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Evaluation of methodology and quality characteristics of systematic reviews in orthodontics

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Abstract

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Systematic reviews (SRs) are published with an increasing rate in many fields of biomedical literature, including orthodontics. Although SRs should consolidate the evidence-based characteristics of contemporary orthodontic practice, doubts on the validity of their conclusions have been frequently expressed. The aim of this study was to evaluate the methodology and quality characteristics of orthodontic SRs as well as to assess their quality of reporting during the last years. Electronic databases were searched for SRs (without any meta-analytical data synthesis) in the field of orthodontics, indexed up to the start of 2010. The Assessment of Multiple Systematic Reviews (AMSTAR) tool was used for quality assessment of the included articles. Data were analyzed with Student's *t*-test, one-way ANOVA, and linear regression. Risk ratios (RR) with 95% confidence intervals were calculated to represent changes during the years in reporting of key items associated with quality. A total of 110 SRs were included in this evaluation. About half of the SRs (46.4%) were published in orthodontic journals, while few (5.5%) were updates of previously published reviews. Using the AMSTAR tool, thirty (27.3%) of the SRs were found to be of low quality, 63 (57.3%) of medium quality, and 17 (15.5%) of high quality. No significant trend for quality improvement was observed during the last years. The overall quality of orthodontic SRs may be considered as medium. Although the number of orthodontic SRs has increased over the last decade, their quality characteristics can be characterized as moderate.

Key words: assessment of multiple systematic reviews; orthodontic; quality; reporting; systematic review

Introduction

According to the Cochrane handbook, a systematic review (SR) consists of a clearly formulated question and explicit methods to identify, select, and critically appraise relevant research. It collects and analyzes data from the studies that are included in the review. On the other hand, a meta-analysis is the use of statistical techniques in a SR, which integrates the results of the included studies (1). SRs are recognized as an efficient means of summarizing current evidence regarding a certain question and are becoming increasingly popular (2). Many forms of bias have been docu-

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mented in biomedical research (3), and SRs should ideally include strategies to identify and, if possible, minimize them. One of the most common shortcomings assessed is publication bias, which is found in nearly every biomedical field, including dentistry (4, 5). SRs are sometimes considered as a necessary link between innovative trials and preceding evidence (6). In fact, some medical journals even require authors of clinical trials to assess the impact of their results on the summary of existing research, usually by means of a SR (7).

Systematic reviews do not require pooling of results (as it is the case with meta-analyses), especially when heterogeneous results exist, and thus they do not always synthesize data by meta-analytic procedures (8). Conversely, articles summing evidence by means of meta-analysis should always fulfill the requirements of a SR. In the field of orthodontics in particular, clinical research of the past included many study designs, which were relatively weak concerning the hierarchy of evidence (9), namely of low power and reliability (10). As an editorial points out, much of the research in dentistry is focused on surrogate endpoints, which are intangible at the patient level and could possibly account for inconsistencies between studies (11).

Because quality of reporting is directly related to the quality of methodology and conclusions of a study (12, 13), it seems very useful to evaluate the quality of published SRs. During the years, attempts were made to assess the quality of SRs, and several relevant instruments have been created for reporting and appraising them with varying validation of efficacy (14). The Quality of Reporting of Meta-analyses (QUOROM) statement (15) was updated at 2009 giving birth to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement (16) by incorporating items deemed important for transparent reporting. Lately, the Assessment of Multiple Systematic Reviews (AMSTAR) (17), an 11-item tool, was introduced, which was designed to critically appraise the methodological quality of SRs. This tool proved to be a reliable and valid measurement method to assess the methodological quality of SRs (18, 19). To our knowledge, quality and reporting of orthodontic SRs have not been studied extensively so far. A recently relevant investigation shed some light on the limitations of existing SRs in orthodontics, but only sixteen articles were included, and only their search and selection phases were assessed (20).

The aims of this study were 1) to evaluate the methodology and quality characteristics of all published SRs (without any meta-analytical data synthesis) related to orthodontics and 2) to assess whether their quality reporting has been improved during the last years.

Material and methods

Study sample

Electronic search strategies were developed and executed to identify SRs relevant to orthodontics, which have been published in journals, dissertations, or conference proceedings. No restrictions were made concerning year, language, or publication status. However, studies with missing English abstract were excluded. The reference lists of acquired articles were also searched for relevant articles. Databases of research registers were searched to identify ongoing or unpublished reviews. All databases were searched on January 12, 2010. Two of the authors (SNP and MAP) screened independently the titles and abstracts of the retrieved citations to exclude non-eligible articles. A copy of the full text was obtained for the remaining articles. The same authors read each full-text article to determine whether it met the inclusion criteria. Additional material about the articles included as appendix was acquired, when needed. Any disagreement was resolved by consulting the last author (AEA) until a final consensus was achieved. Inter-reviewer agreement on study selection was assessed by Cohen's kappa coefficient.

In this evaluation, an article was considered as eligible for inclusion if it 1) was labeled in the title, abstract, or full text as a 'systematic review', 2) clearly stated the topic of the review or the hypothesis to be tested, and 3) provided explicitly the inclusion and exclusion criteria for eligible studies. All other types of studies, such as case reports, case series without a control, case–control observational studies, retrospective uncontrolled cohort studies, prospective uncontrolled cohort studies, retrospective controlled cohort studies, prospective controlled clinical trials (CCTs), randomized controlled clinical trials (RCTs), narrative reviews, SRs including meta-analytic procedures, as well as meta-analyses, were excluded.

Data extraction

Data to be collected were defined *a priori* from pilot search of the literature and discussion among the authors. A number of general and specific items for each review were assessed. Two of the reviewers (SNP and MAP) completed in duplicate data extraction in a predesigned collection form. The reviewers were not blinded to journal and author names, as masked assessment is inconsistent (21). Any disagreement was resolved by consulting the last author (AEA) until a final consensus was achieved. Inter-reviewer agreement on data extraction was assessed by Cohen's kappa coefficient.

Epidemiological characteristics were based on the first author of each article, who is usually also responsible for correspondence. In detail, the first author of each article was used to extract the country data, continent data, and the 'academic source' of each article (i.e., whether the first author originated from an orthodontic academic department, a non-orthodontic academic department or not from an academic department). The Cochrane Database of Systematic Reviews was classified as a general journal. Journals having published less than five orthodontic SRs and the Cochrane Database of SRs were unified in a journal category named 'Other'. Journal impact factors (IF) were acquired from ISI Journal Citation Reports (22). Hirsch indices were acquired from SCImago Journal & Country Rank (23). Separate citation counts were acquired from Web of Science, Scopus, and Google Scholar, and their average value was used for analyses. All citation counts and journal metrics were acquired during the second week of June 2010.

Quality assessment

Articles were evaluated using the 11-item AMSTAR tool (Table 1) (17). Each item was assessed using a four-point scale: 'Yes', 'Can't tell', 'No', and 'Not applicable'. A criterion was defined as 'Can't tell', if it was half-met. For example, the fifth criterion, 'A list of included and excluded studies should be provided', was scored as 'Can't tell', if either the included or the excluded studies were listed. Non-applicable items were excluded from the maximum scoring capability of each SR. Summary scores were extracted by giving one point for each 'Yes' and half a point for each 'Can't tell' in an attempt to maximize data output. Summary scores are reported as percentages. The 'acceptance-to-publication time' was calculated as publication date minus acceptance date. Because the exact dates of acceptance and publication were not always available for all SRs, only the corresponding months were used for calculating the 'acceptance-to-publication time'.

Statistical analysis

Data were summarized descriptively as frequencies or means, standard deviations (SD), and 95% confidence intervals (CI). Normality was checked with a Kolmogorov–Smirnov Z test and visual histograms. Differences between groups were assessed with the Student's t-test and with the one-way analysis of variance (ANOVA). All characteristics were used as predictors using the AMSTAR score as the dependent variable in linear regression. Variables found to be significant at the $p \leq 0.05$ level were entered in multivariate linear regression models to assess for potential confounding factors. These models were based on unweighted least squares. Risk ratios (RR) with 95% CI were used as summary statistics to compare quality and reporting between specific time points; years 1999 vs. 2004, as well as years 2004 vs. 2009. The years 1999, 2004 and 2009, indicating the start, middle, and end of this study's coverage, were selected to investigate possible improvements in reporting (24). A two-tailed $\alpha \leq 0.05$ was considered as significant. Analyses were performed using the statistical software SPSS (version 17; SPSS Inc., Chicago, IL, USA), except for the comparisons of reporting quality between years, which were performed with the software RevMan (Review Manager, version 5.0.; Copenhagen, Denmark: The Nordic Cochrane Centre, The Cochrane Collaboration, 2008).

