén *et al.*, 2011).
5. One article was assessed to have moderate risk of bias (McNally *et al.*, 2005).
6. Eight articles had the potential for a high risk of bias on a methodological basis (Table 2).

The 'other possible sources of imprecision' examined are shown in Table 3.

1. Five studies assessed the comparability of the experimental and control group at baseline. Inclusion and exclusion criteria were specified in 9 of 12. All the studies estimated measurement error.
2. The range of the total sample varied from 8 patients to 64. Only a few authors calculated the sample size before undertaking their studies. Patients' gender was not declared in one article (Davidovitch *et al.*, 2005); the sample was composed only of eight females in another article (Garib *et al.*, 2005); the sample was heavily unbalanced between groups in another article (Oliveira *et al.*, 2004); and block or stratification randomization was not reported.

Answers to the clinical questions

Which expansion treatment modality is the most effective?

Significant changes in transversal dimension (surrogate outcome) were recorded in all the articles; the expansion was continued until posterior dental crossbite overcorrection was achieved in most studies.

Table 1 Criteria for judging risks of bias in the trials included according the Cochrane Collaboration's tool for assessing risk of bias. CONSORT, Consolidated Standards of Reporting Trials.

Component	Classification	Definition
1. Method of randomization (Moher *et al.*, 2010)	Adequate	Any random sequence satisfying the CONSORT criteria.
	Inadequate	Alternate assignment, case record number, and dates of birth.
	Unclear	Just the term 'randomized' or 'randomly allocated' without further elaboration of the exact methodology.
2. Allocation concealment	Adequate	Any random sequence satisfying the CONSORT. Central randomization, opaque sealed sequentially numbered envelopes, and sequence concealed until interventions were assigned.
	Inadequate	Allocation by alternate assignment, case record number, date of birth, or open tables of random numbers.
	Unclear	No reported negation of disclosing participants' prognostic data to central office staff before clinician obtains treatment assignment: no reported information on whether allocation sequence is concealed to central staff before a participant is irreversibly registered and no assurance that the sequence is strictly sequentially administered.
	Not used	Insufficient information to permit judgement of 'yes' or 'no'.
3. Blinding of outcome assessors	Yes	Outcome assessors did not know to which group the participants were randomized.
	No	Outcome assessors could assume to which group the participant had been randomized.
	Unclear	Insufficient information to permit judgement of 'yes' or 'no'.
4. Completeness of follow-up	Yes	No missing outcome data. Numbers in the methods and results are the same or not the same but with all dropouts explained.
	No	Numbers in the methods and results were not the same, and dropouts were not explained.
	Unclear	Insufficient reporting of attrition/exclusions to permit judgement of 'yes' or 'no'.
5. Selective outcome reporting	Yes	Primary and secondary outcomes of interest in the review have been reported in the pre-specified way; the published reports include all expected outcomes.
	No	Not all of the study's pre-specified primary outcomes have been reported; one or more outcomes of interest in the review are reported incompletely so that they cannot be entered in a meta-analysis.
	Unclear	Insufficient information to permit judgement of 'yes' or 'no'.

Table 2 Possible sources of biased effect size estimate.

Study	Adequate randomization	Allocation concealed	Assessor blinding	Dropouts described	Risk of bias
Godoy *et al.* (2011)	Yes	NR	Yes	Yes	Low
Petrén *et al.* (2011)	Yes	NR	Yes	Yes	Low
Lagravère *et al.* (2010)	Yes	NR	No	No	High
Ramoglu and Sari (2010)	No	NR	No	No	High
Petrén and Bondemark (2008)	Yes	YES	Yes	Yes	Low
Kılıç *et al.* (2008)	No	NR	No	No	High
Ölmez *et al.*(2007)	No	NR	No	No	High
Garib *et al.* (2005)	No	NR	No	No	High
Davidovitch *et al.* (2005)	No	NR	No	No	High
McNally *et al.* (2005)	Yes	NR	No	Yes	Moderate
Oliveira *et al.* (2004)	Yes	NR	No	No	High
Lamparski *et al.* (2003)	No	NR	No	No	High

NR, not reported.

