Review Article

Long-term Skeletal Changes with Rapid Maxillary Expansion: A Systematic Review

Manuel O. Lagravere[a]; Paul W. Major[b]; Carlos Flores-Mir[c]

Abstract: The objective was to evaluate long-term transverse, anteroposterior and vertical skeletal changes after rapid maxillary expansion (RME). The data were clinical trials that assessed skeletal changes through cephalometric analysis. No surgical or other simultaneous treatment during the evaluation period was accepted. Electronic databases (PubMed, Medline, Medline In-Process & Other Non-Indexed Citations, Cochrane Database of Systematic Reviews, ASP Journal Club, DARE, CCTR, Embase, Web of Sciences and Lilacs) were searched with the help of a senior Health Sciences librarian. Abstracts that appeared to fulfill the initial selection criteria were selected by consensus. The original articles were then retrieved. A methodological checklist was used to evaluate the quality of the selected articles. Their references were also hand-searched for possible missing articles. Articles without an adequate control group to factor out growth changes were excluded. Only three articles (one measuring transverse and two anteroposterior and vertical changes) measured RME stability after active expansion, all of them had some methodological flaws, which limit the attainable conclusions. An individual analysis of these articles was made. Long-term transverse skeletal maxillary increase is approximately 25% of the total dental expansion for prepubertal adolescents. Better long-term outcomes are expected in transverse changes because of RME in less skeletally mature patients. RME appears not to produce clinically significant anteroposterior or vertical changes in the position of the maxilla and mandible. The conclusions from this systematic review should be considered with caution because only a secondary level of evidence was found. Long-term randomized clinical trials are needed. (*Angle Orthod* 2005;75:1046–1052.)

Key Words: Rapid maxillary expansion; Skeletal changes; Rapid palatal expansion

INTRODUCTION

When a skeletal constricted maxillary arch is diagnosed, orthopedic skeletal expansion involving separation of the midpalatal suture is the treatment of choice. Three treatment alternatives are available for this purpose: rapid maxillary expansion (RME), slow maxillary expansion (SME), and surgical-assisted RME (SARME). Both SME and RME are indicated for growing patients, whereas SARME is the alternative selected for nongrowing adolescent and young adult patients.

Even though RME treatments were reported to bring clinically stable results,[1] others reported relapse after expansion was attained.[2] Years later, other studies demonstrated that the attained changes were produced primarily in the underlying structures and, therefore, stable results were expected.[3,4]

Although, SME and RME were reported to bring similar results,[5] theoretically RME delivers forces ranging from 15 to 50 N whereas the SME incorporates forces that only reach 10 N of magnitude. Because RME treatments exert a greater force on paramaxillary

[a] PhD Student, Orthodontic Graduate Program, Faculty of Medicine and Dentistry, University of Alberta, Edmonton, Canada.

[b] Professor, Director of the Orthodontic Graduate Program, Faculty of Medicine and Dentistry, University of Alberta, Edmonton, Canada.

[c] Postdoctoral Fellow, Orthodontic Graduate Program, Faculty of Medicine and Dentistry, University of Alberta, Edmonton, Canada.

Corresponding author: Carlos Flores-Mir, DDS, MSc, Cert Orth, PhD, Faculty of Medicine and Dentistry, Room 4051A, Dentistry/Pharmacy Centre, University of Alberta, Edmonton, Alberta, Canada T6G 2N8
(e-mail: carlosflores@ualberta.ca)

Accepted: September 2004. Submitted: June 2004.
© 2005 by The EH Angle Education and Research Foundation, Inc.

structures, changes in skeletal structures other than in the maxilla are more feasible. Some disadvantages have been reported in RME including: bite opening,[6] relapse,[7,8] microtrauma of the TMJ and the midpalatal suture,[7,8] and root resorption.[7,8]