Results

Literature search

The electronic search yielded 818 initial citations (Table 2), 225 of which were selected for further evaluation. After reading the full texts, 149 articles remained. Finally, following application of the specific inclusion and exclusion criteria, 39 articles were excluded (Table 3), and thus 110 SRs were deemed eligible for data extraction (Fig. 1). The kappa score

Table 1. **Evaluation of the quality of orthodontic systematic reviews using the Assessment of Multiple Systematic Reviews (AMSTAR) checklist**

AMSTAR items	Yes: n (%)	Can't tell: n (%)	No: n (%)	N/A: n (%)
1. Was an '*a priori*' design provided? The research question and inclusion criteria should be established before the conduct of the review	88 (80.0)	22 (20.0)	0 (0.0)	0 (0.0)
2. Was there duplicate study selection and data extraction? There should be at least two independent data extractors and a consensus procedure for disagreements should be in place	46 (41.8)	39 (35.5)	25 (22.7)	0 (0.0)
3. Was a comprehensive literature search performed? At least two electronic sources should be searched. The report must include years and databases used (e.g., Central, EMBASE, and MEDLINE). Key words and/or MESH terms must be stated and where feasible the search strategy should be provided. All searches should be supplemented by consulting current contents, reviews, textbooks, specialized registers, or experts in the particular field of study, and by reviewing the references in the studies found	32 (29.1)	48 (43.6)	30 (27.3)	0 (0.0)
4. Was the status of publication (i.e., gray literature) used as an inclusion criterion? The authors should state that they searched for reports regardless of their publication type. The authors should state whether or not they excluded any reports (from the systematic review), based on their publication status, language etc.	31 (28.2)	54 (49.1)	25 (22.7)	0 (0.0)
5. Was a list of studies (included and excluded) provided? A list of included and excluded studies should be provided	27 (24.5)	72 (65.5)	9 (8.2)	2 (1.8)
6. Were the characteristics of the included studies provided? In an aggregated form such as a table, data from the original studies should be provided on the participants, interventions and outcomes. The ranges of characteristics in all the studies analyzed e.g., age, race, sex, relevant socioeconomic data, disease status, duration, severity, or other diseases should be reported	90 (81.8)	6 (5.5)	10 (9.1)	4 (3.6)
7. Was the scientific quality of the included studies assessed and documented? '*A priori*' methods of assessment should be provided (e.g., for effectiveness studies if the author(s) chose to include only randomized, double-blind, placebo controlled studies, or allocation concealment as inclusion criteria); for other types of studies alternative items will be relevant	62 (56.4)	26 (23.6)	22 (20.0)	0 (0.0)
8. Was the scientific quality of the included studies used appropriately in formulating conclusions? The results of the methodological rigor and scientific quality should be considered in the analysis and the conclusions of the review, and explicitly stated in formulating recommendations	54 (49.1)	28 (25.5)	28 (25.5)	0 (0.0)
9. Were the methods used to combine the findings of studies appropriate? For the pooled results, a test should be done to ensure the studies were combinable, to assess their homogeneity (i.e., Chi-squared test for homogeneity, I^2). If heterogeneity exists a random effects model should be used and/or the clinical appropriateness of combining should be taken into consideration (i.e., is it sensible to combine?)	10 (9.1)	2 (1.8)	2 (1.8)	96 (87.3)

Table 1. Continued

AMSTAR items	Yes: n (%)	Can't tell: n (%)	No: n (%)	N/A: n (%)
10. Was the likelihood of publication bias assessed? An assessment of publication bias should include a combination of graphical aids (e.g., funnel plot, other available tests) and/or statistical tests (e.g., Egger regression test)	2 (1.8)	3 (2.7)	97 (88.2)	8 (7.3)
11. Was the conflict of interest stated? Potential sources of support should be clearly acknowledged in both the systematic review and the included studies	31 (28.2)	4 (3.6)	75 (68.2)	0 (0.0)

N/A, not applicable.

before reconciliation for the selection and data extraction procedures was 0.966 and 0.993, respectively, which indicate almost perfect agreement.

Publishing characteristics

The 110 SRs included 2190 primary studies, 129 949 patients and were published between 1999 and 2010 in 29 journals. Fig. 2 presents the time evolution of SRs published from 1999 to 2009. No SRs were identified with publication date prior to 1999, and only one was published in 2010 at the time of search. The majority of the SRs originated from Europe (n = 67; 60.9%), while the most prolific countries were Canada (n = 25; 22.7%) followed by the United Kingdom (n = 24; 21.8%). Most of the SRs were single-centered (median of one affiliation) and included one to eight authors (median of four authors), while only three (2.7%) were single-authored. A total of 269 different authors were identified, among whom 65 authors (24.2%) were involved in two or more SRs. The majority of the SRs (n = 91; 82.7%) neither involved as an author nor acknowledged the participation of a statistician or an epidemiologist in the study.

The SRs referred to a wide set of areas in the field of orthodontics with the most common being treatment modalities (n = 49; 44.5%), diagnosis and treatment planning (n = 14; 12.7%), and clinical entities (n = 13; 11.8%), such as cleft lip and palate, and cleidocranial dysplasia (Table 4).

The general characteristics of the SRs are presented in Table 5. Almost half of them (n = 51; 46.4%) were published in orthodontic journals, while 20 SRs (18.2%) were published in the Cochrane Library. More than half of the SRs (n = 68; 61.8%) were published in journals with impact factor. Six SRs (5.5%) were updates of existing SRs, four of which (3.6%) were Cochrane reviews. Only few SRs (n = 26; 23.7%) reported any financial conflict of the authors.

The majority of the SRs (n = 72; 65.5%) used the term 'systematic review' in their title, most reviews (n = 104; 94.5%) were in English, and less than half (n = 38; 34.5%) reported working with a protocol. Sixty reviews (54.5%) provided the Boolean search strategy used, while their majority (n = 89; 80.9%) provided complete dates of coverage. SRs reported searching a median of four databases, while most of them (n = 77; 70.0%) did not provide a flow diagram of identification and

Table 2. **The electronic databases searched, the search strategies used, and the corresponding results**

Electronic database	Search strategy used	Hits
MEDLINE Searched via PubMed (1950 – week 2, January 2010) http://www.ncbi.nlm.nih.gov/sites/entrez/	Orthodont* AND ('systematic review' OR 'systematic literature review')	102
EMBASE Searched via ScienceDirect (1974 – January, 2010) http://www.embase.com	Orthodont* AND ('systematic review' OR 'systematic literature review')	115
Cochrane Database of Systematic Reviews Searched via The Cochrane Library at January 12, 2010 http://www.thecochranelibrary.com	Orthodont*	65
Google Scholar Beta Searched at January 12, 2010 http://www.scholar.google.com	Orthodont AND ('systematic review' OR 'systematic literature review') *in Medicine, Pharmacology, and Veterinary Science*	132
Web of Science Searched at January 12, 2010 http://scientific.thomson.com/products/wos/	Orthodont* AND ('systematic review' OR 'systematic literature review')	62
Evidence-Based Medicine Searched at January 12, 2010 http://ebm.bmjjournals.com	Orthodont* AND ('systematic review' OR 'systematic literature review')	31
Scopus Searched at January 12, 2010 http://www.scopus.com	Orthodont* AND ('systematic review' OR 'systematic literature review') *in Article Title, Abstract* and *Keywords*	123
LILACS database Searched at January 12, 2010 http://bases.bvs.br	Orthodontic and systematic	4
Bibliografia Brasileira de Odontolgogia Searched at January 12, 2010 http://bases.bvs.br	Orthodontic and ((systematic and review) or (systematic and literature and review))	93
Ovid database Searched at January 12, 2010 http://ovidsp.ovid.com/autologin.html	Orthodont* AND ('systematic review' OR 'systematic literature review') *Journal subsets: Clinical medicine, Health Professions, Life and biomedical sciences, Life sciences; Limited to articles with abstracts*	54
Bandolier Searched at January 12, 2010 http://www.jr2.ox.ac.uk/Bandolier	Orthodontic AND ('systematic review' OR 'systematic literature review')	1
Extenza Searched at January 12, 2010 http://www.extenza-eps.com	Orthodont* AND ('systematic review' OR 'systematic literature review')	2
African Journals Online Searched at January 12, 2010 http://www.ajol.info	Orthodontic AND ('systematic review' OR 'systematic literature review')	0
Databases of dissertations and conference proceedings		
Digital Dissertations Searched via UMI ProQuest at January 12, 2010 http://proquest.umi.com/pqdweb?RQT=302&cfc=1	(((orthodont*) AND ('systematic review')) OR ((orthodont*) AND ('systematic literature review'))) *Limited to Dissertations*	16
Conference Paper Index Searched via Cambridge Scientific Abstracts (1982 – January 12, 2010) http://journals.cambridge.org/action/search	Orthodont* AND ('systematic review' OR 'systematic literature review')	19
Databases of research registers		
German National Library of Medicine (ZB MED) Searched via http://www.medpilot.de January 12, 2010	Orthodont* AND ('systematic review' OR 'systematic literature review')	0
Sum		818