Seldom do authors explicitly report whether the expansion obtained by the appliances actually corrected the patients' crossbite (true outcome).

In the study of Petrén and Bondemark (2008), the untreated control group was selected by randomization and received no orthodontic treatment during the 1 year observation period. Postponement of a needed intervention for 4 years was considered ethically unacceptable in the second study where the patients were compared with normal control subjects without random assignment (Petrén *et al.*, 2011). Therefore, this part of the study was excluded.

Table 3 Other possible sources of bias.

Study	Baseline comparison	I/E criteria	Measurement error	Sample size calculation
Godoy *et al.* (2011)	Yes	Yes	Yes	Yes
Petrén *et al.* (2011)	No	Yes	Yes	Yes
Lagravère *et al.* (2010)	Yes	No	Yes	No
Ramoglu and Sari (2010)	No	Yes	Yes	No
Petrén and Bondemark (2008)	Yes	Yes	Yes	Yes
Kılıç *et al.* (2008)	No	Yes	Yes	No
Ölmez *et al.*(2007)	Yes	Yes	Yes	No
Garib *et al.* (2005)	No	Yes	Yes	No
Davidovitch *et al.* (2005)	No	No	Yes	No
McNally *et al.* (2005)	Yes	No	Yes	Yes
Oliveira *et al.* (2004)	No	Yes	Yes	No
Lamparski *et al.* (2003)	No	Yes	Yes	No

The Quad Helix (QDH) appliance was superior to the expansion plate (EP) in success rate and treatment time in a study of good methodological quality. Treatment with the EP was unsuccessful in one-third of the subjects.

In the study of Godoy *et al.* (2011), the QDH and the EP had equal success rates in correcting posterior crossbites in the mixed dentition. Since the average treatment time was significantly shorter and 11 per cent cheaper in the QDH group, QDH was considered the more cost effective choice for treatment.

Posterior crossbites did not spontaneously correct during the transition into the permanent dentition in the untreated patients at the last follow-up, 6 months after the retention plate removal in the treated group (Godoy et al., 2011), and in the untreated group after the trial period of 1 year (Petrén *et al.*, 2011).

In the study of Lagravère *et al.* (2010), bone-anchored maxillary expanders (BAME) and traditional tooth-anchored maxillary expanders (TAME) showed similar results. The greatest changes were seen in the transverse dimension; dental expansion was also greater than skeletal expansion.

Comparison of rapid with semi-rapid maxillary expansion (RME versus SRME) was conducted by Ramoglu and Sari (2010) in patients in mixed dentition at the end of the activation. The results suggested that RME and SRME had similar effects on dentofacial structures in the transverse, vertical, and sagittal planes.

Comparison of buccal dentoalveolar inclinations in subjects treated with a Hyrax or acrylic-bonded palatal expander was conducted by Kılıç *et al.* (2008) and Ölmez *et al.*(2007). The amount of mean maxillary expansion was 7.31 ± 1.45 mm in the acrylic-bonded appliance group and 7.67 ± 1.99 mm in the Hyrax group. Banded and bonded rapid maxillary expanders produced significant dentoalveolar tipping during RME, but this was greater in the Hyrax group. However, these researches appear to be at high risk of bias.

Both Haas and Hyrax produced significant increases in maxillary width with decreasing magnitude from the dental arch to the basal area. The Haas expander produced a greater change in the axial inclination of appliance-supporting teeth compared with Hyrax (Garib *et al.*, 2005).

Comparison between Haas and Hyrax was also conducted by Oliveira *et al.* (2004); Haas appliances achieved expansion with a greater component of orthopaedic movement, whereas Hyrax appliances achieved expansion by dentoalveolar expansion. Molar crown tipping was significant in the Hyrax group.