Because a direct relationship has been reported between increased resistance to skeletal expansion and increased patient age, the use of SME in adolescents may be questioned because it may not offer enough expansion force to separate the midpalatal suture in young adults.[9] Even in young children, no scientific evidence in favor or against is available.[10] Several disadvantages for SME are minor maxillary and mandibular plane changes,[11] poor fit, fracture or loss of the appliance,[12] and palatal irritation.[12]

SARME treatment has been successful in splitting the palatine suture and thus widening the maxilla in young adults.[13] However, this surgical procedure is costly and requires outpatient surgery or hospitalization with attendant morbidity and loss of work time. Other complications reported with the SARME are tissue irritation, hemorrhage, infection, pain, unilateral or asymmetric expansion, periodontal problems, and relapse.[14] For these reasons, a careful cost-effectiveness analysis should be made by patients and orthodontists before undergoing the procedure.[13]

From this literature review, RME appears as the treatment of choice in growing adolescents. Previous reports on RME skeletal and dental effects are contradictory because of variable study designs, sample sizes, and research approaches.[15,16] Two meta-analyses regarding the transverse dental effects of RME have been published.[15,17] One systematic review[18] about the long-term dental effects of RME has been published, but to date there are no systematic reviews regarding long-term skeletal effects.

The purpose of this systematic review is to evaluate long-term (minimum of one-year postactive treatment) transverse, anteroposterior, and vertical skeletal changes obtained after RME.

MATERIALS AND METHODS

The following inclusion criteria were chosen to initially select the appropriate articles from the published abstracts: human clinical trials; measurements made from facial radiographs (anteroposterior and lateral cephalograms); no surgical or other simultaneous treatment that could affect RME effect during the evaluation period.

A computerized search was then conducted using Medline (from 1966 to week 1 of September 2004), Medline In-Process & Other Non-Indexed Citations (from week 1 of September 2004 to week 2 of September 2004), Lilacs (from 1982 to September 2004), PubMed (1966 to week 2 of September 2004), Embase (from 1988 to week 37 of 2004), web of science (1945 to week 2 of September 2004) and all EBM reviews (Cochrane Database of Systematic Reviews, ASP Journal Club, DARE and CCTR) (to the third quarter of 2004) databases for skeletal changes in RME. Terms used in this literature search were rapid palatal expansion or RME, bone and bones or skeletal changes. The selection of these terms were made with the help of a senior librarian specialized in Health Sciences databases.

No attempts were made at this stage to identify studies that did not use adequate control groups to factor out growth changes. It was considered improbable that the abstracts would necessarily report enough information regarding control groups, which would potentially exclude some articles.

Eligibility of potential studies was determined by reading the title and abstracts of each article identified by each search engine. Two researchers selected the articles to be collected on the basis of the abstract information. An interexaminer agreement of 0.900 (interexaminer Kappa) was obtained. Any discrepancies were settled through discussion. All the articles that appeared to meet the inclusion criteria on the basis of their abstracts were selected and collected. In addition, the actual articles were also obtained from abstracts in which not enough relevant information was stated.

The final selection was independently completed by three researchers reading the complete articles and their results were compared. An interexaminer agreement of 0.885 (interexaminer Kappa) was obtained. Use of an adequate control group to factor out growth changes was considered necessary at this stage. Any discrepancies were settled through discussion. Reference lists of the selected articles were handsearched for additional relevant publications that may have been missed in the database searches. In cases where specific data was necessary for the discussion, and was not specified in the article, efforts were made to contact the authors to obtain the required extra information.