Table 3. **Articles excluded on basis of full text from this study and reason for exclusion**

No.	Study	Reason for exclusion
1	Aelbers CM, Dermaut LR. Orthopedics in orthodontics: Part I, Fiction or reality – a review of the literature. *Am J Orthod Dentofacial Orthop* 1996;**110**:513–9.	Not clearly defined question/not clearly defined inclusion and exclusion criteria
2	Beirne P, Clarkson JE, Worthington HV. Recall intervals for oral health in primary care patients. *Cochrane Database Syst Rev* 2007;**17**:CD004346.	Initially included, but deemed not adequately relevant to orthodontics
3	Bonner BC, CLarkson JE, Dobbyn L, Khanna S. Slow-release fluoride devices for the control of dental decay. *Cochrane Database Syst Rev* 2006;**18**:CD005101.	Initially included, but deemed not adequately relevant to orthodontics
4	Car J, Gurol-Urganci I, de Jongh T, Vodopivec-Jamsek V, Atun R. Mobile phone messaging reminders for attendance at scheduled healthcare appointments. *Cochrane Database Syst Rev* 2008:**4**:CD007458.	Protocol, initially included, but deemed not adequately relevant to orthodontics
5	Christakis DA, Garrison MM, Ebel BE, Wiehe SE, Rivara FP. Pediatric smoking prevention interventions delivered by care providers: a systematic review. *Am J Prev Med* 2003;**25**:358–62.	Initially included, but deemed not adequately relevant to orthodontics
6	Favero L, Brollo P, Bressan E. Orthodontic anchorage with specific fixtures: Related study analysis. *Am J Orthod Dentofacial Orthop* 2002;**122**:84–94.	Not clearly defined question/not clearly defined inclusion and exclusion criteria
7	Feldmann I. Orthodontic anchorage – Evidence-based evaluation of anchorage capacity and patients' perceptions. *Swed Dent J Suppl* 2007;**191**:10–86.	SR included in a thesis, also published in a journal
8	Flores-Mir C. Clinical significance of early treatment of overjet is questionable. *Evid Based Dent* 2007;**8**:103–4.	Summary of existing SR
9	Flores-Mir C. Grinding is effective in early orthodontic treatment of unilateral posterior crossbite. *Evid Based Dent* 2005;**6**:24.	Summary of existing SR
10	Gruen RL, Weeramanthri TS, Knight SE, Bailie RS. Specialist outreach clinics in primary care and rural hospital settings. *Cochrane Database Syst Rev* 2004;(1):CD003798.	Initially included, but deemed not adequately relevant to orthodontics
11	Hoekema A. Efficacy and comorbidity of oral appliances in the treatment of obstructive sleep apnea-hypopnea: a systematic review and preliminary results of a randomized trial. *Sleep Breath* 2006;**10**:102–3.	SR presented in a short communication
12	Huang GJ. Insufficient evidence to conclude that orthodontic patients derive benefits from using power toothbrushes. *J Am Dent Assoc* 2009;**140**:914–5.	Summary of existing SR
13	Huber KL, Suri L, Taneja P. Eruption disturbances of the maxillary incisors: a literature review. *J Clin Pediatr Dent* 2008;**32**:221–30.	Not clearly defined inclusion and exclusion criteria
14	Kalha A. What is the most effective adhesive for attaching orthodontic bands? *Evid Based Dent* 2006;**7**:101–2.	Summary of existing SR
15	Kalha AS. Is anchorage reinforcement with implants effective in orthodontics? *Evid Based Dent* 2008;**9**:13–4.	Summary of existing SR
16	Kalha AS. Medication and tooth movement. *Evid Based Dent* 2009;**10**:50–1.	Summary of existing SR

Table 3. **Continued**

No.	Study	Reason for exclusion
17	Kalha AS. Which orthodontic adhesive should I use? – no clear answer yet. *Evid Based Dent* 2003;**4**:52.	Summary of existing SR
18	Major PW, Grubisa HS, Thie NM. Triptans for treatment of acute pediatric migraine: a systematic literature review. *Pediatr Neurol* 2003;**29**:425–9.	Initially included, but deemed not adequately relevant to orthodontics
19	Morgan AG, Owens J, Marshman Z, Rodd HD. The case report in 21st century child dental literature. *Eur J Paediatr Dent* 2008;**9**:145–8.	Initially included, but deemed not adequately relevant to orthodontics
20	O'Neill J. Do lip bumpers work? *Evid Based Dent* 2009;**10**:48–9.	Summary of existing SR
21	O'Neill J. Little evidence exists about optimal caries-prevention strategies during orthodontic treatment. *Evid Based Dent* 2004;**5**:97.	Summary of existing SR
22	O'Neill J. Long-term stability after orthodontic treatment remains inconclusive. *Evid Based Dent* 2007;**8**:81–2.	Summary of existing SR
23	O'Neill J. More evidence required to establish link between premature birth and altered oral development. *Evid Based Dent* 2005;**6**:41–2.	Summary of existing SR
24	Orellana MF, Lagravere MO, Boychuk DG, Major PW, Flores-Mir C. Prevalence of xerostomia in population-based samples: a systematic review. *J Public Health Dent* 2006;**66**:152–8.	Initially included, but deemed not adequately relevant to orthodontics
25	Paulsson L. Premature birth – Studies on orthodontic treatment need, craniofacial morphology and function. *Swed Dent J Suppl* 2009;**199**:9–66.	SR included in a thesis, also published in a journal
26	Pennington L, Miller N, Robson S. Speech therapy for children with dysarthria acquired before three years of age. *Cochrane Database Syst Rev* 2009;**7**:CD006937.	Initially included, but deemed not adequately relevant to orthodontics
27	Pizzo G, Licata ME, Guiglia R, Giuliana G. Root resorption and orthodontic treatment. Review of the literature. *Minerva Stomatol* 2007;**56**:31–44.	Not clearly defined question/not clearly defined inclusion and exclusion criteria
28	Reichert C, Deschner J, Jäger A. Influence of diabetes mellitus on the development and treatment of malocclusions – a case report with literature review. *J Orofac Orthop* 2009;**70**:160–75.	Not clearly defined question/not clearly defined inclusion and exclusion criteria
29	Reichert C, Deschner J, Kasaj A, Jager A. Guided tissue regeneration and orthodontics. A review of the literature. *J Orofacial Orthop* 2009;**70**:6–19.	Not clearly defined question/not clearly defined inclusion and exclusion criteria
30	Ren Y. Rapid maxillary expansion treatment could produce long-term dental arch changes. *Evid Based Dent* 2005;**6**:93–4.	Summary of existing SR
31	Ren Y. Rapid maxillary expansion treatment could produce long-term transverse skeletal changes. *Evid Based Dent* 2005;**6**:92.	Summary of existing SR
32	Ren Y. Soft tissue changes inconclusive in Class II division 1 patients treated with Activator and Bionator appliances. *Evid Based Dent* 2007;**8**:49.	Summary of existing SR
33	Ren Y. Treating anterior open bite. *Evid Based Dent* 2007;**8**:83.	Summary of existing SR

Table 3. Continued

No.	Study	Reason for exclusion
34	Ren YJ. Cell biology in orthodontic tooth movement: the known and the unknown. *Shanghai Kou Qiang Yi Xue* 2005;**14**:182–9.	Not clearly defined inclusion and exclusion criteria
35	Tulloch JF, Medland W, Tuncay OC. Methods used to evaluate growth modification in Class II malocclusion. *Am J Orthod Dentofacial Orthop* 1990;**98**:340–7.	Not clearly defined question
36	van Beek H. [Does orthodontic treatment contribute to oral health?]. *Ned Tijdschr Tandheelkd* 2008;**115**:475–8.	Summary of existing SR
37	Weyant R. Early Orthodontic Treatment is no More Effective in Treating Prominent Upper Front Teeth (Class II malocclusion) Than Late Treatment. *J Evid Based Dent Pract* 2008;**8**:72–3.	Summary of existing SR
38	Xia JJ, Kennedy KA, Teichgraeber JF, Wu KQ, Baumgartner JB, Gateno J. Nonsurgical treatment of deformational plagiocephaly: A systematic review. *Arch Pediatr Adolesc Med* 2008;**162**:719–27.	Initially included, but deemed not adequately relevant to orthodontics
39	Zhang X-G, Yang F, Wu T-X, Shi Z-D, Yi X-Z. Evidence of cochrane systematic reviews on the treatment of temporomandibular disorders. *Chin J Evid Based Med* 2008;**8**:1130–2.	Overview of existing SRs

selection procedures. A median of 9 primary studies and a median of 389 participants were included per SR. In few SRs (n = 18; 16.4%), only RCTs were sought, while in four SRs (3.6%), no eligible studies could be identified. Among SRs providing submission dates (n = 63), the median 'acceptance-to-publication time' was 385 days.