All these researches (Oliveira *et al.*, 2004; Garib *et al.*, 2005; Ölmez *et al.*, 2007; Kılıç *et al.*, 2008; Lagravère *et al.*, 2010; Ramoglu and Sari, 2010) appear to be at high risk of bias: moreover, the multiple comparison artefact may affect the conclusions.

Skeletal and dental response to RME with two- versus four-band appliances was compared by Davidovitch *et al.* (2005). Four-band RME appeared to be indicated when severe anterior crowding is accompanied by a tapered arch form, and two-band RPE was recommended in the mixed dentition when mild crowding occurs with posterior constriction. Lamparski *et al.*'s (2003) results showed that the two-point appliance produced similar effects on the mid-palatal suture and the dentition as did the four-point appliance. The patient ages of the samples were different. This fact and some flaws in the study designs preclude a reasonable comparison of the results.

QDH and the expansion arches were compared by McNally *et al.* (2005). The force produced by the arches used in the study was measured in the laboratory (1.8 N) at 10 mm of expansion. The two expansion devices, QDH and expansion arches, had the same clinical effectiveness in terms of crossbite correction. At 12 week follow-up, intermolar width increased 5.09 mm (1.67 SD) with expansion arches and 4.54 mm (1.27 SD) with the QDH.

Which treatment yields most stable results 6 months post retention or later?

Transverse relationships, maxillary and mandibular widths, overbite, overjet, arch length changes, and crossbite correction were stable at the end of treatment and at the 3 year follow-up in the treatment QDH and EP groups (Petrén and Bondemark, 2008).

The comparison with untreated patients was carried out by Godoy *et al.* (2011). The patients being followed for approximately 20 months after correction. All children treated with QDH or EP had their crossbite corrected. Relapses occurred in 9.1 per cent of the two experimental groups after 1 year of follow-up.

At 12 month follow-up, BAME and TAME used by Lagravère *et al.* (2010) showed similar results. The greatest width increase occurred at the level of the first molar crowns (BAME, 5.36 ± 1.95 mm and TAME, 5.51 ± 1.79 mm); changes in the vertical and antero-posterior dimensions were negligible.

Long-term results were not reported in any study reviewed. Primary outcomes and descriptive statistics of the outcomes of the reliable studies are summarized in Tables 4 and 5.

Discussion

This SR was aimed at selecting the best possible evidence (RCTs) of the last 12 years regarding the changes in transverse dimension in patients with crossbite.

Some methodological flaws in this review are possible: only abstracts in English were considered, not all database were searched, and contacts with some authors for explanations failed.

The strength of evidence is high for RCTs, but depends also on the risk of bias, that is inversed correlated with methodological quality. Data coming from well-conducted RCTs could be useful for health care providers and policy makers.

Twelve trials were considered appropriate for inclusion in this review, but their protocols were too heterogeneous to proceed with a quantitative analysis. Meta-analysis of the studies of Petrén and Bondemark (2008) and Godoy *et al.* (2011) was not carried out because of different baseline clinical orthodontic condition.

The article of Davidovitch *et al.* (2005) had the same purpose as the article of Lamparski *et al.* (2003), comparison of 2/4 bands expanders, but the sample was insufficiently described by Davidovitch. Meta-analysis of the selected studies was not carried out because of heterogeneity of the samples.

The possibility of detection bias according to Higgins and Green (2009) was considered.

The 'primary outcome' is defined as the variable of interest in the trial (also called end point) or the outcome of greatest importance. If the primary outcome or end point is not defined and statistical tests are applied to more outcomes,

Table 4 Primary outcome and measurements. CB, crossbite; QDH, The Quad Helix; EP, expansion plate; TAME, tooth-anchored maxillary expanders; BAME, bone-anchored maxillary expanders; CBCT, cone-beam computed tomography; SRME, semi-rapid maxillary expansion; RME, rapid maxillary expansion.

