Systematic Review

Unilateral Versus Bilateral Balloon Kyphoplasty for Osteoporotic Vertebral Compression Fractures: A Systematic Review of Overlapping Meta-analyses

Cui Zhiyong, MD[1], Tian Yun, MD[1], Feng Hui, MD[1], Yang Zhongwei, MD[1], and Liu Zhaorui, MD[2]

From: [1]Department of Orthopedic Trauma, Peking University Third Hospital, Beijing, China; [2]Peking University Sixth Hospital, Beijing, China

Address Correspondence:
Tian Yun, MD
Department of Orthopedics, Peking University Third Hospital
No 49 Huayuan Road
Beijing, China
E-mail: tiany@bjmu.edu.cn

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Background: There have been many meta-analyses and systematic reviews that have discussed the differences between unilateral and bilateral balloon kyphoplasty. However, their conclusions regarding the efficacy and safety of bilateral balloon kyphoplasty in the treatment of osteoporotic vertebral compression fractures (OVCFs) are discordant.

Objective: We attempted to select the best evidence review to determine the differences between unilateral and bilateral balloon kyphoplasty, and we wanted to determine the best treatment approach for OVCFs.

Study Design: A systematic review of overlapping meta-analyses

Setting: The electronic databases of PubMed, Embase and The Cochrane Library were searched. The search extended through Sept. 30, 2017. Moreover, we manually searched the last 10 years of conference reports and papers from the Peking University Health Science Library and consulted 2 experts in the field for any additional relevant information.

Methods: We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Statement and used "A Measurement Tool to Assess Systematic Reviews" (AMTASR) and the Oxford Levels of Evidence to assess the methodological quality of the studies. We applied the Jadad decision algorithm to select the best evidence review.

Results: Seven meta-analyses were included in this systematic review. The AMTASR scores of the studies ranged from 4 to 9, with an average of 6. Finally, Sun H et al was shown to represent the best evidence study. Sun H et al proposed that the unilateral kyphoplasty required less surgical time and consumed less cement, reduced cement leakage, and improved short-term general health compared with that of bilateral kyphoplasty.

Limitations: The AMTASR scores indicated that some of the included studies were of low quality. In addition, not all of the studies used the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) level. When used, the GRADE level indicated that most of the results consisted of studies of low quality.

Conclusions: Unilateral kyphoplasty reduces the operative time, cement volume, and cement leakage rate compared with bilateral kyphoplasty. Therefore, we conclude that unilateral kyphoplasty is more advantageous, effective and safe, compared to bilateral kyphoplasty for the treatment of OVCFs.

Key words: Osteoporotic vertebral compression fracture, kyphoplasty, unilateral, bilateral, unipedicular, bipedicular, systematic review

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Osteoporotic vertebral compression fractures (OVCFs) are very common in the elderly (1, 2) with most osteoporotic fractures occurring in the lower thoracic and thoracolumbar spine (3). The main sequelae of OVCFs are kyphosis and back pain caused by spinal misalignment (4). Therefore, the treatment for OVCFs should focus on pain relief and restoring the vertebral height, thereby improving the kyphosis (5, 6).

Balloon kyphoplasty is a percutaneous, minimally invasive surgery that has been found to be a safe and effective therapy for OVCFs (7). Currently, the standard technique for kyphoplasty is the bilateral approach using 2 balloon tamps (8). However, the unilateral approach has also been effective in producing mechanically sufficient support for OVCFs (9). Tohmeh et al (10) conducted a biomechanical trial examining the 2 approaches and proposed that both approaches could restore the vertebral body strength, stiffness, and height.

There were many meta-analyses and systematic reviews that compared the differences between unilateral and bilateral balloon kyphoplasty. However, their conclusions were discordant, which could confuse the decision makers when attempting to choose 1 suitable approach. Therefore, it is necessary to separate and distinguish the best evidence for treatment from the published literature.

This systematic review used the Jadad decision algorithm (11) to evaluate the methodology of the current meta-analyses or systematic reviews, and from this algorithm, the best evidence concerning unilateral versus bilateral balloon kyphoplasty was selected.

Methods

Prior Design

The design of this review was determined prior to the study. We assessed the quality of the current meta-analyses and systematic reviews for unilateral versus bilateral kyphoplasty for the treatment of OVCFs. We then selected the 1 meta-analysis or systematic review that had the best quality. Finally, we compared reported differences between unilateral and bilateral kyphoplasty for the treatment of OVCFs using the chosen best quality meta-analysis or systematic review as the standard. For our study, we followed the guidelines reported in the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Statement, which should increase both the reporting and methodological quality (12).