Out of the 110 SRs, 96 (87.3%) were cited at least once in one of the three databases searched. For 100 SRs (90.9%), the citations from Google Scholar were equal or higher to those from Scopus or Web of Science. Also, the three most extreme citation counts (over 100 citations) for a SR were identified via Google Scholar and Web of Science. The average citations per SR from the three databases had a median of four citations [95% CI: 6.5–11.3, interquartile range (IQR) = 10.3]. SRs received a median of 1.17 citations (95% CI: 1.2–1.9) per year. Chronologically, the highest citation counts per SR were found for those published in 2003 (21.4 citations), followed by 2001 (18.7 citations) and 2002 (15 citations), respectively. SRs from Europe received more citations per SR than from other continents (10.8 citations), while SRs from the Netherlands received more citations per SR globally (17.1 citations). At journal level, the highest citation count per SR belonged to the European Journal of Orthodontics (13.3 citations), followed by the Journal of Orthodontics (11.0 citations) and the Angle Orthodontist (10.7 citations). SRs originating from a university department (based on the first author) received on average more citations than non-academic ones (9.6 vs. 3.4 citations, respectively). Through Web of Science, a total of 724 citations could be tracked for the 110 SRs. At country level, the USA contributed the greatest to the citing of orthodontic SRs (18.2%), followed by the UK (13.7%) and Canada (9.5%). At continent level, Europe contributed the greatest (45.2%), followed by North America (27.8%) and Asia (16.9%).

Methodological quality

Reporting quality varied among reviews ranging from 13.6 to 100.0%, with a mean of 51.7% and a SD of 20.1% (mean = 5.7 and SD = 2.2 AMSTAR points). Thirty SRs (27.2%) were of low quality (i.e., AMSTAR scores 0–4), 63 (57.3%) were of moderate quality (AMSTAR scores 4.5–8), and 17 (15.5%) were of high quality (AMSTAR scores 8.5–11). Table 1 provides in summary the evaluation of the 110 SRs according to the AMSTAR tool.

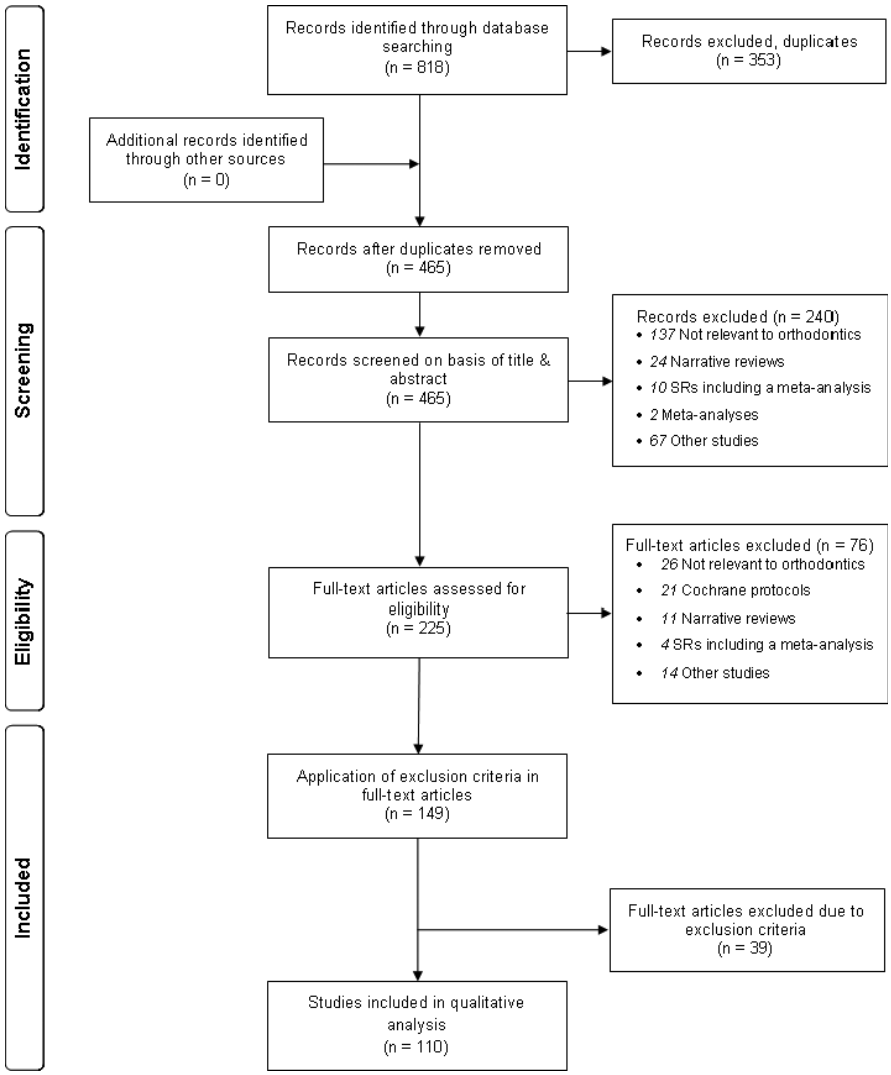

Fig. 1. Flow diagram of the included studies according to the PRISMA.

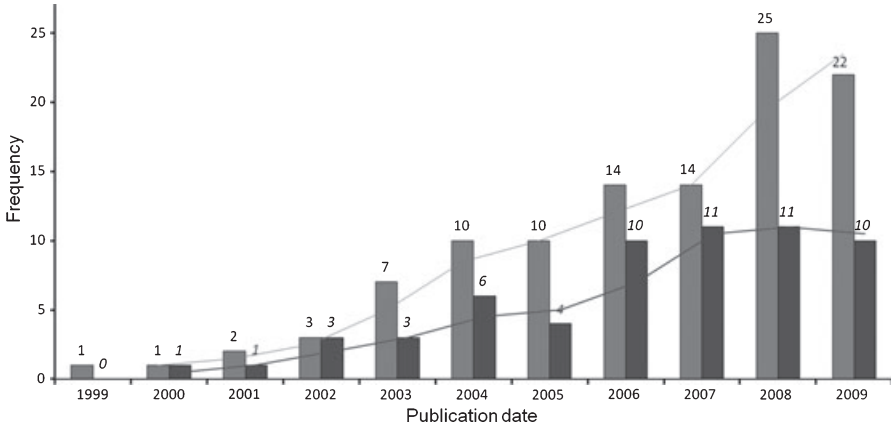

Fig. 2. Time trend of the number of systematic reviews overall (black) and of the systematic reviews of medium and high quality (white) published from 1999 to 2009.

Twenty-two reviews (20.0%) clearly reported only the review question or only the inclusion criteria. Thirty-nine reviews (35.5%) conducted in duplicate only study selection, but not data extraction. Gray literature was not scanned for relevant articles in 54 reviews (49.1%). Excluded studies were not provided in 72 reviews (65.5%), while 9 reviews (8.2%) did not provide included or excluded studies in a list or a table at all.

In addition to the general characteristics of the SRs, Table 5 provides also the modified AMSTAR score.