RESULTS

The search results and the final number of abstracts selected according to the initial selection criteria from the various databases are provided in Table 1. Comparing the database results, Medline obtained the greatest diversity of finally selected abstracts (78.6%), whereas the other databases obtained significantly fewer finally selected abstracts (<33.3%). The different databases repeated most of the abstracts, except Lilacs, which included only Latin-American publica-

TABLE 1. Search Results from Different Databases

Database	Keywords	Results	Selected	Percentage of Total Selected Abstracts (42)[a]
PubMed	(1) Rapid maxillary expansion and skeletal changes; (2) rapid palatal expansion and skeletal changes; (3) #1 OR #2	27	14	33.3
Medline	(1) Rapid maxil$ expan$.mp or rapid palat$ expan$.mp; (2) limit to human; (3) skeletal changes.mp; (4) 1 and 2 and 3	159	33	78.6
Medline In-Process & Other Non-Indexed Citations	(1) Rapid maxil$ expan$.mp or rapid palat$ expan$.mp; (2) limit to human; (3) skeletal changes.mp; (4) 1 and 2 and 3	0	0	0
Embase	(1) Rapid maxil$ expan$.mp or rapid palat$ expan$.mp; (2) limit to human; (3) skeletal changes.mp; (4) 1 and 2 and 3	33	2	4.8
All EBM reviews (Cochrane Database of Systematic Reviews, ASP Journal Club, DARE and CCTR)	(1) Rapid maxil$ expan$.mp or rapid palat$ expan$.mp; (2) limit to human; (3) skeletal changes.mp; (4) 1 and 2 and 3	21	4	9.6
Web of Science	(1) TS = (rapid maxillary expansion); (2) TS = (rapid palatal expansion); (3) TS = (skeletal changes); (4) #1 OR #2; (5) #3 AND #4 DocType = Article; Language = All languages; Database(s) = SCI-EXPANDED, SSCI, A&HCI	9	2	4.8
Lilacs	(1) Rapid maxillary expansion; (2) Rapid palatal expansion; (3) #1 OR #2	33	9	21.4

[a] Percentages do not add up to 100% as the same reference could be found in several databases.

TABLE 2. Studies that Fulfilled Initial Selection Criteria but Were Later Rejected[a]

Authors	Reason(s) for Rejection
Bhatt and Jacob[19]	No control group and no error of method
Linder-Aronson and Lindgren[20]	No control group, no error of method and appliance design
da Silva et al[21]	No control group, no error of method and no retention period
da Silva et al[22]	No control group, no error of method and no retention period
Velazquez et al[23]	No control group
Asanza et al[24]	No control group and no error of method
Sandikcioglu and Hazar[9]	No control group
Akkaya et al[6]	No control group and no retention period
Memikoglu and Iseri[25]	No control group
Ursi et al[26]	No control group and no error of method
Bramante and Almeida[27]	No control group, no error of method and appliance design
Franchi et al[28]	Database repetition
Cozza et al[29]	Only short-term changes
Cross et al[30]	Only short-term changes

[a] Error of method, magnitude of the measurement error; retention period, specified retention period and type; appliance design, appliance modified significantly compared to RME traditional design; database repetition, same data used in a different study; short-term changes, only immediate changes (after expansion phase) were reported.

tions and accounted for a significant percentage (21.4%) of the finally selected abstracts. From the 42 studies that on the basis of the abstracts seemed to be potentially useful, only 17 studies actually fulfilled the initial selection criteria after reading the complete article. Manual searching of the references from these 42 studies did not reveal any study that had not appeared in the electronic search.

At the final stage of article selection, eleven[5,12,19–27] of the 17 articles were rejected because of the lack of an adequate control group, one[28] because it used the same database as another selected study and two[29,30] because they only evaluated short-term (six and three months after insertion of appliance, respectively) skeletal changes. Lack of reported measurement error[19–22,24,26,27] or use of unconventional cephalometric analysis[28] were also found in some studies (Table 2).