Articles	Outcomes	Measurements
Godoy *et al.* (2011)	Correction of posterior CB; amounts of maxillary and mandibular intermolar and intercanine expansion; length of treatment; cost-benefit (treatment time, number of appliances used, and number of appointments); success rate; and number of complications	Casts (4)
Petrén *et al.*	Long-term stability in patients who had CB correction with QDH and EP, with a matched HUC (Health Untreated Control)	Casts (14)
Lagravère *et al.*	Transverse, vertical, and antero-posterior skeletal and dental immediate and long-term changes in adolescents receiving treatment with both TAME and BAME	Distances and angles on CBCT (30)
Ramoglu and Sari (2010)	Short-term effects of SRME on the vertical, sagittal, and transverse planes in mixed dentition patients for both SRME and RME	Lateral and frontal cephalometric (18 and 3) and dental casts (4)
Petrén and Bondemark (2008)	Success rates of CB correction; maxillary and mandibular intercanine expansion; maxillary and mandibular intermolar expansion; and treatment time	Casts (8)
Kılıç *et al.* (2008)	Differences in molar crown tipping and process inclination using two different appliances	Xr of study models transferred to digital medium (4)
Ölmez *et al.*(2007)	Differences in tipping of posterior teeth using bonded RME or banded RME	Tomographic images (8)
Garib *et al.*	Differences in maxillary trasversal dimensions and in posterior dental inclination between Ha/Hy	CT images; maxillary trasversal dimensions (20); and inclination of maxillary posterior teeth (3)
Davidovitch *et al.* (2005)	Skeletal and dental effects of 4-band and 2-band RME devices	Occlusal (4) and Ant-post Xr (4) and casts (2)
McNally *et al.* (2005)	Intermolar and intercanine distances; attitudes of participants towards the appearance and comfort of the two appliances (QDH; Expansion arches)	Casts (2)
Oliveira *et al.* (2004)	Dentoskeletal differences between Ha/Hy; evaluation of a new 3D methodology for analysing changes of the maxilla after Expansion therapy	Laser scanning technique and computerized cast analysis (7) and ant-post Xr (6)
Lamparski *et al.* (2003)	Differences in dentoskeletal response using 2/4 bands	Occlusal Xr (3) and casts (6)

Table 5 Means, relative risk and 95% confidence intervals of intermolar and intercanine expansion, and of failure rates in correcting crossbite. CI, confidence interval; QDH, Quad Helix; EP, expansion plate; UC, untreated controls.

Articles	Outcome	Mean	Relative risk	CI 95%
Godoy *et al.* (2011)	QDH			
	Intermolar expansion end of treatment	5.70		4.91–6.49
	Intercanine expansion end of treatment	3.48		2.72–4.24
	Intermolar expansion 6 months post retention	4.31		3.49–5.13
	Intercanine expansion 6 months post retention	2.06		2.11–3.81
	EP			
	Intermolar expansion end of treatment	4.46		3.70–5.22
	Intercanine expansion end of treatment	1.80		0.79–2.81
	Intermolar expansion 6 months post retention	3.09		2.27–3.91
	Intercanine expansion 6 months post retention	1.43		0.82–2.04
	UC			
	Intermolar expansion end of treatment	0.15		−0.11 to 0.41
	Intercanine expansion end of treatment	−0.17		−0.37 to0.03
	Intermolar expansion 6 months post retention	0.84		0.49–1.19
	Intercanine expansion 6 months post retention	0.36		−0.21 to 0.93
	Relapse at 12 months QDH/EP		1	0.43–2.32
Petrén *et al.* (2011)	QDH			
	Intermolar expansion cusp tips, 1 year	3.4		2.7–4
	Intercanine expansion cusp tips, 1 year	3.2		2.1–4.3
	EP			
	Intermolar expansion cusp tips, 1 year	3.5		2.8–4.1
	Intercanine expansion cusp tips, 1 year	2.5		1.5–3.5
Petrén and Bondemark (2008)	QDH			
	Intermolar expansion cusp tips, 1 year	4.6		4.0–5.2
	Intercanine expansion cusp tips, 1 year	2.0		1.4–2.6
	EP			
	Intermolar expansion cusp tips, 1 year	3.5		2.72–4.28
	Intercanine expansion cusp tips, 1 year	2.7		2.09–3.31
	UC			
	Intermolar expansion cusp tips, 1 year	0.4		−0.7 to 0.87
	Intercanine expansion cusp tips, 1 year	0.3		0.08–0.52
	Crossbite correction failure			
	QDH/EP		0	0–1.51*
	QDH/UC		0	0–0.49
	EP/UC		0.33	0.16–0.68
McNally *et al.* (2005)	QDH			
	Intermolar at 12 weeks	4.54		4.07–5.01
	Intercanine at 12 weeks	1.4		0.75–2.05
	Expansion arches			
	Intermolar at 12 weeks	5.09		4.46–5.72
	Intercanine at 12 weeks	2.12		1.7–2.54