The selection criteria were determined. The inclusion criteria were as follows: a) meta-analyses and systematic reviews that compared unilateral kyphoplasty with bilateral kyphoplasty; b) meta-analyses that were based on randomized controlled trials (RCTs); and c) studies that had at least one outcome variable between the 2 groups. The exclusion criteria were a) meta-analyses and systematic reviews that included non-randomized controlled trials; b) the systematic reviews without quantitative analysis; and c) narrative reviews. We modeled our study of overlapping meta-analyses and systematic reviews after the design was developed.

Search Strategy

We searched the electronic databases of PubMed, Embase and The Cochrane Library for literature. We included articles through Sept. 30, 2017. The articles were limited to meta-analyses and systematic reviews. Key words were kyphoplasty, unilateral kyphoplasty, bilateral kyphoplasty, unipedicular, bipedicular and osteoporotic vertebral compression fracture. The Boolean operators were used to link the key words, and only English language publications were included. We then reviewed the abstracts and read the full text of the articles that potentially met our inclusion criteria. We reviewed the references of the included articles. We manually searched the recent conference reports and papers over the last decade from the Peking University Health Science Library and consulted with 2 experts in the field for additional information. The search process was completed by 2 independent investigators, and discordant decisions were reviewed by a third investigator whose decision would be final.

Data Extraction

Two investigators independently extracted useful data in a standardized manner. The extracted data included the first author's name, searched databases, the publication date, the last search date, the publication status, the sensitivity analysis, language limitations, and heterogeneity. The data that were included were the outcome effect, statistical software, conflict of interest statement, and the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) level.

Assessment of Methodological Quality

Two investigators used "A Measurement Tool to Assess Systematic Reviews" (AMTASR) (13) to evaluate the methodological quality of the meta-analyses and systematic reviews. The AMTASR contains 11 terms

and has good face and content validity from which to measure the methodological quality of systematic reviews (13). For the evidence level of the included meta-analyses and systematic reviews, the investigators used the Oxford Levels of Evidence (14). The assessment was completed independently, and the divergence was resolved by a third-party decision.

Assessment of Heterogeneity and GRADE Level

We extracted the heterogeneity and GRADE level of each outcome effect in the meta-analyses and systematic review. The heterogeneity was tested using quantity I^2, which provides consistency between trials in the meta-analyses and systematic reviews (15). The I^2 value lies between 0% and 100%. A value of 0% indicates that there was no observed heterogeneity, while larger values demonstrate increasing values of heterogeneity (15). The Cochrane Handbook for Systematic Reviews of Intervention (Version 5.1.0) assesses the heterogeneity using the range of the I^2 value as follows: 0%-40% as "might not be important"; 40%-60% as "may represent moderate heterogeneity"; 50%-90% as "may represent substantial". The GRADE system was used to evaluate the quality of evidence for the outcomes in the included meta-analyses and systematic reviews. This system classifies the quality of evidence into 4 levels: high, moderate, low, and very low (16).

Application of the Jadad Decision Algorithm

The 1997 Jadad decision algorithm was used to help the reviewers who were making the decisions to understand discordance among reviews, guide their decisions, and help reviewers select the best evidence from discordant quantitative reviews (11). The algorithm contains a total of 9 steps. Decision-makers should judge every step and make selections from the included reviews. In our study, 3 investigators judged and made decisions independently, following the Jadad decision algorithm.

Results

Literature Characteristics

We initially found 110 publications primarily from the electronic databases with 1 publication obtained through searching the references of the reviewed articles. Seven meta-analyses (4,17-22) were included on the basis of the selection criteria previously described. The selection process and the reasons are described in detail in Fig. 1. The publication

Table 1. *The databases searched by every meta-analysis.*

Author/Year	Pubmed	Medline	Embase	Cochrane Library	CENTRAL[a]	Web of Science	Chinese Databases[b]	Others
Sun H (17) 2016	+	+	+	+	-	+	-	-
Feng H (18) 2015	+	+	+	+	-		+	+
Chen H (4) 2014	+	-	+	+	-	+	+	-
Huang Z (19) 2014	+	+	+	+	-	-	-	+
Lin J (20) 2013	+	+	+	-	+	-	-	+
Yang L (21) 2013	-	+	+	-	+	-	-	-
Li L (22) 2013	+	-	-	-	+	-	+	+

a: CENTRAL is the abbreviation of The Cochrane Central Register of Controlled Trials; b: Chinese Databases mean the electronic database where the literature was published in chinese; +: The database was searched; -: The database was not searched.