Finally, only three articles that met all the inclusion criteria remained. A summary of the sample size, retention period, radiographs, and appliance used is given in Table 3. A methodological quality checklist was developed to evaluate the selected articles (Table 4),

TABLE 3. Studies Finally Included

Authors	Sample	Control	Method Error Reported	Radiographs
Chang et al[6]	18 female and seven male (11.8 years)	seven female and 16 male (11.8 years)	Yes	Lat Cephs
Baccetti et al[31]	25 females and 17 males (grouped according to skeletal age)	nine females and 11 males (grouped according to skeletal age)	Yes	PA Cephs
Garib et al[32]	11 males and 14 females (13.6 years; 11–17.4 years)	13 males and 13 females (paired according to age with treatment group)	Yes	Lat Cephs

TABLE 4. Methodological Score for the Clinical Trials[a]

I. Study Design (9√)
- A. Objective: objective clearly formulated (√)
- B. Population: described (√)
- C. Selection criteria: clearly described (√); adequate (√)
- D. Sample size: considered adequate (√); estimated before collection of data (√)
- E. Baseline characteristics: similar baseline characteristics (√)
- F. Timing: prospective (√)
- G. Randomization: stated (√)

II. Study Measurements (5√)
- H. Measurement method: appropriate to the objective (√)
- I. Blind measurement: blinding (examiner √, statistician √)
- J. Reliability: described (√), adequate level of agreement (√)

III. Statistical Analysis (6√)
- K. Dropouts: dropouts included in data analysis (√)
- L. Statistical analysis: appropriate for data (√); combined subgroup analysis (√)
- M. Confounders: confounders included in analysis (√)
- N. Statistical significance level: *P* value stated (√); confidence intervals (√)

[a] Maximum number of √s = 20.

and the application of the methodological quality checklist is provided in Table 5. A flow diagram of the literature search appears in Table 6. From the three final articles, one measured transverse changes, two anteroposterior changes, and two vertical changes. All the three articles measured long-term RME stability (more than five years after finishing full active treatment).

Transverse changes

The only statistically significant difference in skeletal width increase for patients before and after peak pubertal growth spurt was lateronasal width (+1.5 mm). For the early-treated group, the maxillary width increase was significant (three mm) but not for the late-treated group (0.9 mm). The authors concluded that patients treated before compared with after pubertal peak exhibit clinically significant and more effective long-term changes at the skeletal level in both maxillary and circummaxillary structures.[31]

Anteroposterior changes

There was no significant difference except for the position of A point, which was more retruded in the RME-treated group (−1.05° when compared with control group). No significant changes were also found for the anteroposterior position of the maxilla and mandible.[6]

When compared with the control group, they found that the maxilla and mandible presented similar changes in both groups. No statistically significant changes were found concerning the anteroposterior position of the maxilla and mandible.[32]

Vertical changes

Any statistically significant short-term differences were found in skeletal vertical cephalometric variables. The mandibular plane angle reduction between pretreatment and long-term follow-up (−0.85°) was less for the RME than the two comparison groups (−2.52° in group treated with full fixed appliances and −2.21° for control group).[6]

A statistically significant long-term difference was present in the SN-PP (0.8°) and SN-Gn (0.8°) angles when comparing the treatment group with the control

TABLE 5. Methodological Score of Selected Articles[a]

Articles	A	B	C	D	E	F	G	H	I	J	K	L	M	N	Total no. of Checks	Percentage of The Total
Chang et al[6]	√	≠	√≠	√	√	–	–	√	–	√√	–	√	–	≠	9.5	45.00
Garib et al[32]	√	≠	√≠	√	√	–	–	√	–	√√	–	√	–	≠	9.5	45.00
Baccetti et al[31]	√	√	√√	√	–	–	–	√	–	√√	–	√√	√	√	12	60

[a] A–M: methodological criteria in Appendix 1; √, fulfilled satisfactorily the methodological criteria (1 check point); ≠, fulfilled partially the methodological criteria (0.5 check point); −, did not fulfill the methodological criteria (0 check point).

