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## Methodological Quality Assessment of Meta-analyses in Endodontics

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## Abstract

**Introduction** The objectives of this review were to assess the methodological quality of published meta-analyses related to endodontics using the assessment of multiple systematic reviews (AMSTAR) tool and to provide a follow-up to previously published reviews. **Methods** Three electronic databases were searched for eligible studies according to the inclusion and exclusion criteria: Embase via Ovid, The Cochrane Library, and Scopus. The electronic search was amended by a hand search of 6 dental journals (International Endodontic Journal; Journal of Endodontics; Australian Endodontic Journal; Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology; Endodontics and Dental Traumatology; and Journal of Dental Research). The searches were conducted to include articles published after July 2009, and the deadline for inclusion of the meta-analyses was November 30, 2016. The AMSTAR assessment tool was used to evaluate the methodological quality of all included studies. **Results** A total of 36 reports of meta-analyses were included. The overall quality of the meta-analyses reports was found to be medium, with an estimated mean overall AMSTAR score of 7.25 (95% confidence interval, 6.59–7.90). The most poorly assessed areas were providing an a priori design, the assessment of the status of publication, and publication bias. **Conclusions** In recent publications in the field of endodontics, the overall quality of the reported meta-analyses is medium according to AMSTAR. © 2017 American Association of Endodontists

## Keywords

Assessment of multiple systematic reviews, endodontics, meta-analysis, methodologic quality, Data Accuracy, Endodontics, Humans, Meta-Analysis as Topic, Publishing, endodontics, human, measurement accuracy, meta analysis (topic), publishing, standards

## Disciplines

Dental Public Health and Education | Dentistry | Endodontics and Endodontology | Other Dentistry

# Methodological Quality Assessment of Meta-analyses in Endodontics



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## Abstract

**Introduction:** The objectives of this review were to assess the methodological quality of published meta-analyses related to endodontics using the assessment of multiple systematic reviews (AMSTAR) tool and to provide a follow-up to previously published reviews. **Methods:** Three electronic databases were searched for eligible studies according to the inclusion and exclusion criteria: Embase via Ovid, The Cochrane Library, and Scopus. The electronic search was amended by a hand search of 6 dental journals (*International Endodontic Journal*; *Journal of Endodontics*; *Australian Endodontic Journal*; *Oral Surgery*; *Oral Medicine*, *Oral Pathology*, *Oral Radiology*; *Endodontics and Dental Traumatology*; and *Journal of Dental Research*). The searches were conducted to include articles published after July 2009, and the deadline for inclusion of the meta-analyses was November 30, 2016. The AMSTAR assessment tool was used to evaluate the methodological quality of all included studies. **Results:** A total of 36 reports of meta-analyses were included. The overall quality of the meta-analyses reports was found to be medium, with an estimated mean overall AMSTAR score of 7.25 (95% confidence interval, 6.59–7.90). The most poorly assessed areas were providing an a priori design, the assessment of the status of publication, and publication bias. **Conclusions:** In recent publications in the field of endodontics, the overall quality of the reported meta-analyses is medium according to AMSTAR. (*J Endod* 2018;44:22–31)

## Key Words

Assessment of multiple systematic reviews, endodontics, meta-analysis, methodologic quality

Systematic reviews and meta-analyses (SRs/MAs) are on the highest level of the evidence hierarchy scale in medical science (1). SRs/MAs have become the benchmark for assessing and summarizing applied health research and are often used for decision making in health care (2). However, the quality of SRs/MAs has received relatively little attention. The quality of systematic reviews with major methodological flaws can lead to false conclusions about evidence, which might have a negative impact on decision-making processes.

Several tools have been developed to assess the methodological quality of SRs/MAs. One measurement tool for the assessment of multiple systematic reviews (AMSTAR) was created based on the most commonly used instruments in the literature (3). The AMSTAR tool assesses 11 relevant methodology domains directly related to the necessary steps to be taken when performing a systematic review. The authors of the AMSTAR checklist explicitly stated the rationale for the inclusion of each item with clear definitions and guidance on the use of the items to evaluate a systematic review. All definitions are listed in Table 1. AMSTAR checklist items are presented in the form of questions, with possible responses of yes (item/question fully addressed), no (item/question not addressed), cannot answer (not enough information to answer the question), and not applicable. As a result, the quality of the investigated methodology of an individual SR/MA gets a cumulative numeric value from 0 to 11. AMSTAR characterizes quality at 3 levels: high, medium, and low. It has been shown to have a good inter-rater agreement, test-retest reliability, construct validity, and feasibility to assess the quality of systematic reviews, performing equally or better than similar tools in these areas (4). Furthermore, AMSTAR has been endorsed as the best way to assess the methodological quality of SRs/MAs by the Canadian Agency for Drugs and Technologies in Health (5).

Various studies across the medical specialties have exposed weaknesses in the quality of SRs/MAs by applying this tool (6–9). In endodontics, the overall quality of reports of meta-analyses published between January 1, 2001, and July 31, 2009, was evaluated using AMSTAR (10). The results indicated that the overall quality of reports addressing topics related to endodontics is generally high with an AMSTAR score of 8.33 out of 11. It has been speculated that the high quality of reporting might be because of the strict implementation of well-accepted guidelines such as the Quality of Reporting of Meta-Analyses statement to improve the quality of reports (10).

The aims of this review were to assess the methodological quality of meta-analyses related to endodontics published between August 1, 2009, and November 30, 2016,

## Significance

The overall quality of the reported meta-analyses (from August 1, 2009–November 30, 2016) was found to be medium, with an AMSTAR score of 7.25 out of 11. There are clear needs for authors' self-evaluation and incorporation of the AMSTAR checklist for the review process before publication.