Table 4. **Subjects investigated by the orthodontic systematic reviews**

Thematic category	n	N
Treatment modalities		49
Temporomandibular joint Disorders (TMD)	10	
Treatment for transverse problems	10	
Functional appliances for Class II treatment	7	
Miniscrew implants and orthodontic anchorage	7	
Treatment for vertical problems	4	
Ankylosis/impaction/surgical exposure	3	
Orthognathic surgery	3	
Aligners	1	
Mandibular arch dimensions	1	
Maxillary distalization for Class II treatment	1	
Maxillary protraction for Class III treatment	1	
Self-ligation	1	
Diagnosis and treatment planning		14
Clinical entities		13
Cleft Lip and Palate (CLP): Etiology, management and impact	5	
Obstructive Sleep Apnea	4	
Amelogenesis Imperfecta	1	
Cleidocranial Dysplasia	1	
Premature birth	1	
Premature loss of teeth	1	
Stability/retention		6
Fluoridation and caries prevention		5
Periodontic considerations		5
Adhesives		4
Factors affecting duration and outcome		4
Tooth movement and biology		3
Clinical research		2
Iatrogenic effects and preventive measures		2
Multidisciplinary orthodontics (prosthodontic/endodontic)		2
Orthodontics and quality of life		1

Reviews published in specialty journals had a lower mean AMSTAR score than those published in not specialized journals (45.7 vs. 58.6%). Also, SRs originating from a non-orthodontic academic department (based on the first author) had higher mean score compared to those from an orthodontic department (59.0 vs. 48.6%). Cochrane reviews had higher mean score than non-Cochrane (81.4 vs. 45.1%). Non-English reviews had lower mean score than English reviews (30.7 vs. 52.9%). Updated SRs were of higher score than primary ones (73.5 vs. 50.4%), as well as reviews not stating 'systematic review' in their title (62.2 vs. 46.1%). Usage of protocol improved the mean AMSTAR score (69.6 vs. 42.2%), as well as the involvement of a statistician or epidemiologist and author involvement in multiple SRs (73.0 vs. 47.2% and 54.7 vs. 42.3%, respectively).

Factors associated with reporting quality

Table 6 provides the results from univariate and multivariate regression analysis used to explore reviews' characteristics possibly related to the modified AMSTAR score. Comparisons were made between baseline (reference category) and each of the remaining groups per characteristic.

Univariate analysis showed that SRs published in not specialized journals or in the Cochrane Library had higher quality score. In addition, updating an existing SR, working from a protocol, providing a forest plot, including the participation of a statistician or epidemiologist, having published more than one SR, and not including 'systematic review' in title were associated with higher quality scores. Regarding the conduct of SRs, the numbers of affiliations, authors, included studies, and participants were also significant predictors of quality score. Academic department source, SR language, dates of search, and journal were significant predictors as well.

Adjusting for potential confounding factors through the multivariate analysis, several characteristics remained significantly associated with quality score (Table 6). Publication in the Cochrane Library was associated with a 17.7% (95% CI: 9.0–26.4%) increase in AMSTAR score. Usage of a forest plot was associated with increased quality score by 10.5% (95% CI: 2.6–18.5%). The involvement of statistician or epidemiologist, usually acknowledged for error-checking the statistical analyses, was associated with a net score increase of 8.6% (95% CI: 1.8–15.5%). Corresponding AMSTAR score seemed to increase by 2.5% (95% CI: 0.6–4.4%) for every additional author. On the contrary, corresponding score seemed to decrease by 0.07% (95% CI: 0.02–0.1%) for every additional primary study included in the SR.

Comparisons of methodological items during the years

With regard to the comparison in reporting of the methodological items of SRs between the years 1999

Table 5. **General characteristics of the included orthodontic SRs and the corresponding modified AMSTAR score**

General characteristics of the SRs	n (%)	Mean	SD	95% CI	*p*-value[$] Significance
Journal type (N[a] = 110)					
General dentistry	59 (53.6)	58.6	24.6	51.6 to 65.5	**0.001*** **
Specialty (orthodontics)	51 (46.4)	45.7	12.5	42.4 to 48.9	
Published in the Cochrane Library (N[a] = 110)					
Yes	20 (18.2)	81.4	10.7	76.3 to 86.4	**0.000*** **
No	90 (81.8)	45.1	15.0	41.9 to 48.2	
Journal (N[a] = 110)					
AO	28 (25.5)	46.9	10.6	42.8 to 51.0	0.053
AJODO	14 (12.7)	42.9	14.0	34.8 to 50.9	
JO	6 (5.5)	61.4	7.5	53.5 to 69.2	
EJO	5 (4.5)	42.7	10.5	29.7 to 55.7	
Other	57 (51.8)	55.9	24.6	49.4 to 62.4	
Number of affiliations (N[a] = 110)					
One	56 (50.9)	44.4	15.0	40.4 to 48.4	**0.00009*** **
More than one	54 (49.1)	59.2	22.0	53.2 to 65.2	
Number of authors (N[a] = 110)					
1–2	26 (23.6)	41.3	17.7	34.1 to 48.4	**0.00007*** **
3–4	51 (46.4)	50.7	19.4	45.3 to 56.2	
>4	33 (30.0)	61.3	18.9	54.6 to 68.0	
Biostatistician/epidemiologist involved (N[a] = 110)					
Yes	19 (17.3)	73.0	15.4	65.6 to 80.4	**0.000*** **
No	91 (82.7)	47.2	18.0	43.5 to 51.0	
Authored multiple SRs (N[a] = 110)					
Yes	83 (75.5)	54.7	18.9	50.6 to 58.8	**0.005** **
No	27 (24.5)	42.3	20.9	34.0 to 50.5	
Academic source (N[a] = 110)					
Orthodontic department	66 (60.0)	48.6	18.2	44.1 to 53.0	**0.011***
Other department	34 (30.9)	59.0	21.5	51.5 to 65.5	
Non-academic	10 (9.1)	47.3	22.4	31.3 to 63.3	
Financial support (N[a] = 110)					
External	17 (15.5)	50.0	22.5	38.4 to 61.6	0.306
Internal	9 (8.2)	42.4	17.3	29.1 to 55.7	
None reported	84 (76.4)	53.0	19.8	48.7 to 57.3	
'Systematic review' stated in title (N[a] = 110)					
Yes	72 (65.5)	46.1	14.3	42.7 to 49.4	**0.00004*** **
No	38 (34.5)	62.2	24.9	54.0 to 70.4	
Language (N[a] = 110)					
English	104 (94.5)	52.9	19.9	49.0 to 56.8	**0.026***
English bilingual	2 (1.8)	29.5	3.2	0.7 to 58.4	
Other	4 (3.6)	30.7	6.8	19.8 to 41.5	
Update of review (N[a] = 110)					
Yes	6 (5.5)	73.5	16.6	56.0 to 90.9	**0.006** **
No	104 (94.5)	50.4	19.6	46.6 to 54.2	

Table 5. **Continued**

General characteristics of the SRs	n (%)	Mean	SD	95% CI	*p*-value[$] Significance
Protocol (N[a] = 110)					
Yes	38 (34.5)	69.6	17.7	63.8 to 75.4	**0.000*** **
No	72 (65.5)	42.2	13.8	38.9 to 45.4	
Dates of search (N[a] = 110)					
None	9 (8.2)	35.9	11.5	27.0 to 44.7	**0.016***
Starting date	1 (0.9)	18.2	–	–	
Ending date	11 (10.0)	47.9	18.6	35.5 to 60.4	
Complete dates	89 (80.9)	54.1	20.0	49.9 to 58.3	
Boolean strategy (N[a] = 110)					
Yes	60 (54.5)	52.1	18.6	47.3 to 56.9	0.790
No	50 (45.5)	51.1	21.9	44.9 to 57.3	
Number of databases (N[a] = 110)					
1–2	30 (27.3)	42.4	18.0	35.7 to 49.1	**0.011***
3–5	43 (39.1)	55.6	21.3	49.0 to 62.1	
>5	37 (33.6)	54.5	18.2	48.5 to 60.6	
Participant flow diagram (N[a] = 110)					
Yes	33 (30.0)	49.2	12.8	44.6 to 53.7	0.299
No	77 (70.0)	52.7	22.5	47.6 to 57.8	
Forest plot (N[a] = 110)					
Yes	15 (13.6)	80.9	17.1	71.4 to 90.4	**0.000*** **
No	95 (86.4)	47.0	16.3	43.7 to 50.4	
Eligible studies found (N[a] = 110)					
Yes	106 (96.4)	51.1	20.2	47.2 to 55.0	**0.0004*** **
No	4 (3.6)	67.0	4.4	60.1 to 74.0	
Included RCTs studies type (N[a] = 110)					
RCTs	18 (16.4)	50.0	21.8	39.1 to 60.9	0.910
RCTs and other	28 (25.5)	51.3	20.8	43.2 to 59.4	
RCTs and other	64 (58.2%)	52.3	19.6	47.4 to 57.2	
Number of included studies (N[a] = 106)					
0–10	59 (55.7)	56.0	20.6	50.4 to 61.5	**0.001*** **
11–50	45 (42.5)	48.6	17.4	43.3 to 53.8	
>50	6 (5.7)	25.0	13.7	10.6 to 39.4	
Number of participants (N[a] = 98)					
0–100	20 (20.4)	57.7	21.5	47.7 to 67.8	0.436
101–300	24 (24.5)	54.4	18.2	46.7 to 62.0	
301–1000	29 (30.0)	54.9	21.5	46.7 to 63.0	
>1000	25 (25.5)	48.5	16.0	42.0 to 55.2	
Participants per included study (N[a] = 98)					
0–30	26 (26.5)	49.1	16.6	42.4 to 55.8	0.233
30.1–60	35 (35.7)	57.7	23.4	49.6 to 65.7	
>60	37 (37.8)	53.2	16.6	47.7 to 58.7	