TABLE 6. Flow Diagram of the Literature Search

		Electronic search 188 abstracts ↓ Selection criteria on 188 abstracts ↓ → excluded 146 Selection criteria on 42 papers ↓ → excluded 25
Manual search 0 papers ↓ Potentially appropriated to be included 0 papers	→ ↓ ←	Potentially appropriated to be included 17 papers
	17 papers ↓ → excluded 11 lack of control group 6 papers ↓ → excluded 1 repetition of sample 5 papers finally selected	

group. No significant change was found for the vertical measurements between the end of active treatment and the follow-up.[32]

DISCUSSION

Much information about RME has been published, but the conclusions have been contradictory. Two meta-analyses[15,17] and one systematic review[16] analyzed only RME dental changes. These meta-analyses and systematic review concluded that trial results for dental changes were inconclusive and recommendations for clinical practice could not be supported. However, one previous systematic review[18] found that long-term transversal changes were clinically significant. No previous systematic review or meta-analysis has been published regarding the long-term skeletal effects of RME.

Even though there are a considerable number of studies dealing with skeletal changes with RME procedures, the majority of reports about RME skeletal changes were excluded because of the absence of a control group to factor out the normal growth changes that could have happened during the expansion and retention periods. Also, some of them did not provide the error of methods. Knowledge of the measurement error is essential in judging the clinical significance of any reported statistically significant findings.

Finally, methodological factors such as different postactive treatment evaluation periods and differences in the landmarks evaluated between the two studies that met the inclusion criteria and evaluated skeletal anteroposterior and vertical changes prevented use of a meta-analysis. The individual significant differences found were statistically significant not clinically significant, and therefore, a meta-analysis would not have added significantly to our knowledge about long-term skeletal changes after RME.

Although three studies satisfied the final inclusion criteria for this systematic review, conclusions should be made and evaluated with caution. The finally selected studies presented methodological issues such as a lack of description of a statistical estimation process for the sample size, dropouts, and intra- and interexaminer reliability. Although assessing study quality is subjective and dependent on adequate reporting in the journal articles,[33] it gives a comparative idea of the methodological quality of the studies. Within the limitations of the quality score list used, scores for the finally selected studies were limited. Long-term randomized clinical trials are required to obtain sound clinical conclusions about the effectiveness of RME at the skeletal level.

Also, these studies failed to give the higher level of scientific evidence, which is only attainable through the use of randomized clinical trials.[34] In the absence of the highest level of evidence, clinicians have to make decisions based on lower levels of evidence. Nonrandomized controlled trials, such as the ones found, represent only the second level of evidence and are prone to confounding and selection bias.[35] Therefore, a careful analysis of their results that considers their limitations is required.

Differences were found for the transverse maxillary skeletal changes according to the maturation stage of the subjects. For the lateronasal width (+1.5 mm), the expansion effects were significant for both groups. On the other hand, the maxillary width increase was only significant (three mm) for the early-treated group but not for the late-treated group. The authors concluded that patients treated before pubertal peak growth exhibit clinically significant and more effective long-term changes at the skeletal level in both maxillary and circummaxillary structures.[31] Therefore, maxillary skeletal width increase appears to be approximately 20% of the total appliance activation in prepubertal adolescents but not significant for postpubertal adolescents.

Concerning anteroposterior changes in the maxilla and mandible, no significant alterations were found in any of the studies reviewed.[6,32] After the posttreatment and postretention, the maxilla and mandible of the treated groups presented similar behavior to the ones of the control group, ie, the differences presented no statistical or clinical significance.

Short-term and long-term vertical skeletal changes associated with RME appear to be restricted to the maxilla. The magnitude of change reported by Garib et al[32] was small and, in view of the range of measurement error, has little, if any, clinical significance. The long-term changes in mandibular plane angle reported by Chang et al[6] are also of little, if any, clinical significance.

Scientific evidence alone does not automatically dictate the selection of the treatment. A combination of values from the patient and professional (clinical, personal, and social) should determine whether the intervention benefits are worth the costs.[36] Therefore, the application of evidence into clinical practice has to be related to professional expertise and patient value needs. As in any usual clinical environment, clinicians will need to rely on their clinical experience, the opinion of experts, and the presented limited evidence concerning RME skeletal short- and long-term results.