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**TABLE 1.** A Measurement Tool to Assess Systematic Reviews (AMSTAR) Score Results

AMSTAR question	Yes (item/question fully addressed) (%)	Cannot answer (not enough information to answer the question) (%)	No (item/question not addressed) (%)	Not applicable (%)
1. Was an "a priori" design provided? The research question and inclusion criteria should be established before the conduct of the review. <i>Note: need to refer to a protocol, ethics approval, or predetermined/a priori published research objectives to score a "yes."</i>	10/36 (27.8)	0/36 (0)	26/36 (72.2)	0/36 (0)
2. Was there duplicate study selection and data extraction? There should be at least 2 independent data extractors and a consensus procedure for disagreements should be in place. <i>Note: 2 people do study selection, 2 people do data extraction, consensus process or one person checks the other's work.</i>	36/36 (100)	0/36 (0)	0/36 (0)	0/36 (0)
3. Was a comprehensive literature search performed? At least 2 electronic sources should be searched. The report must include years and databases used (eg, Central, Embase, and MEDLINE). Key words and/or Medical Subject Headings 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. <i>Note: If at least 2 sources + 1 supplementary strategy used, select "yes" (Cochrane register/Central counts as 2 sources; a grey literature search counts as supplementary).</i>	33/36 (91.67)	0/36 (0)	3/36 (8.33)	0/36 (0)
4. Was the status of publication (ie, 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. <i>Note: If review indicates that there was a search for "gray literature" or "unpublished literature" indicate "yes." SINGLE database, dissertations, conference proceedings, and trial registries are all considered gray for this purpose. If searching a source that contains both gray and nongray, must specify that they were searching for gray/unpublished lit.</i>	13/36 (36.11)	0/36 (0)	23/36 (68.89)	0/36 (0)
5. Was a list of studies (included and excluded) provided? A list of included and excluded studies should be provided. <i>Note: acceptable if the excluded studies are referenced. If there is an electronic link to the list but the link is dead, select "no."</i>	19/36 (52.78)	0/36 (0)	17/36 (47.22)	0/36 (0)
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 (eg, age, race, sex, relevant socioeconomic data, disease status, duration, severity, or other diseases) should be reported. <i>Note: acceptable if not in table format as long as they are described as above.</i>	35/36 (97.22)	0/36 (0)	1/36 (2.78)	0/36 (0)
7. Was the scientific quality of the included studies assessed and documented? "A priori" methods of assessment should be provided (eg, 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. <i>Note: can include use of a quality scoring tool or checklist (eg, Jadad scale, risk of bias, sensitivity analysis, etc) or a description of quality items, with some kind of result for EACH study ("low" or "high" is fine, as long as it is clear which studies scored "low" and which scored "high"; a summary score/range for all studies is not acceptable).</i>	25/36 (69.44)	0/36 (0)	11/36 (30.56)	0/36 (0)

(continued)

TABLE 1. (continued)

AMSTAR question	Yes (item/question fully addressed) (%)	Cannot answer (not enough information to answer the question) (%)	No (item/question not addressed) (%)	Not applicable (%)
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. <i>Note: might say something such as "the results should be interpreted with caution due to poor quality of included studies" Cannot score "yes" for this question if scored "no" for question 7.</i>	19/36 (52.78)	0/36 (0)	17/36 (47.22)	0/36 (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 (ie, chi-square 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 (ie, is it sensible to combine?). <i>Note: indicate "yes" if they mention or describe heterogeneity (ie, if they explain that they cannot pool because of heterogeneity/variability between interventions).</i>	34/36 (94.44)	0/36 (0)	2/36 (5.56)	0/36 (0)
10. Was the likelihood of publication bias assessed? An assessment of publication bias should include a combination of graphic aids (eg, funnel plot and other available tests) and/or statistical tests (eg, Egger regression test and Hedges-Olken). <i>Note: if no test values or funnel plot included, score "no". Score "yes" if mentions that publication bias could not be assessed because there were fewer than 10 included studies.</i>	14/36 (38.89)	0/36 (0)	22/36 (61.11)	0/36 (0)
11. Was the conflict of interest included? Potential sources of support should be clearly acknowledged in both the systematic review and the included studies. <i>Note: to get a "yes," must indicate source of funding or support for the systematic review AND for each of the included studies.</i>	23/36 (63.89)	0/36 (0)	13/36 (36.11)	0/36 (0)

**TABLE 2.** Search Strategy to Identify Meta-analyses in Endodontics Using Embase Ovid MEDLINE

1	endodontics.mp. or exp Endodontics/	25506
2	Dental pulp.mp. or exp Dental Pulp/	24131
3	dental pulp cavity.mp. or exp Dental Pulp Cavity/	7500
4	dental pulp diseases.mp. or exp Dental Pulp Diseases/	9978
5	dental pulp test.mp. or exp Dental Pulp Test/	975
6	Periapical diseases.mp. or exp Periapical Diseases/	6725
7	"root canal filling materials".mp. or exp "Root Canal Filling Materials"/	6762
8	"root canal".mp.	23736
9	exp Pulpectomy/or exp "Pulp Capping and Pulpectomy Agents"/or pulpectomy.mp.	1382
10	exp "Root Canal Obturation"/or exp Retrograde Obturation/or obturation.mp.	5505
11	retrogradefilling.mp.	397
12	pulpotomy.mp. or exp Pulpotomy/	1450
13	gutta-percha.mp. or exp Gutta-Percha/	3070
14	thermofil.mp.	1
15	ultrafil.mp.	41
16	"root canal therapy".mp. or exp "Root Canal Therapy"/	18845
17	toothapex.mp. or exp Tooth Apex/	2442
18	toothroot.mp. or exp "Tooth Root"/	14301
19	exp Tooth Replantation/or "root replantation".mp.	1882
20	apicoectomy.mp. or exp Apicoectomy/	1551
21	"root end surgery".mp.	18
22	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21	57111
23	limit 22 to (English language and humans and yr = "2009 -Current")	9908
24	limit 23 to meta-analysis	57
25	limit 23 to systematic reviews	249
26	25 not 24	192

#	Search statement	Results
Cochrane Library		
1	Endodontic	2079
2	Dental pulp	1450
3	Pulpectomy	137
4	Pulpotomy	185
5	Apicoectomy	104
6	Tooth replantation	25
7	Root end surgery	374
8	Retrograde obturation	94
9	#1 or#2 or#3 or#4 or#5 or#6 or#7 or#8 Publication Year from 2009 to 2016	331