Table 5. **Continued**

General characteristics of the SRs	n (%)	Mean	SD	95% CI	*p*-value[$] Significance
Conclusions (N[a] = 110)					
Positive/significant	16 (14.5)	56.8	20.7	45.8 to 67.9	0.373
Negative/not significant	13 (11.8)	55.2	22.7	41.5 to 69.0	
Can't tell	81 (73.6)	50.1	19.5	45.7 to 54.4	
Country (N[a] = 110)					
Canada	25 (22.7)	47.8	9.1	44.1 to 51.6	**0.0002*** **
UK	24 (21.8)	68.2	18.0	60.6 to 75.8	
Brazil	9 (8.2)	57.1	25.5	37.5 to 76.7	
The Netherlands	9 (8.2)	50.0	16.7	37.2 to 62.8	
Sweden	8 (7.3)	46.6	21.3	28.8 to 64.6	
Italy	7 (6.4)	46.8	6.8	40.5 to 53.0	
Germany	6 (5.5)	40.9	22.1	17.7 to 64.1	
Switzerland	4 (3.6)	27.3	3.7	21.4 to 33.2	
USA	3 (2.7)	45.5	29.8	−28.6 to 119.5	
Belgium	2 (1.8)	20.5	3.2	−8.4 to 49.3	
China	2 (1.8)	72.7	38.6	−273.8 to 419.3	
Greece	2 (1.8)	47.7	22.5	−154.4 to 249.9	
Ireland	2 (1.8)	65.9	3.2	37.0 to 94.8	
Austria	1 (0.9)	27.3	–	–	
Bahrain	1 (0.9)	81.8	–	–	
Denmark	1 (0.9)	31.8	–	–	
Egypt	1 (0.9)	27.3	–	–	
Korea	1 (0.9)	50.0	–	–	
Peru	1 (0.9)	31.8	–	–	
Poland	1 (0.9)	31.8	–	–	
Continent (N[a] = 110)					
Europe	67 (60.9)	52.2	21.3	47.0 to 57.4	0.595
North America	28 (25.5)	47.6	11.8	43.0 to 52.2	
South America	10 (9.1)	54.5	25.4	36.4 to 72.7	
Asia	3 (2.7)	65.2	30.3	−10.0 to 140.3	
Africa	2 (1.8)	54.5	38.6	−292.0 to 401.1	
Mean citations (N[a] = 110)					
0–10	77 (70.0)	51.4	21.2	46.6 to 56.2	0.969
10.1–30	27 (24.5)	52.2	17.3	45.3 to 59.1	
>30	6 (5.5)	53.0	19.8	32.2 to 73.9	
Annual citation rate (N[a] = 110)					
0–1	52 (47.3)	49.0	20.9	43.1 to 54.8	0.218
1.1–3	41 (37.3)	56.0	19.4	49.9 to 62.1	
>3	17 (15.5)	49.5	18.2	40.1 to 58.8	
Journal's impact factor (IF) (N[a] = 68)					
0–1.166	38 (55.9)	45.0	11.7	41.1 to 48.8	0.331
1.167–1.442	22 (32.4)	41.3	15.5	34.5 to 48.2	
>1.442	8 (11.8)	49.4	17.4	34.9 to 64.0	

Table 5. **Continued**

General characteristics of the SRs	n (%)	Mean	SD	95% CI	*p*-value[$] Significance
Journal's Hirsch Index (h-index) (N[a] = 68)					
29–34	39 (57.4)	45.1	12.3	41.1 to 49.1	0.849
35–44	6 (8.8)	42.4	20.9	20.5 to 64.3	
> 44	23 (33.8)	43.4	14.9	36.8 to 50.0	
Acceptance-to-publication time (days) (N[a] = 63)					
1–250	9 (14.3)	39.9	17.1	26.7 to 53.1	0.253
251–450	40 (63.5)	48.1	11.5	44.4 to 51.7	
> 450	14 (22.2)	46.8	15.1	38.1 to 55.5	

SD, standard deviation; CI, confidence interval; AO, angle orthodontist; AJODO, American Journal of Orthodontics and Dentofacial Orthopedics; JO, Journal of Orthodontics; EJO, European Journal of Orthodontics; AMSTAR, Assessment of Multiple Systematic Reviews.
Levels of significance: ***, $p < 0.001$; **, $p < 0.01$, *, $p < 0.05$
[$]Based on *t*-test or one-way ANOVA.

and 2004, no definitive conclusions can be drawn. Only one SR was identified in 1999, possibly contributing to the non-significance level of the results and the wide 95% CI observed (Fig. 3).

With regard to the comparison between the years 2004 and 2009, no significant changes were observed. However, specific trends were identified, with overall improvement in four items and deterioration in three (Fig. 4). There was a decrease in 2009 in the number of authors who had authored more than one SR (RR = 0.85, 95% CI: 0.56–1.30%), while a lower rate of protocol usage was also found (RR = 0.57, 95% CI: 0.19–1.68%). Reporting of the literature search improved both in the provision of Boolean strategy (RR = 1.59, 95% CI: 0.70–3.62%) and complete dates of search (RR = 4.09, 95% CI: 0.60–28.07%). The reporting of results deteriorated, as fewer studies provided a flow diagram of included studies (RR = 4.55, 95% CI: 0.67–30.85%) or a forest plot (RR = 0.07, 95% CI: 0.00–1.21%). Lastly, there was an increased proportion of SRs including the participation of a statistician or epidemiologist (RR = 1.36, 95% CI: 0.16–11.55%).

Discussion

This study provides a comprehensive assessment of the design and reporting characteristics of a large cohort of orthodontic SRs published until the beginning of 2010. Results show that the number of these reviews has increased over time with variability in reporting quality. The SRs examined predominantly addressed questions about the effectiveness of therapeutic interventions and rare clinical entities (e.g., obstructive sleep apnea or amelogenesis imperfecta).

Although SRs have the potential to provide solid evidence for clinical practice, many of the identified SRs did not report methods and bias in sufficient detail. Certain characteristics of proper design or transparent methodology were not reported by a large number of reviews. In particular, they did not utilize a precise and comprehensive search of the literature, did not evaluate validity of selection/abstraction procedures, or did not assess quality of included studies, which are important for the replication and evaluation of the SR (25). Moreover, many of the reviews did not report potential conflicts of interest, despite the increasing concern that funding agencies influence the outcomes of biomedical research (26, 27). It should be noted however that articles disclosing sources of funding have been shown to be significantly more likely to be published than those without any disclosure (28).

About 46% (n = 51) of the 110 SRs were published in orthodontic journals. Although previous reporting verifies that North America is the most prolific continent regarding orthodontic literature (29), SRs in orthodontics were mainly produced in Europe (60.9%) with North America coming second (25.5%). At the journal level, the *American Journal of Orthodontics and Dentofacial Orthopedics* and the *Angle Orthodontist* received SRs from four continents and the *European Journal of Orthodontics* from two continents. The

Table 6. **Regression analyses for predictors of modified AMSTAR score among orthodontic SRs**

	Univariate			Multivariate		
General characteristics of the SRs	*β*	95% CI	*p*-value	*β*	95% CI	*p*-value
Journal type (N[a] = 110)						
General dentistry	Reference			Reference		
Specialty (orthodontics)	−12.9	−20.1 to −5.6	**0.001*** **	−4.2	−9.9 to 1.4	0.136
Published in the Cochrane Library (N[a] = 110)						
Yes	36.3	29.3 to 43.4	**0.000*** **	17.7	9.0 to 26.4	**0.0001*** **
No	Reference			Reference		
Journal (N[a] = 110)						
AO	Reference			Reference		
AJODO	−4.1	−16.8 to 8.6	0.528	−0.3	−8.3 to 7.7	0.933
JO	14.4	−3.0 to 31.9	0.104	8.5	−3.3 to 20.4	0.156
EJO	−4.2	−23.0 to 14.7	0.660	0.4	−11.7 to 12.5	0.953
Other	9.0	0.0 to 17.9	**0.049***	−1.7	−15.3 to 12.0	0.807
Number of affiliations (N[a] = 110)	6.7	4.0 to 9.4	**0.000006*** **	0.5	−1.9 to 2.9	0.682
Publication year (N[a] = 110)	−1.2	−2.8 to 0.4	0.132	NT		
Number of authors (N[a] = 110)	5.0	2.8 to 7.3	**0.0005*** **	2.5	0.6 to 4.4	**0.011***
Biostatistician/epidemiologist involved (N[a] = 110)						
Yes	25.8	17.0 to 34.6	**0.000*** **	8.6	1.8 to 15.5	**0.014***
No	Reference			Reference		
Authored multiple SRs (N[a] = 110)						
Yes	12.5	3.9 to 21.0	**0.005** **	4.2	−2.8 to 11.2	0.235
No	Reference			Reference		
Academic source (N[a] = 110)						
Orthodontic department	1.3	−11.9 to 14.5	0.848	NT		
Other department	11.7	−2.3 to 25.7	0.101			
Non-academic	Reference					
Financial support (N[a] = 110)						
External	−3.0	−13.5 to 7.6	0.578	NT		
Internal	−10.6	−24.5 to 3.4	0.136			
None reported	Reference					
'Systematic review' stated in title (N[a] = 110)						
Yes	−16.1	−23.5 to −8.7	**0.00004*** **	−0.6	−7.1 to 5.9	0.851
No	Reference			Reference		
Language (N[a] = 110)						
English	Reference			NT		
English bilingual	1.1	−32.5 to 34.8	0.947			
Other	23.3	−4.4 to 51.0	0.098			
Update of review (N[a] = 110)						
Yes	23.1	6.9 to 39.3	**0.006** **	−3.1	−13.8 to 7.6	0.562
No	Reference			Reference		
Protocol (N[a] = 110)						
Yes	27.4	21.4 to 33.5	**0.000*** **	5.8	−1.1 to 12.7	0.097
No	Reference			Reference		