CONCLUSIONS

The following conclusions for this systematic review should be considered with caution because only a secondary level of evidence was found. Long-term prospective randomized clinical trials are needed to support these findings:

- Long-term stability of transverse skeletal maxillary increase is better in skeletally less mature individuals (prepubertal growth peak) than skeletally more mature (pubertal and postpubertal growth peak) individuals. The clinical significance of long-term maxillary expansion in skeletally more mature groups is questionable.
- Long-term transverse skeletal maxillary increase is approximately 25% of the total appliance adjustment (dental expansion) in prepubertal adolescents but not significant for postpubertal adolescents.
- RME did not produce significant anteroposterior or vertical changes in the position of the maxilla and mandible.

ACKNOWLEDGMENT

Special thanks to Linda Seale for her professional assistance in the database search.

REFERENCES

1. Haas AJ. Palatal expansion: just the beginning of dentofacial orthopedics. *Am J Orthod.* 1970;57:219–255.
2. Timms DJ. An occlusal analysis of lateral maxillary expansion with midpalatal suture opening. *Dent Pract Dent Rec.* 1968;18:435–441.
3. Haas AJ. Long-term posttreatment evaluation of rapid palatal expansion. *Angle Orthod.* 1980;50:189–217.
4. Pavlin D, Vukicevic D. Mechanical reactions of facial skeleton to maxillary expansion determined by laser holography. *Am J Orthod.* 1984;85:498–507.
5. Akkaya S, Lorenzon S, Ucem TT. A comparison of sagittal and vertical effects between bonded rapid and slow maxillary expansion procedures. *Eur J Orthod.* 1999;21:175–180.
6. Chang JY, McNamara JA Jr, Herberger TA. A longitudinal study of skeletal side effects induced by rapid maxillary expansion. *Am J Orthod Dentofacial Orthop.* 1997;112:330–337.
7. Darendeliler MA, Strahm C, Joho JP. Light maxillary expansion forces with the magnetic expansion device. A preliminary investigation. *Eur J Orthod.* 1994;16:479–490.
8. Akkaya S, Lorenzon S, Ucem TT. Comparison of dental arch and arch perimeter changes between bonded rapid and slow maxillary expansion procedures. *Eur J Orthod.* 1998;20:255–261.
9. Bell RA. A review of maxillary expansion in relation to rate of expansion and patient's age. *Am J Orthod.* 1982;81:32–37.
10. Lagravere MO, Major PW, Flores-Mir C. Skeletal and dental changes with fixed slow maxillary expansion treatment: a systematic review. *J Am Dent Assoc.* 2005; In press.
11. Hicks EP. Slow maxillary expansion. A clinical study of the skeletal versus dental response to low-magnitude force. *Am J Orthod.* 1978;73:121–141.
12. Sandikcioglu M, Hazar S. Skeletal and dental changes after maxillary expansion in the mixed dentition. *Am J Orthod Dentofacial Orthop.* 1997;111:321–327.
13. Handelman CS. Nonsurgical rapid maxillary alveolar expansion in adults: a clinical evaluation. *Angle Orthod.* 1997;67:291–305.
14. Lanigan DT, Mintz SM. Complications of surgically assisted rapid palatal expansion: review of the literature and report of a case. *J Oral Maxillofac Surg.* 2002;60:104–110.
15. Schiffman PH, Tuncay OC. Maxillary expansion: a meta analysis. *Clin Orthod Res.* 2001;4:86–96.
16. Petren S, Bondemark L, Soderfeldt B. A systematic review concerning early orthodontic treatment of unilateral posterior crossbite. *Angle Orthod.* 2003;73:588–596.
17. Harrison JE, Ashby D. Orthodontic treatment for posterior crossbites. *Cochrane Database Syst Rev.* 2002. CD000979.
18. Lagravere MO, Major PW, Flores-Mir C. Long term dental arch changes after rapid maxillary expansion treatment: a systematic review. *Angle Orthod.* 2005;75:151–157.
19. Bhatt AK, Jacob PP. Skeletal and dental changes in rapid maxillary expansion. *J Indian Orthod Soc.* 1978;10:17–27.
20. Linder-Aronson S, Lindgren J. The skeletal and dental effects of rapid maxillary expansion. *Br J Orthod.* 1979;6:25–29.
21. da Silva Filho OG, Boas MC, Capelozza Filho L. Rapid maxillary expansion in the primary and mixed dentitions: a cephalometric evaluation. *Am J Orthod Dentofacial Orthop.* 1991;100:171–179.
22. da Silva Filho OG, Montes LA, Torelly LF. Rapid maxillary expansion in the deciduous and mixed dentition evaluated