*Adding 0.5 to each cell of the contingency table.

the multiple comparison artefact could alter the true *P* value and entails the risk of type I error.

Eight variables were measured and analysed in a sample of eight girls in one article (Garib *et al.*, 2005), but the primary outcome was not determined; the statistical power is minimal and the multiple comparison artefact is possible.

The correct approach entails the choice of a single experimental variable before analysing data; the choice should be based on a sound rationale: a hypothesis deriving from previous studies or from current theories. Nevertheless, it is sometimes clear what the intended primary outcome is, even if the authors do not explicitly indicate it in the article. In the study of Godoy *et al.* (2011), the focus is obviously on the success rate in correcting the crossbite at the end of the treatment and on the relapse rate 1 year later. The same applies to the study by Petrén and Bondemark (2008) and Petrén *et al.* (2011).

Implications for further research

1. Due to the strict requirements imposed by ethics committees and new regulations regarding the use of X-rays, researches involving radiographic examinations should be avoided if they cannot reach any conclusive evidence.
2. Methodological flaws were noted in many RCTs; reliability and validity of trial findings are defective, and information for SR and clinical choices is incomplete. The CONSORT Statement could be helpful in improving reporting of RCTs.

Implications for practice

1. Many treatments appear to be successful in the short term, but challenges remain in the search for better long-term outcomes. If long-term objectives are to be achieved, lengthy studies must be carried out where the patients need to be followed up to evaluate the stability of correction.
2. Future studies should address another clinical question: which is the most effective modality to correct crossbite of different severity? EP may be adequate to correct a minor crossbite, while more aggressive treatments may be required to treat severe bilateral crossbite.

Conclusions

The review of RCTs of the last 12 years on expansion treatment modality effectiveness has added some information to the results of previous reviews that allowed for the collection of sound evidence that:

1. Treatment with the EP was unsuccessful in one-third of the subjects; the QDH appliance was superior to the EP in success rate and treatment time; compliance could be a predictable limitation.
2. Expansion arches were as effective as QDH for the correction of crossbite, if the force produced by the two types of appliances was equivalent.
3. Stable results have been measured at the 6 month follow-up after removal of the retention plate in the treated groups in the maxillary intermolar and intercanine distances.
4. Most of the studies appear to be at high risk of bias since they did not meet any of the major criteria for methodological quality. Treatment outcomes were different depending on the appliance used (Hyrax/Haas, bonded SRME or RME, and 2/4 bands expanders), but small sample size, bias and confounding variables, lack of blinding in measurements, and deficient statistical methods do not allow for any sound comparison.

Disclosure

The authors report no commercial, proprietary, or financial interest in the products or companies described in this article.

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