Table 6. **Continued**

	Univariate			Multivariate		
General characteristics of the SRs	*β*	95% CI	*p*-value	*β*	95% CI	*p*-value
Dates of search (N[a] = 110)						
None	Reference			Reference		
Starting date	−17.7	−58.2 to 22.9	0.389	−17.7	−76.4 to 41.1	0.550
Ending date	12.1	−5.2 to 29.4	0.169	9.6	−1.5 to 20.6	0.090
Complete dates	18.2	4.8 to 31.7	**0.008****	4.5	−4.6 to 13.5	0.328
Boolean strategy (N[a] = 110)						
Yes	1.0	−6.6 to 8.7	0.790	NT		
No	Reference					
Number of databases (N[a] = 110)	0.7	−0.6 to 2.0	0.290	NT		
Participant flow diagram (N[a] = 110)						
Yes	−3.5	−11.8 to 4.7	0.399	NT		
No	Reference					
Forest plot (N[a] = 110)						
Yes	33.9	24.8 to 42.9	**0.000*****	10.5	2.6 to 18.5	**0.010****
No	Reference			Reference		
Eligible studies found (N[a] = 110)						
Yes	Reference			NT		
No	16	−4.2 to 36.1	0.119			
Included studies type (N[a] = 110)						
RCT	Reference			NT		
RCT and other	2.3	−8.4 to 13.0	0.675			
Other	1.3	−10.8 to 13.4	0.832			
Number of included studies (N[a] = 106)	−0.1	−0.2 to −0.04	**0.0002*****	−0.0007	−0.001 to −0.0002	**0.005****
Number of participants (N[a] = 98)	−0.001	−0.0002 to −0.0001	**0.025***	−0.000002	−0.00002 to −0.00001	0.802
Participants per included study (N[a] = 98)	−0.0002	−0.04 to 0.01	0.228	NT		
Conclusions (N[a] = 110)						
Positive/significant	6.8	−4.1 to 17.6	0.221	NT		
Negative/Not significant	5.2	−6.7 to 17.1	0.389			
Can't tell	Reference					
Country (N[a] = 110)						
Canada	Reference			Reference		
UK	20.4	10.6 to 30.1	**0.00008*****	−1.6	−11.3 to 8.1	0.746
Brazil	9.3	−4.0 to 22.5	0.170	−7.7	−17.8 to 2.3	0.130
The Netherlands	2.2	−11.1 to 15.5	0.745	−2.2	−10.8 to 6.3	0.604
Sweden	−1.2	−15.1 to 12.6	0.861	−2.4	−12.2 to 7.3	0.619
Italy	−1.1	−15.7 to 13.5	0.885	−5.1	−15.1 to 5.0	0.318
Germany	−6.9	−22.4 to 8.6	0.379	−3.9	−15.9 to 8.1	0.517
Switzerland	−20.5	−38.9 to −2.2	**0.029***	−15.7	−30.1 to −1.3	**0.033***
USA	−2.4	−23.2 to 18.5	0.822	6.5	−11.4 to 2.4	0.474
Belgium	−27.4	−52.5 to −2.3	**0.033***	−21.3	−38.7 to −3.9	**0.017***
China	24.9	−0.2 to 50.0	0.052	10.2	−8.2 to 28.5	0.274
Greece	0.0	−25.2 to 25.0	0.994	11.8	−6.1 to 29.8	0.193

Table 6. **Continued**

General characteristics of the SRs	Univariate			Multivariate		
	β	95% CI	*p*-value	*β*	95% CI	*p*-value
Ireland	18.1	−7.0 to 43.2	0.156	−10.8	−29.2 to 7.6	0.245
Austria	−20.5	−55.4 to 14.3	0.244	−23.6	−47.0 to 0.0	**0.049***
Bahrain	34.0	−0.8 to 68.8	0.056	−14.0	−37.2 to 9.2	0.234
Denmark	−16.0	−50.8 to 18.8	0.364	−27.9	−51.7 to −4.1	**0.022***
Egypt	−20.5	−55.4 to 14.3	0.244	−11.3	−33.7 to 11.0	0.316
Korea	2.2	−32.6 to 37.0	0.901	1.9	−21.9 to 25.7	0.877
Peru	−16.0	−50.8 to 18.8	0.364	−16.0	−37.1 to 5.0	0.133
Poland	−16.0	−50.8 to 18.8	0.364	−10.2	−32.5 to 12.1	0.366
Continent (N[a] = 110)						
Europe	Reference			NT		
North America	−4.7	−13.7 to 4.3	0.306			
South America	2.3	−11.3 to 15.9	0.737			
Asia	12.9	−10.7 to 36.5	0.281			
Africa	2.3	−26.4 to 31.0	0.874			
Mean citations (N[a] = 110)	0.0	−0.3 to 0.3	0.766	NT		
Annual citation rate (N[a] = 110)	0.7	−1.5 to 2.9	0.506	NT		
Journal's impact factor (IF) (N[a] = 68)	8.2	−5.1 to 21.5	0.221	NT		
Journal's Hirsch Index (h-index) (N[a] = 68)	−0.1	−0.6 to 0.4	0.668	NT		
Acceptance-to-publication time (days) (N[a] = 63)	0.01	−0.01 to 0.04	0.318	NT		

NT, not tested; CI, confidence interval; AO, Angle Orthodontist; AJODO, American Journal of Orthodontics and Dentofacial Orthopedics; JO, Journal of Orthodontics, EJO, European Journal of Orthodontics; AMSTAR, Assessment of Multiple Systematic Reviews.
Levels of significance: ***, $p < 0.001$; **, $p < 0.01$, *, $p < 0.05$

majority of SRs published by each of the three journals originated from Europe (57.1, 50.0 and 80.0%, respectively). This may be attributed to the direct application of evidence-based dentistry outcomes in justifying financing of orthodontic services by public sector in several European countries. Although the number of orthodontic journals has increased during the last years, the quality of the SRs, which they accepted for publication, was significantly lower than general biomedical journals ($p = 0.001$). The journal impact factor of orthodontic journals has been analyzed previously (30). In this study, scientific impact was measured both by the journal's IF and the h-index equivalent for journals (31). The latter has been shown to be quite robust (32). However, no association was found between AMSTAR score and either journal IF or h-index.

The impact of orthodontic SRs was also indirectly assessed with the average of the citation counts from three databases. Citation counts differed between Google Scholar, Web of Science, and Scopus. Diversity in citation counts could just reflect the quantitatively and qualitatively different coverage of each database (33) and the small overlap among them (34). No association was observed between AMSTAR score and average citations, or between individual citation counts of each database. Although no respective study was found in orthodontics, the same observation was made by a citation analysis of articles in psychiatry. In that study, only the publishing journals, without reporting on quality or appropriate statistical analysis, were associated with higher citation counts (35). In the present study, self-citations were not excluded. However, it is known that a citation does not guarantee the respect of the reference article, but only that it is active in the scientific debate.