through posteroanterior cephalometric analysis. *Am J Orthod Dentofacial Orthop.* 1995;107:268–275.
23. Velazquez P, Benito E, Bravo LA. Rapid maxillary expansion. A study of the long-term effects. *Am J Orthod Dentofacial Orthop.* 1996;109:361–367.
24. Asanza S, Cisneros GJ, Nieberg LG. Comparison of Hyrax and bonded expansion appliances. *Angle Orthod.* 1997;67: 15–22.
25. Memikoglu TU, Iseri H. Effects of a bonded rapid maxillary expansion appliance during orthodontic treatment. *Angle Orthod.* 1999;69:251–256.
26. Ursi WJ, Dale RCXS, Claro CA, Chagas RV, Almeida G. Transversal changes produced by the bonded rapid maxillary expander, evaluated by postero-anterior cephalographs. *Ortodontia* 2001;34:43–55.
27. Bramante FS, Almeida RR. Dentoskeletal changes evaluated with lateral cephalometry initially and after three months of use of a maxillary expansor with occlusal coberage. *J Bras Ortod Ortop Facial* 2002;39:202–216.
28. Franchi L, Baccetti T, Cameron CG, Kutcipal EA, McNamara JAJ. Thin-plate spline analysis of the short- and long-term effects of rapid maxillary expansion. *Eur J Orthod.* 2002;24:143–150.
29. Cozza P, Giancotti A, Petrosino A. Rapid palatal expansion in mixed dentition using a modified expander: a cephalometric investigation. *J Orthod.* 2001;28:129–134.
30. Cross DL, McDonald JP. Effect of rapid maxillary expansion on skeletal, dental, and nasal structures: a postero-anterior cephalometric study. *Eur J Orthod.* 2000;22:519–528.
31. Baccetti T, Franchi L, Cameron CG, McNamara JA Jr. Treatment timing for rapid maxillary expansion. *Angle Orthod.* 2001;71:343–350.
32. Garib DG, Henriques JFC, Janson GP. Longitudinal cephalometric appraisal of rapid maxillary expansion effects. *Rev Dent Press Ortod Ortop Facial.* 2001;6:17–30.
33. Hodges JS. Are quality assessment methods any good? *J Evid Based Dent Pract.* 2004;4:24–31.
34. Eccles M, Freemantle N, Mason J. Using systematic reviews in clinical practice guidelines. In: Egger M, Smith GD, Altman DG, eds. *Systematic Reviews in Health Care: Meta-analysis in Context.* London: BMJ Books; 2003:400–409.
35. Egger M, Smith GD, Schneider M. Systematic reviews of observational studies. In: Egger M, Smith GD, Altman DG, eds. *Systematic Reviews in Health Care: Meta-analysis in Context.* London: BMJ Books; 2003:211–227.
36. Guyatt G, Haynes B, Jaeschke R, et al. Introduction: the philosophy of evidence-based medicine. In: Guyatt G, Rennie D, eds. *Users' Guides to the Medical Literature: A Manual for Evidence-based Practice.* Chicago, Ill: AMA Press; 2002:3–12.