#	Search statement	Results
Scopus		
1	TITLE-ABS-KEY (endodontics)	29,522
2	TITLE-ABS-KEY ("root canal therapy")	12,423
3	TITLE-ABS-KEY ("pulp pulp")	109
4	TITLE-ABS-KEY ("periapical disease")	5,704
5	TITLE-ABS-KEY ("root canal filling materials")	5,954
6	TITLE-ABS-KEY ("root canal")	28,405
7	TITLE-ABS-KEY ("obturation")	6,234
8	TITLE-ABS-KEY ("gutta percha")	3,928
9	TITLE-ABS-KEY ("retrograde filling")	543
10	TITLE-ABS-KEY (pulpectomy)	1,467
11	TITLE-ABS-KEY (pulpotomy)	1,610
12	TITLE-ABS-KEY ("root end surgery")	38
13	TITLE-ABS-KEY ("tooth replantation")	1,914
14	TITLE-ABS-KEY (apicoectomy)	1,616
15	TITLE-ABS-KEY (root replantation)	1,332
16	TITLE-ABS-KEY (#1 AND#2 AND#3 AND#4 AND#5 AND#6 AND#7 AND#8 AND#9 AND#10 AND#11 AND#12 AND#13 AND#14 AND#15)	6,043
17	TITLE-ABS-KEY (#1 AND#2 AND#3 AND#4 AND#5 AND#6 AND#7 AND#8 AND#9 AND#10 AND#11 AND#12 AND#13 AND#14 AND#15) AND (LIMIT-TO ( PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2012) OR LIMIT-TO (PUBYEAR, 2011) OR LIMIT-TO (PUBYEAR, 2010) OR LIMIT-TO (PUBYEAR, 2009) )	2,326
18	TITLE-ABS-KEY (#1 AND#2 AND#3 AND#4 AND#5 AND#6 AND#7 AND#8 AND#9 AND#10 AND#11 AND#12 AND#13 AND#14 AND#15) AND (LIMIT-TO ( PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2012) OR LIMIT-TO (PUBYEAR, 2011) OR LIMIT-TO (PUBYEAR, 2010) OR LIMIT-TO (PUBYEAR, 2009) ) AND (LIMIT-TO ( LANGUAGE, "English" )	1,749
19	TITLE-ABS-KEY (#1 AND#2 AND#3 AND#4 AND#5 AND#6 AND#7 AND#8 AND#9 AND#10 AND#11 AND#12 AND#13 AND#14 AND#15) AND (LIMIT-TO ( PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2012) OR LIMIT-TO (PUBYEAR, 2011) OR LIMIT-TO (PUBYEAR, 2010) OR LIMIT-TO (PUBYEAR, 2009) ) AND (LIMIT-TO ( LANGUAGE, "English" )	1,540

(continued)

**TABLE 2.** (continued)

#	Search statement	Results
20	TITLE-ABS-KEY (#1 AND#2 AND#3 AND#4 AND#5 AND#6 AND#7 AND#8 AND#9 AND#10 AND#11 AND#12 AND#13 AND#14 AND#15) AND (LIMIT-TO ( PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2012) OR LIMIT-TO (PUBYEAR, 2011) OR LIMIT-TO (PUBYEAR, 2010) OR LIMIT-TO (PUBYEAR, 2009) ) AND (LIMIT-TO ( LANGUAGE, "English" ) ) AND (LIMIT-TO ( DOCTYPE, "ar" ) OR LIMIT-TO (DOCTYPE, "re" ) ) AND (LIMIT-TO ( SUBJAREA, "MEDI" ) OR LIMIT-TO (SUBJAREA, "HEAL" ) OR LIMIT-TO (SUBJAREA, "DENT" ) )	821

using the AMSTAR tool and to provide a follow-up to the previously published review by Suebnukarn et al (10).

## Materials and Methods

### Literature Search

Three electronic databases were searched for meta-analyses related to endodontics (Embase via Ovid, The Cochrane Library, and Scopus). A specific strategy for each database was developed with the help of an experienced librarian. Table 2 details the search strategy for Embase. Hand searches involved reviewing the table of contents for every issue of 6 journals (*International Endodontic Journal*; *Journal of Endodontics*; *Australian Endodontic Journal*; *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology; Endodontics and Dental Traumatology*; and *Journal of Dental Research*) within the same time period.

### Literature Screening and Study Selection

After a review of the initial search results, a number of articles were collected and further selected based on the following inclusion and exclusion criteria:

1. The study addressed an issue related to endodontics.
2. The study was limited to human subjects.
3. The meta-analyses used statistical methods to produce a summary result.
4. The report was published in English.
5. The report of the study was first published on August 1, 2009, and November 30, 2016.

The exclusion criteria included the following:

1. Studies that failed to meet these inclusion criteria.
2. Studies for which full text was not available.
3. Studies that reported duplicate data.

According to the predetermined inclusion criteria, 2 reviewers (S.K. and S.L.) independently screened all search results by title and abstract. Subsequently, if at least 1 of the 2 reviewers deemed an article potentially relevant, the full-text version was obtained. Final inclusion for AMSTAR assessment after full-text review was resolved by discussion and consulting with a third reviewer (B.K.) if an initial agreement had not been reached. Finally, all included studies underwent data extraction and quality assessment.

### Data Extraction and Quality Assessment

Data were extracted from each included study (such as the name of the author, year of publication, journal, and number of studies included in the meta-analysis) to create a table of evidence. The quality of the included studies was assessed independently by 2 reviewers (S.K. and S.L.) using the AMSTAR tool; any disagreements were resolved by discussion and consulting with a third reviewer (B.K.). Reviewers scored the compliance of each report with all 11 AMSTAR criteria including the provision of an a priori design, duplicate study selection

and data extraction, comprehensive literature search, publication status used as an inclusion criterion, listing of included and excluded studies, provision of characteristics of included studies, assessment and documentation of scientific quality of included studies, appropriate use of scientific quality of included studies to formulate conclusions, appropriate methods used to combine findings, assessment of publication bias, and stated conflict of interest. According to these criteria, a score of 0 or 1 was given for each criterion, with equal weighting given to each domain. A cumulative grade was given for the article overall after conversion to a percentage scale based on the fulfillment of these 11 criteria. Final grading of the methodological quality of each study was based on the overall score and reported as either "high," "medium," or "low" in concordance with the rating system used by the Canadian Agency for Drugs and Technologies in Health (5) as follows: high quality, scores 8–11; medium quality, scores 4–7; and low quality, scores 0–3.