In this study, the safety reporting of orthodontic SRs was assessed with the AMSTAR tool, which is the most recent evidence-based appraisal instrument that has been validated (14, 18, 19). The Canadian Agency for Drugs and Technologies in Health (CADTH) and the

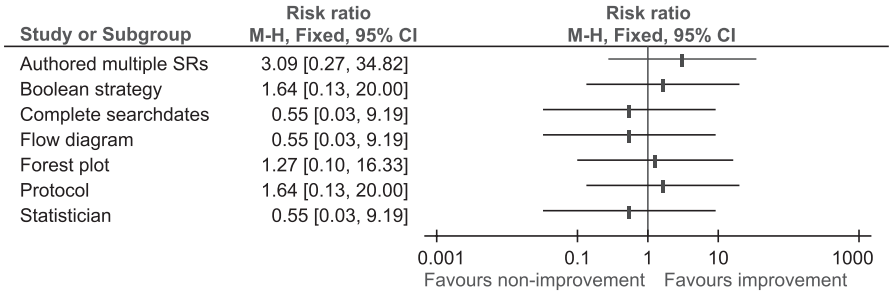

Fig. 3. Difference in reporting of methodological items between the years 1999 and 2004.

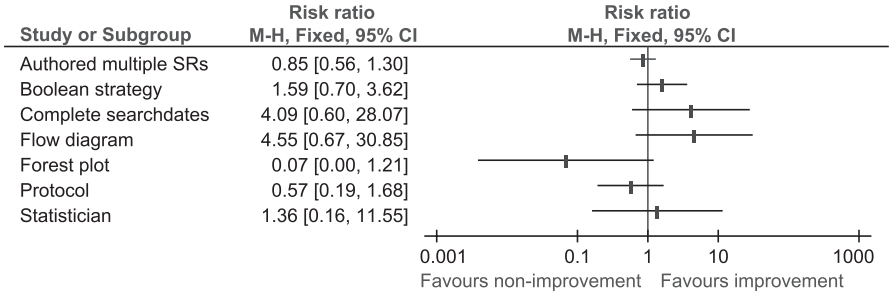

Fig. 4. Difference in reporting of methodological items between the years 2004 and 2009.

WHO Advisory Committee on Health Research (ACHR) have proposed AMSTAR as the best tool to critically appraise SRs (36, 37). Nevertheless, AMSTAR does present weaknesses. There is no recommendation on how the scientific quality of studies should be assessed. Moreover, the item concerning the presence of publication bias may not be entirely appropriate for the evaluation of non-meta-analytic SRs.

Improved quality was related to certain characteristics. The importance of the participation of statisticians or epidemiologists among authors to improve quality ($p = 0.014$), which was found in this study, has been previously recognized (38) and has been associated with higher publication acceptance rates (39). This could be attributed to the moderate statistical skills of clinical medical researchers (40) or orthodontic postgraduate students (41). It seems that quality increases as the number of included studies decreases ($p = 0.005$), which can be attributed to stricter inclusion criteria used or simply higher-quality primary studies. Multiple authors tended to produce SRs of higher reporting quality ($p = 0.011$), which can be expected, as the contribution of each to the review is stacked.

In some areas of methodological importance, reporting seems to have improved over time, but not significantly. Between the years 2004 and 2009, a modest trend for improvement was found regarding Boolean strategy reporting and participation of a statistician or epidemiologist, as well as a stronger trend for provision of complete search dates and flow diagrams of included studies. The greatly decreased usage of forest plots is of minor importance, as these are mainly used in meta-analysis. A smaller decrease was noted in the number of authors having multiple SRs and the number of SRs reporting working from a protocol.

The comparison of Cochrane vs. non-Cochrane SRs in orthodontics seems to be in concordance with general medicine trends, as the Cochrane reviews were the highest scoring SRs. The superior reporting of Cochrane SRs has been noted previously (42) and is aided by the strict set of rules and guidelines provided by the Cochrane Collaboration, as well as electronic publishing, because that allows authors to freely submit more complete details of study conduct. Published evidence indicates that Cochrane reviews update more often and provide more details concerning inclusion/exclusion criteria (43–45).

Evaluation of SRs in dentistry has yielded similar results. A survey of dental SRs' authors reported the lack of comprehensive literature searches (46), which can also be seen in this study. Indeed, only 29.1% (n = 32) of the SRs included in this investigation reported an extensive literature search undertaken according to the AMSTAR tool. A comprehensive assessment of the quality of SRs in dentistry (47) found that 8 out of 15 proposed key items were not assessed by the majority of the included reviews, with literature search having the most problems. In an earlier study, better search and selection methodologies were found for certain dental specialties compared to others,

although these specialties were also the most prolific ones in terms of publications (48). A number of articles investigate the quality of SRs in various specialties and areas. SRs concerning topical fluorides in dentistry were found to be below an acceptable level for reporting various key items (49). A recent evaluation of endodontic SRs with meta-analyses using AMSTAR found that the overall summary score was relatively high, with 13 out of 16 reviews scoring 8–11 (50). A recent evaluation of periodontic SRs and meta-analyses considering root coverage used AMSTAR and highlighted the need for improvement in key aspects, such as the identification/selection of primary studies and the assessment of publication bias (51).

In the field of orthodontics, Flores-Mir et al. (20) pointed out that the suboptimal reporting during search and the selection procedures needs improvement, while no trend for improvement was identified during 2000–2004. In this study, the AMSTAR score likewise showed no evidence of improvement from 1999, with a coefficient of −1.2%, albeit non-significant ($p = 0.132$). A study assessing meta-analyses in orthodontics reported their low reporting quality and the inclusion of few high-quality primary studies (52). In the area of temporomandibular joint disorders (TMD), a study that included reviews comparing surgical and non-surgical treatment found only one meta-analysis and one SR, the second being of low quality according to AMSTAR (53). A more recent appraisal covering all TMD treatment modalities reported the median AMSTAR score of the included studies to be 6, with considerable variation in methodology among them (54). A further study evaluating meta-analyses in endodontics found that they scored higher positive answers than the orthodontic SRs studied in every AMSTAR item (50). However, that could be due to the smaller sample size (only 16 meta-analyses found), improved sensitivity of the modified AMSTAR score used in this study, or variations in rating between author groups.

Some of the existing articles also evaluated the quality of RCTs with subjects related to orthodontic (55, 56). In these studies, it was found that the mean quality of orthodontic RCTs was low. Pandis et al. (56) found however a significant net increase in the quality for RCTs of all specialties, when a statistician or epidemiologist was involved.

Systematic reviews have to be up to date to provide valid summaries of existing knowledge. Very few of the SRs included in this report were updates of previous ones (n = 6), most of which originated from the Cochrane Database. The low update rate of non-Cochrane SRs, which account for the 80% of all SRs (42), may relate to the few methods or strategies currently exist for the actual updating of published SRs (57). The rapid dissemination of the informative value of an SR can deteriorate owing to publication lag, which may account for up to 20% of a meta-analysis' life span (58). Even worst, SRs without meta-analysis are usually given lower priority by editors.

This study relies only on published material. Therefore, it is possible that the included SRs were conducted more completely and transparently, but certain information was omitted by the authors or discarded during the peer-review process. As has been stated before, poor reporting does not necessarily mean poor methods, as protocol, study, and final article may differ substantially (24).

A narrow set of study designs and research methodologies was included in this report. This article's aim was to provide an overview of the reporting characteristics and trends of SRs in the field of orthodontics, focusing on methodological expertise. The use of this implicit definition of SR (1) was also used because meta-analytic articles require the assessment of the various methods used for data synthesis and their appropriateness. It may be possible that their traits differ from those of the included SRs. The phenomenon of avoiding meta-analysis in SRs has been documented in the medical literature and is possibly attributed to high heterogeneity among studies, limited data or simply 'data considered inappropriate' (8). Moreover, Cochrane Reviews used to include forest plots with one or even none studies until the 2008 version of the 'Cochrane Handbook for Systematic Reviews of Interventions' (1).

Systematic reviews are now produced with an increasing rate in the field of biomedical sciences. However, narrative reviews outgrow the increase in SRs and remain the most popular way of knowledge synthesis (59). Provision of reporting guidelines is a validated means of improving the quality of published material. The reporting quality of RCTs and meta-analyses has improved (60, 61) since the introduction of the Consolidated Standards of Reporting Trials (CONSORT) and QUOROM Statements (15, 62) and their subsequent endorsement by major journals.

Regarding the trends of increasing SR production and use, it should be emphasized that 'many reviews are systematic but some are more transparent and completely reported than others' (63).

Conclusions

This critical appraisal of SRs in the field of orthodontics suggests that the quality of SRs is moderate. No significant trend for quality improvement was observed during the last decade. Without complete and transparent reporting, it is difficult for readers to assess the validity of SRs or distinguish between reliable and possibly misleading conclusions. With the wide endorsement of PRISMA Statement (16), it is hoped that the conduct of SRs, and consequently their reporting, will be improved.

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