Table 2. *The fundamental characteristics of the meta-analyses.*

Author/Year	Publication Journal	Last Search Date	Publication Date	RCTs' numbers
Sun H (17) 2016	Pain Physician	June 2015	June 2016	6
Feng H (18) 2015	Journal of Orthopaedic Research	January 2015	July 2015	12
Chen H (4) 2014	Orthopedics	April 2013	September 2014	14
Huang Z (19) 2014	Clinical Orthopaedics and Related Research	June 2013	June 2014	5
Lin J (20) 2013	Pain Physician	July 2012	October 2012	3
Yang L (21) 2013	Pain Physician	September 2012	February 2013	4
Li L (22) 2013	Chinese Medical Journal (English)	March 2013	October 2013	7

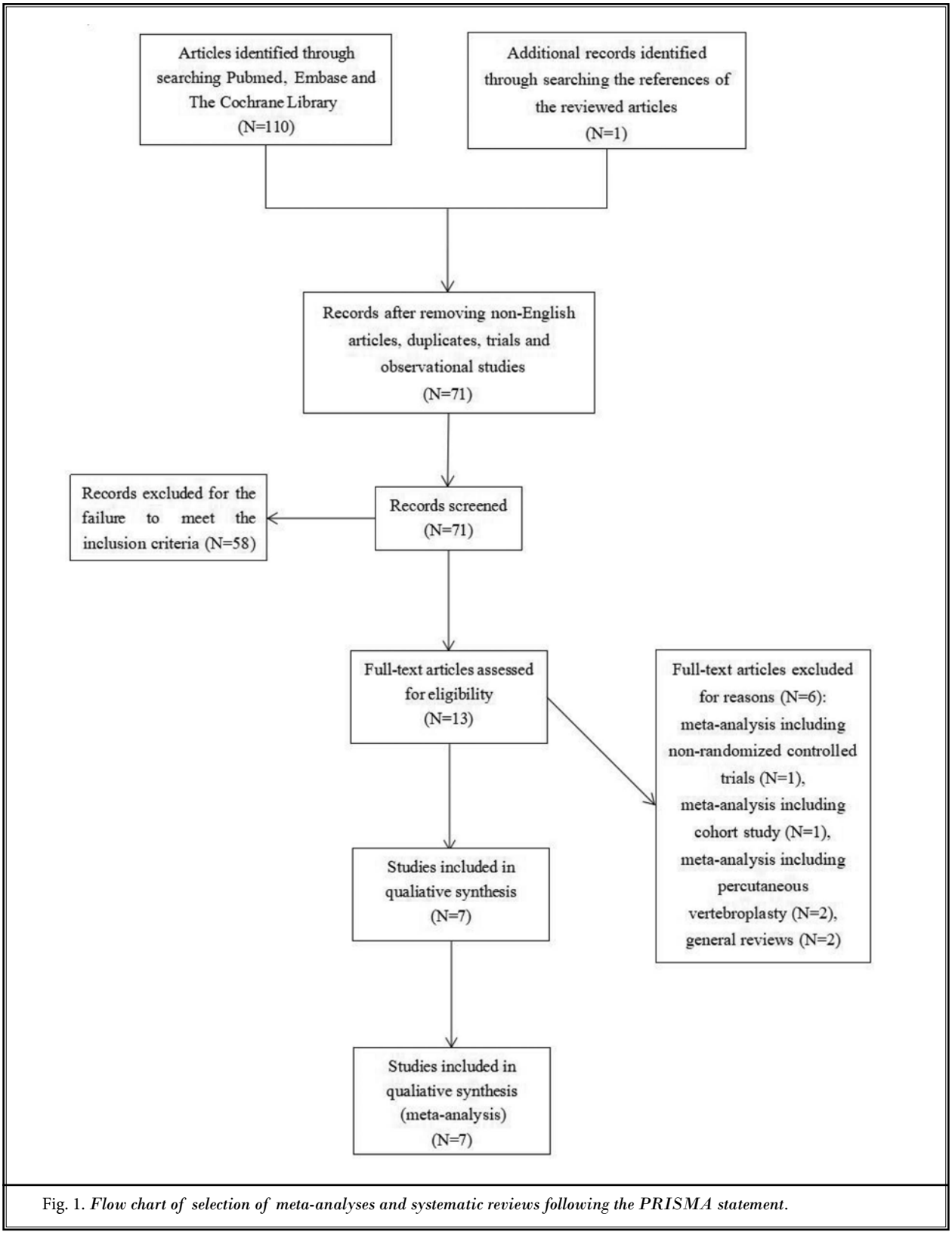

Fig. 1. *Flow chart of selection of meta-analyses and systematic reviews following the PRISMA statement.*

date of the 7 meta-analyses ranged from February 2013 to January 2016. The number of original studies in the meta-analyses ranged from 3 to 13, with an average of 7. The fundamental characteristics of the 7 meta-analyses are described in Tables 1 and 2. The primary trials included in the meta-analyses are shown in Table 3.