### Data Analysis

The proportion of studies that met each of the criteria was determined and tabulated. The overall quality summary score was calculated and found to be medium. Agreement on the inclusion of studies and evaluating each study was assessed using the kappa statistic (95% confidence interval [CI]). Statistical calculations were performed using Excel 15.33 (Microsoft, Redmond, WA).

## Results

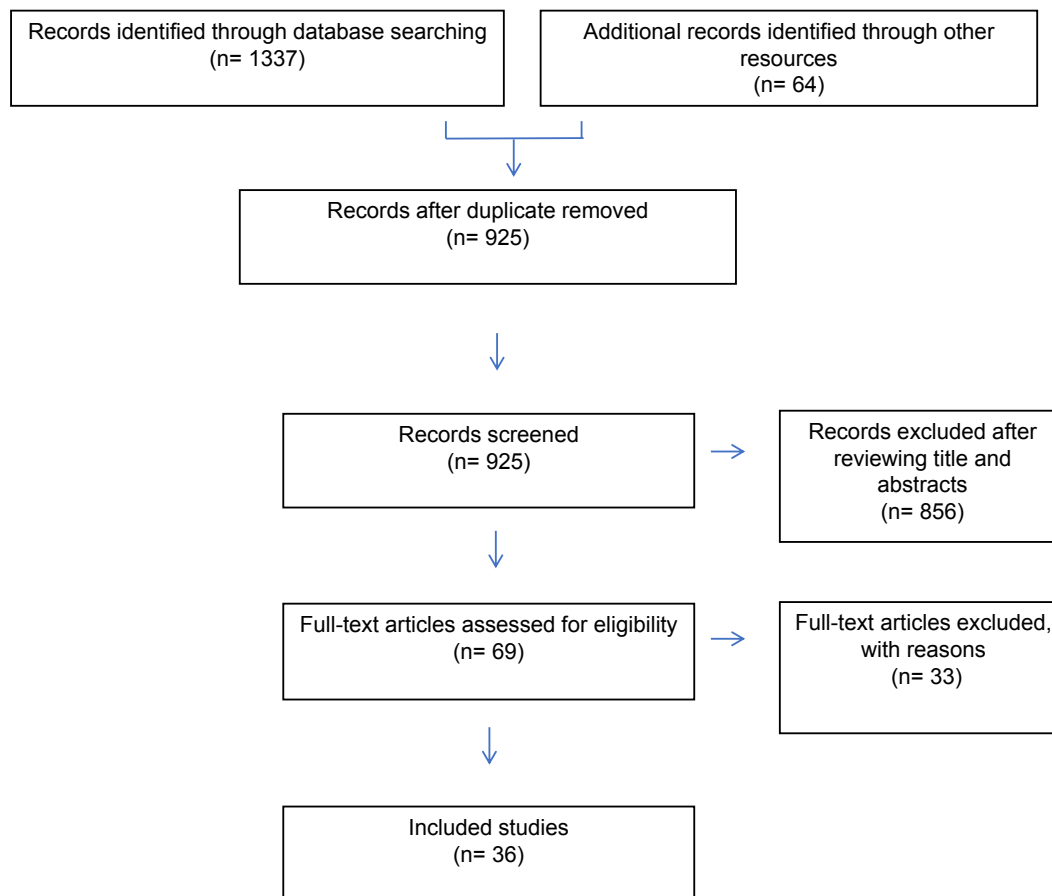
A total of 1401 articles were identified by the initial electronic and hand search. After title and abstract screening, 69 full-text articles were reviewed; 36 were included and analyzed as shown in Figure 1. Agreement among the reviewers on the inclusion of articles was high (Cohen kappa = 0.97; 95% CI, 0.92–1.02).

### Characteristics of the Included Articles

All 36 articles included were published in English (100%). Two studies were Cochrane reviews (5.56%). The publication years ranged from 2009 to 2016. The countries of publication included China (12/36, 33.33%), the United States (9/36, 25%), Spain (2/36, 5.56%), the United Kingdom (2/36, 5.56%), Brazil (2/36, 5.56%), Israel (2/36, 5.56%), Bahrain (1/36, 2.78%), Morocco (1/36, 2.78%), Italy (1/36, 2.78%), Taiwan (1/36, 2.78%), Canada (1/36, 2.78%), Thailand (1/36, 2.78%), and Serbia (1/36, 2.78%). The number of authors for the included articles ranged from 2 to 8, and the average number of authors was 5.19. Overall, 1 to 13 databases had been searched per article, with a mean of 5.75 databases.

### Methodological Quality

Agreement was reached on the scoring of all component scores and the overall quality scores (mean weighted kappa at 0.92; 95% CI, 0.83–1.00). Table 2 presents the compliance rate with each AMSTAR item. Eight items obtained a compliance rate above 50%. The item with the best compliance rate was duplicate study selection and



**Figure 1.** A flowchart of the review search and identification.

data extraction ( $n = 36$ , 100%), whereas the item with the worst compliance rate was whether a priori design was provided ( $n = 10$ , 27.8%).

Table 2 also shows that less than half of the reports failed to provide an a priori design, report the publication status as inclusion criteria, or assess the publication of bias of the included studies. The overall quality of reports of meta-analyses published in the endodontic literature from 2009 to 2016 was found to be medium, with an estimated mean overall AMSTAR score of 7.25 (95% CI, 6.59–7.90). A total of 20 studies (55.56%) had medium quality shown by an overall score of 4 to 7, 16 studies (44.44%) had a high-quality score of 8 to 11 on the overall quality summary score, and none of the studies were identified as having a low-quality score of 0 to 3. Table 3 shows the AMSTAR scores of each included study; the weakest areas of the included meta-analyses were the provision of an a priori design, the status of publication (ie, gray literature) used as an insertion measure, and whether the probability of publication bias was assessed.

## Discussion

Evaluating the methodological quality of SRs/MAs is a mean to evaluate how well the design and procedure of the research controlled bias. The AMSTAR scale has been widely used since it was published in 2007, and this scale has become a recommended tool to evaluate the methodological quality of SRs/MAs. The aims of this review were primarily to assess the methodological quality of published meta-analyses related to endodontics using the AMSTAR tool and to provide a follow-up to

the previously published review by Suebnukarn et al (10). The previous review by Suebnukarn et al concluded that the overall reported quality of SRs/MAs between January 1, 2001, and July 31, 2009 was high, with an estimated mean overall AMSTAR score of 8.33 out of 11. For studies evaluated in this review, covering the time period of August 1, 2009, to November 30, 2016, the results show a medium overall quality of the reported meta-analyses that addressed the topics in endodontics with an estimated mean of an overall AMSTAR score of 7.25 out of 11, showing a statistically significant difference between the current review and the previous one ( $P < .05$ ). This leads to the conclusion that the number of published SRs/MAs in the field of endodontics has increased in recent years, but the reporting and the methodological quality were not proven to be optimal.

Suebnukarn et al (10) included a total of 16 studies in the final analysis. Contrary to our findings, they noted that the majority of studies provided an a priori design and an assessment of the status of publication. In the present review, 36 studies published between August 2009 and November 2016 were identified and included in the final analysis. Our results showed the quality of reporting to be moderate, with only 3 studies achieving perfect scores with regard to the AMSTAR criteria (16, 19, 23). The expertise of the primary authors in the reviewed subjects had no effect on the quality of SRs/MAs. We also found that the quality of Cochrane systematic reviews was better than that of non-Cochrane reviews selected in this study, which is consistent with the findings of the previous studies (47, 48). This finding indicates that strict training of the methodologies and collaborative guidance among experts are beneficial for producing high-quality SRs/MAs



**TABLE 3.** Evidence Table and the Assessment of Multiple Systematic Reviews (AMSTAR) Score for Included Studies

Authors	Year	Title	Journal	Number of included studies	AMSTAR score (maximum score = 11)
Arx et al (11)	2010	Prognostic Factors in Apical Surgery with Root-end Filling: A Meta-analysis	<i>Journal of Endodontics</i>	38	4
Brandt et al (12)	2011	The Pulpal Anesthetic Efficacy of Articaine Versus Lidocaine in Dentistry	<i>Journal of the American Dental Association</i>	13	8
Chala et al (13)	2011	Apexification of Immature Teeth with Calcium Hydroxide or Mineral Trioxide Aggregate: Systematic Review and Meta-analysis	<i>Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology</i>	2	5
Chang et al (14)	2016	Cone-beam Computed Tomography for Detecting Vertical Root Fractures in Endodontically Treated Teeth: A Systematic Review	<i>Journal of Endodontics</i>	4	9
Chung et al (15)	2014	Outcomes of Autotransplanted Teeth with Complete Root Formation: A Systematic Review and Meta-analysis	<i>Journal of Clinical Periodontology</i>	26	10
Cope et al (16)	2014	Systemic Antibiotics for Symptomatic Apical Periodontitis and Acute Apical Abscess in Adults	<i>Cochrane Database of Systematic Reviews</i>	2	11
Deng et al (17)	2016	The Effect of Regeneration Techniques on Periapical Surgery with Different Protocols for Different Lesion Types: A Meta-Analysis	<i>Journal of Oral and Maxillofacial Surgery</i>	8	8
Duo et al (18)	2013	The Effectiveness of an Additional Lingual Infiltration in the Pulpal Anesthesia of Mandibular Teeth: A Systematic Review	<i>Quintessence International</i>	7	6
Fedorowicz et al (19)	2012	Irrigants for Non-surgical Root Canal Treatment in Mature Permanent Teeth	<i>Cochrane Database of Systematic Reviews</i>	11	11
Figueiredo et al (20)	2015	Do Metal Post-retained Restorations Result in More Root Fractures than Fiber Post-retained Restorations? A Systematic Review and Meta-analysis	<i>Journal of Endodontics</i>	14	9
Gillen et al (21)	2011	Impact of the Quality of Coronal Restoration versus the Quality of Root Canal Fillings on Success of Root Canal Treatment: A Systematic Review and Meta-analysis	<i>Journal of Endodontics</i>	9	5
Jakovljevic & Andric (22)	2014	Human Cytomegalovirus and Epstein-Barr Virus in Etiopathogenesis of Apical Periodontitis: A Systematic Review	<i>Journal of Endodontics</i>	7	6
Kung et al (23)	2015	Does Articaine Provide an Advantage over Lidocaine in Patients with Symptomatic Irreversible Pulpitis? A Systematic Review and Meta-analysis	<i>Journal of Endodontics</i>	10	11
Leite et al (24)	2015	Prevalence of Treponema Species Detected in Endodontic Infections: Systematic Review and Meta-Regression Analysis	<i>Journal of Endodontics</i>	51	6
Li et al (25)	2012	Preoperative Oral Nonsteroidal Anti-inflammatory Drugs for the Success of the Inferior Alveolar Nerve Block in Irreversible Pulpitis Treatment: A Systematic Review and Meta-analysis Based on Randomized Controlled Trials	<i>Quintessence International</i>	7	8
Li et al (26)	2015	Direct Pulp Capping with Calcium Hydroxide or Mineral Trioxide Aggregate: A Meta-analysis	<i>Journal of Endodontics</i>	13	8
Long et al (27)	2014	Diagnostic Accuracy of CBCT for Tooth Fractures: A Meta-analysis	<i>Journal of Dentistry</i>	12	9

Ng et al (28)	2010	Tooth Survival Following Non-surgical Root Canal Treatment: A Systematic Review of the Literature	<i>International Endodontic Journal</i>	14	5
Nixdorf et al (29)	2010	Frequency of Persistent Tooth Pain after Root Canal Therapy: A Systematic Review and Meta-Analysis	<i>Journal of Endodontics</i>	26	8
Nixdorf et al (30)	2010	Frequency of Nonodontogenic Pain after Endodontic Therapy: A Systematic Review and Meta-Analysis	<i>Journal of Endodontics</i>	10	6
Pak et al (31)	2011	Pain Prevalence and Severity before, during, and after Root Canal Treatment: A Systematic Review	<i>Journal of Endodontics</i>	72	7
Panitvisai et al (32)	2010	Impact of a Retained Instrument on Treatment Outcome: A Systematic Review and Meta-analysis	<i>Journal of Endodontics</i>	2	8
Segura-Egea et al (33)	2016	Association Between Diabetes and the Prevalence of Radiolucent Periapical Lesions in Root-filled Teeth: Systematic Review and Meta-analysis	<i>Clinical Oral Investigations</i>	7	8
Setzer et al (34)	2010	Outcome of Endodontic Surgery: A Meta-analysis of the Literature—Part 1: Comparison of Traditional Root-end Surgery and Endodontic Microsurgery	<i>Journal of Endodontics</i>	21	6
Setzer et al (35)	2012	Outcome of Endodontic Surgery: A Meta-analysis of the Literature—Part 2: Comparison of Endodontic Microsurgical Techniques with and without the Use of Higher Magnification	<i>Journal of Endodontics</i>	16	5
Siew et al (36)	2015	Treatment Outcome of Repaired Root Perforation: A Systematic Review and Meta-analysis	<i>Journal of Endodontics</i>	12	5
Su et al (37)	2013	Efficacy and Safety of Bupivacaine Versus Lidocaine in Dental Treatments: A Meta-analysis of Randomized Controlled Trials	<i>International Dental Journal</i>	15	10
Su et al (38)	2016	Efficacy and Safety of Articaine Versus Lidocaine for Irreversible Pulpitis Treatment: A Systematic Review and Meta-analysis of Randomized Controlled Trials	<i>Australian Endodontic Journal</i>	18	10
Su et al (39)	2011	Healing Rate and Post-obturation Pain of Single- Versus Multiple-visit Endodontic Treatment for Infected Root Canals: A Systematic Review	<i>Journal of Endodontics</i>	11	7
Tang et al (40)	2010	Outcomes of MTA as Root-end Filling in Endodontic Surgery: A Systematic Review	<i>Quintessence International</i>	5	5
Torabinejad et al (41)	2015	Survival of Intentionally Replanted Teeth and Implant-supported Single Crowns: A Systematic Review	<i>Journal of Endodontics</i>	8	6
Torabinejad et al (42)	2015	Tooth Retention through Endodontic Microsurgery or Tooth Replacement Using Single Implants: A Systematic Review of Treatment Outcomes	<i>Journal of Endodontics</i>	50	6
Tsisis et al (43)	2009	Outcome of Surgical Endodontic Treatment Performed by a Modern Technique: A Meta-analysis of Literature	<i>Journal of Endodontics</i>	11	4
Tsisis et al (44)	2011	Effect of Guided Tissue Regeneration on the Outcome of Surgical Endodontic Treatment: A Systematic Review and Meta-analysis	<i>Journal of Endodontics</i>	5	7
Tsisis et al (45)	2013	Outcomes of Surgical Endodontic Treatment Performed by a Modern Technique: An Updated Meta-analysis of the Literature	<i>Journal of Endodontics</i>	18	7
Zhang et al (46)	2015	Correlation between Enterococcus faecalis and Persistent Intraradicular Infection Compared with Primary Intraradicular Infection: A Systematic Review	<i>Journal of Endodontics</i>	10	7

(49). Furthermore, the Cochrane group requires specific training with rigorous standards for methodology, which is more likely to attribute higher scoring of SRs/MAs.

After assessing the results as indicated in the tables (Tables 1 and 3), it is evident that some areas were more poorly addressed than others. The most poorly assessed area was “the provision of an a priori design.” This item in the AMSTAR tool requires SRs/MAs to have a protocol addressing specific questions (eg, trial inclusion and exclusion criteria, the methodological approach to be taken, and analyses that are planned). To add scientific credibility and to improve research standards, the protocol should be formulated before the SRs/MAs. A predetermined protocol is believed to reduce the possibility of publication bias and contribute to making the research process prospective, strict, and transparent. In this review, only 10 of 36 (27.8%) of the reports had a published protocol, indicating that authors should pay more attention to this area for future studies. Furthermore, registration on open-access platforms (eg, PROSPERO) is a practical way to assist researchers in complying with reporting preferred items for SRs/MAs. Open access to registered research can allow researchers to review protocols, which is helpful to prevent duplications and selective outcome reporting biases (50). Therefore, preregistration on an open platform with a prospective protocol should be considered for future authors before conducting SRs/MAs.

Another area that has been poorly addressed was “the status of the publication” as an inclusion criterion. This item is mainly used to evaluate the selection bias. Authors and journals are inclined toward publishing articles with positive outcomes while discarding those with negative outcomes that have been published mostly in informal journals. Therefore, the item tested the bias as a result of the authors’ intentional or nonintentional neglect of gray literature; 36.11% (13/36) of the researchers of the reviewed articles in this study checked on the status of publication, whereas the rest of them (68.89%, 23/36) were not checked.

The assessment of publication bias is of a great importance, and the lack of proper evaluation is alarming because this is a vital element in the performance of a meta-analysis. The review herein found that the publication bias was assessed in 14 of 36 (38.89%) of the articles only. The AMSTAR checklist provides that the assessment of bias should consider the use of statistical tests such as the Egger regression test (51) and graphical tests. The simplest graphical test for publication bias is the funnel plots that provide for plotting the individual trial effect estimates against sample size (52, 53). A symmetrically distributed plot of a large number of trials in an inverted funnel shape around an arbitrary reference point suggests an absence of publication bias. However, if publication bias is present, the plot will be asymmetrical, and it is likely to exist if the type of samples included in the studies is not representative of the population. This can be caused by language bias, availability bias, cost bias, familiarity bias, and outcome bias (54). Publication bias may negatively affect the validity of the results under investigation (55). Thus, the authors of SRs/MAs should take the methods to prevent publication bias seriously. Publication bias may be reduced by journals that publish high-quality studies regardless of novelty or unexciting results, protocols, or full-study data sets. No single step can be relied on to fully overcome the complex actions involved in publication bias, and a multipronged approach is required by researchers, patients, journal editors, peer reviewers, research sponsors, and research ethics committees.

There were some limitations in reporting the quality of SRs/MAs in this study. SRs/MAs written in English were only included. This language restriction may subject the study to potential publication bias. Furthermore, SRs/MAs published since August 2009 were only screened and selected as the follow-up of Suebnukarn et al (10). Despite the best ef-

forts of authors in this review, some articles may be missing either through the initial search or human error during the screening process. To minimize these limitations and risks in this study, 2 authors performed screening, selection, and extraction independently. In addition, high interobserver reliability was achieved by their in-depth knowledge of inclusion and exclusion criteria and prior thorough calibration. However, notwithstanding these limitations, this review evaluated the need to improve the quality of SRs/MAs in the field of endodontics.

### Implications for Further Research

In recent years, the number of published SRs/MAs in the field of endodontics has increased, but the reporting and methodological quality was not proven optimal and has decreased. More effort should be expended on the assessment of the status of publication, publication bias, the provision of detailed information about the protocol and the registration process, and the implementation of additional analyses to improve the validity of the SRs/MAs. Shortcomings of the methodological quality of reports could severely affect the application of evidence, decision making, and evidence-based dentistry practice progress. To solve such problems, health professionals should consider bringing forth evidence-based curriculum into higher institutions. Researchers should consider guidelines for quality assessment, such as AMSTAR, when designing and conducting SRs/MAs to increase the validity and clinical applicability of future reviews. Furthermore, the editors and reviewers of journals should pay more attention to the general methodological quality of reports and clearly inform authors of their requirements of submitted papers to keep SRs/MAs as 1 of the best methods for achieving credible evidence in the field of endodontics.

### Conclusion

In recent publications in the field of endodontics (from August 1, 2009 to November 30, 2016), the overall quality of meta-analyses reports was found to be medium, with an estimated mean overall AMSTAR score of 7.25 out of 11. There are clear needs for authors’ self-evaluation and incorporation of the AMSTAR checklist for the review process before publication.

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### References

1. Guyatt G. *Users’ Guides to the Medical Literature: A Manual for Evidence-based Clinical Practice*. New York: McGraw-Hill Medical; 2008.
2. Wallace BC, Dahabreh IJ, Schmid CH, et al. Modernizing the systematic review process to inform comparative effectiveness: tools and methods. *J Comp Eff Res* 2013;2: 273–82.
3. Shea BJ, Grimshaw J, Wells G, et al. Development of AMSTAR: a measurement tool to assess the methodological quality of systematic reviews. *BMC Med Res Methodol* 2007;7:1–7.
4. Shea BJ, Hamel C, Wells G, et al. AMSTAR is a reliable and valid measurement tool to assess the methodological quality of systematic reviews. *J Clin Epidemiol* 2009;62: 1013–20.
5. Canadian Agency for Drugs and Technologies in Health. Available at: Methods for Development. April 28, 2011. <https://www.cadth.ca/methods-development>. Accessed October 15, 2016.
6. Brito J, Tsapas A, Griebeler M, et al. Systematic reviews supporting practice guideline recommendations lack protection against bias. *J Clin Epidemiol* 2013;66: 633–8.
7. Fleming P, Seehra J, Polychronopoulou A, et al. Cochrane and non-cochrane systematic reviews in leading orthodontic journals: a quality paradigm? *Eur J Orthod* 2013;35:244–8.

8. Martel G, Duhaime S, Barkun J, et al. The quality of research synthesis in surgery: the case of laparoscopic surgery for colorectal cancer. *Syst Rev* 2012;1:1–17.
9. Monasta L, Batty G, Cattaneo A, et al. Early-life determinants of overweight and obesity: a review of systematic reviews. *Obes Rev* 2010;11:695–708.
10. Suebnukarn S, Ngamboonsirisingh S, Rattanabanlang A. A systematic evaluation of the quality of meta-analyses in endodontics. *J Endod* 2010;36:602–8.
11. Von Arx T, Peñarrocha M, Jensen S. Prognostic factors in apical surgery with root-end filling: a meta-analysis. *J Endod* 2010;36:957–73.
12. Brandt R, Anderson P, McDonald N, et al. The pulpal anesthetic efficacy of articaine versus lidocaine in dentistry: a meta-analysis. *J Am Dent Assoc* 2011;142:493–504.
13. Chala S, Abouqal R, Rida S. Apexification of immature teeth with calcium hydroxide or mineral trioxide aggregate: systematic review and meta-analysis. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2011;112:e36–42.
14. Chang E, Lam E, Shah P, et al. Cone-beam computed tomography for detecting vertical root fractures in endodontically treated teeth: a systematic review. *J Endod* 2016;42:177–85.
15. Chung W, Tu Y, Lin Y, et al. Outcomes of autotransplanted teeth with complete root formation: a systematic review and meta-analysis. *J Clin Periodontol* 2014;41:412–23.
16. Cope A, Francis N, Wood F, et al. Systemic antibiotics for symptomatic apical periodontitis and acute apical abscess in adults. *Cochrane Database Syst Rev* 2014;26:CD010136.
17. Deng Y, Zhu X, Yang J, et al. The effect of regeneration techniques on periapical surgery with different protocols for different lesion types: a meta-analysis. *J Oral Maxillofac Surg* 2016;74:239–46.
18. Dou L, Luo J, Yang D, et al. The effectiveness of an additional lingual infiltration in the pulpal anesthesia of mandibular teeth: a systematic review. *Quintessence Int* 2013;44:457–64.
19. Fedorowicz Z, Nasser M, Sequeira-Byron P, et al. Irrigants for non-surgical root canal treatment in mature permanent teeth. *Cochrane Database Syst Rev* 2012;CD008948.
20. Figueiredo F, Martins-Filho P, Faria-e-Silva A. Do metal post-retained restorations result in more root fractures than fiber post-retained restorations? A systematic review and meta-analysis. *J Endod* 2015;41:309–16.
21. Gillen B, Looney S, Gu L, et al. Impact of the quality of coronal restoration versus the quality of root canal fillings on success of root canal treatment: a systematic review and meta-analysis. *J Endod* 2011;37:895–902.
22. Jakovljevic A, Andric M. Human cytomegalovirus and Epstein-Barr virus in etiopathogenesis of apical periodontitis: a systematic review. *J Endod* 2014;40:6–15.
23. Kung J, McDonagh M, Sedgley C. Does articaine present an advantage over lidocaine in patients with symptomatic irreversible pulpitis? A systematic review and meta-analysis. *J Endod* 2015;41:1784–94.
24. Leite F, Nascimento G, Demarco F, et al. Prevalence of treponema species detected in endodontic infections: systematic review and meta-regression analysis. *J Endod* 2015;41:579–87.
25. Li C, Yang X, Ma X, et al. Preoperative oral nonsteroidal anti-inflammatory drugs for the success of the inferior alveolar nerve block in irreversible pulpitis treatment: a systematic review and meta-analysis based on randomized controlled trials. *Quintessence Int* 2012;43:209–19.
26. Li Z, Cao L, Fan M, et al. Direct pulp capping with calcium hydroxide or mineral trioxide aggregate: a meta-analysis. *J Endod* 2015;41:1412–7.
27. Long H, Zhou Y, Ye N, et al. Diagnostic accuracy of CBCT for tooth fractures: a meta-analysis. *J Dent* 2014;42:240–8.
28. Ng Y, Mann V, Gulabivala K. Tooth survival following non-surgical root canal treatment: a systematic review of the literature. *Int Endod J* 2010;43:171–89.
29. Nixdorf D, Moana-Filho E, Law A, et al. Frequency of persistent tooth pain after root canal therapy: a systematic review and meta-analysis. *J Endod* 2010;36:224–30.
30. Nixdorf DR, Moana-Filho EJ, Law AS, et al. Frequency of non-odontogenic pain after endodontic therapy: a systematic review and meta-analysis. *J Endod* 2010;36:1494–8.
31. Pak JG, White SN. Pain prevalence and severity before, during, and after root canal treatment: a systematic review. *J Endod* 2011;37:429–38.
32. Panitvisai P, Parunni P, Sathorn C, et al. Impact of a retained instrument on treatment outcome: a systematic review and meta-analysis. *J Endod* 2010;36:775–80.
33. Segura-Egea JJ, Martín-González J, Cabanillas-Balsera D, et al. Association between diabetes and the prevalence of radiolucent periapical lesions in root-filled teeth: systematic review and meta-analysis. *Clin Oral Investig* 2016;20:1133–41.
34. Setzer FC, Shah SB, Kohli MR, et al. Outcome of endodontic surgery: a meta-analysis of the literature—part 1: comparison of traditional root-end surgery and endodontic microsurgery. *J Endod* 2010;36:1757–65.
35. Setzer FC, Kohli MR, Shah SB, et al. Outcome of endodontic surgery: a meta-analysis of the literature—part 2: comparison of endodontic microsurgical techniques with and without the use of higher magnification. *J Endod* 2012;38:1–10.
36. Siew K, Lee AH, Cheung GS. Treatment outcome of repaired root perforation: a systematic review and meta-analysis. *J Endod* 2015;41:1795–804.
37. Su N, Wang H, Zhang S, et al. Efficacy and safety of bupivacaine versus lidocaine in dental treatments: a meta-analysis of randomised controlled trials. *Int Dent J* 2014;64:34–45.
38. Su N, Li C, Wang H, et al. Efficacy and safety of articaine versus lidocaine for irreversible pulpitis treatment: a systematic review and meta-analysis of randomised controlled trials. *Aust Endod J* 2016;42:4–15.
39. Su Y, Wang C, Ye L. Healing rate and post-obturation pain of single- versus multiple-visit endodontic treatment for infected root canals: a systematic review. *J Endod* 2011;37:125–32.
40. Tang Y, Li X, Yin S. Outcomes of MTA as root-end filling in endodontic surgery: a systematic review. *Quintessence Int* 2010;41:557–66.
41. Torabinejad M, Dinsbach NA, Turman M, et al. Survival of intentionally replanted teeth and implant-supported single crowns: a systematic review. *J Endod* 2015;41:992–8.
42. Torabinejad M, Landaez M, Milan M, et al. Tooth retention through endodontic microsurgery or tooth replacement using single implants: a systematic review of treatment outcomes. *J Endod* 2015;41:1–10.
43. Tsesis I, Faivishvsky V, Kfir A, et al. Outcome of surgical endodontic treatment performed by a modern technique: a meta-analysis of literature. *J Endod* 2009;35:1505–11.
44. Tsesis I, Rosen E, Tamse A, et al. Effect of guided tissue regeneration on the outcome of surgical endodontic treatment: a systematic review and meta-analysis. *J Endod* 2011;37:1039–45.
45. Tsesis I, Rosen E, Taschieri S, et al. Outcomes of surgical endodontic treatment performed by a modern technique: an updated meta-analysis of the literature. *J Endod* 2013;39:332–9.
46. Zhang C, Du J, Peng Z. Correlation between enterococcus faecalis and persistent intraradicular infection compared with primary intraradicular infection: a systematic review. *J Endod* 2015;41:1207–13.
47. Page MJ, Shamseer L, Altman DG, et al. Epidemiology and reporting characteristics of systematic reviews of biomedical research: a cross-sectional study. *PLoS Med* 2016;13:e1002028.
48. Petticrew M, Wilson P, Wright K, et al. Quality of Cochrane reviews. Quality of Cochrane reviews is better than that of non-Cochrane reviews. *BMJ* 2002;324:545.
49. Liu D, Jin J, Tian J, et al. Quality assessment and factor analysis of systematic reviews and meta-analyses of endoscopic ultrasound diagnosis. *PLoS One* 2015;10:e0120911.
50. Booth A, Clarke M, Ghera D, et al. An international registry of systematic-review protocols. *Lancet* 2011;377:108–9.
51. Egger M, Smith G, Schneider M, et al. Bias in meta-analysis detected by a simple, graphical test. *BMJ* 1997;315:629–34.
52. Pastorino R, Milovanovic S, Stojanovic J, et al. Quality assessment of studies published in open access and subscription journals: results of a systematic evaluation. *PLoS One* 2016;11:1–11.
53. Perera R. Interpreting meta-analysis in systematic reviews. *Ann Intern Med* 2009;150:JC2-2, JC2-3.
54. Rothstein HR, Sutton AJ, Borenstein M. Publication bias in meta-analysis. In: Rothstein H, ed. *Publication Bias in Meta-analysis: Prevention, Assessment and Adjustments*. Chichester, West Sussex, UK: Wiley; 2005.
55. Thornton A, Lee P. Publication bias in meta-analysis its causes and consequences. *J Clin Epidemiol* 2000;53:207–16.