Search Methodology

We extracted the databases, language limitation, publication status, sensitivity analysis and the software for analysis from the included meta-analyses (Table 4). All the meta-analyses involved a comprehensive literature search, and Chinese databases were searched in 3 studies (4,18, 22). PubMed, Medline and Embase were the most common databases used for the search. One study (22) used the STATA 12.0 software (Stata Corporation, College Station, TX, USA) for the statistical analysis, while the remaining studies (4,17-21) used the Revman software (The Cochrane Collaboration, Copenhagen, Denmark) (Table 4).

Methodological Quality

All 7 studies were evaluated for methodological quality. Each study included RCTs (Table 3). The AMTASR scores for the studies ranged from 4 to 9, the average of which was 6 (Table 5). Yang L et al (21) achieved the highest AMTASR score. We used the Oxford Levels of Evidence (15) to evaluate the studies. Three studies (4,18,22) met Level II evidence criteria, while the remaining studies met Level I evidence criteria (Table 4). The meta-analysis by Yang L et al (21) represented the highest quality study.

Heterogeneity and GRADE Level

All studies assessed the heterogeneity of the outcome effects with the statistical quantity I2 (Table 6). Four studies (17,19,21,22) centered their sensitivity analysis around their outcome effects (Table 4). Only 3 studies (4,17,18) used the GRADE level, which can be found in Table 6.

Results of the Jadad Decision Algorithm

From the 7 studies, the final decision regarding the best evidence study was made by the 3 investigators using the Jadad decision algorithm. Each of the 7 studies compared unilateral to bilateral kyphoplasty for the treatment of OVCFs. However, the selection criteria of the 7 studies differed. The 3 investigators then reviewed the 7 studies with respect to publication

Table 3. *The primary trials included in the every meta-analysis.*

Author/ Year	Chen L 2011	Chen 2011	Chen 2010	Chung 2008	Rebolledo 2013	Huang 2013	Zhang 2012	Luo 2012	Li Q 2012	Li G 2012	He 2012	Feng 2012	Jiang Y 2010	Gu 2009	Feng 2013	Mao 2013	Zhai 2013	He 2014	Lin 2014	Liu 2014	Yan 2014
Sun H (17) 2016	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Feng H (18) 2015	+	+	+	+	+	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+
Chen H (4) 2014	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-
Huang Z (19) 2014	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lin J (20) 2013	+	+	-	+	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yang L (21) 2013	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Li L (22) 2013	+	+	+	+	+	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-

+: The primary trial was included; -: The primary trial was not included.

Table 4. *The methodological messages of the meta-analyses.*

Author/Year	Design of Included Studies	Level of Evidence	Language Limitation	Publication Status	Sensitivity Analysis	Software	GRADE Use
Sun H (17) 2016	RCT	I	English	Published	YES	Revman 5.3	YES
Feng H (18) 2015	RCT	II	English & Chinese	Published	NO	Revman 5.2	NO
Chen H (4) 2014	RCT	II	No	Published	NO	Revman 5.2	YES
Huang Z (19) 2014	RCT	I	English	Published	YES	Revman 5.1	YES
Lin J (20) 2013	RCT	I	No	Published	NO	Revman 5.1	NO
Yang L (21) 2013	RCT	I	No	Published	YES	Revman 5.1	NO
Li L (22) 2013	RCT	II	No	Published	YES	STATA 12.0	NO

Table 5. *AMTASR scores of every meta-analysis.*

Items	Sun H (17) 2016	Feng H (18) 2015	Chen H (4) 2014	Huang Z (19) 2014	Lin J (20) 2013	Yang L (21) 2013	Li L (22) 2013
Was an 'a priori' design provided?	0	0	0	0	0	1	0
Was there duplicate study selection and data extraction?	1	1	1	1	1	1	1
Was a comprehensive literature search performed?	0	0	0	0	0	1	0
Was the status of publication (i.e. grey literature) used as an inclusion criterion?	0	0	0	0	0	0	0
Was a list of studies (included and excluded) provided?	1	1	0	1	0	1	1
Were the characteristics of the included studies provided?	1	1	1	1	1	1	0
Was the scientific quality of the included studies assessed and documented?	1	1	1	1	1	1	0
Was the scientific quality of the included studies used appropriately in formulating conclusions?	1	1	1	1	0	1	0
Were the methods used to combine the findings of studies appropriate?	1	1	1	1	1	1	1
Was the likelihood of publication bias assessed?	0	1	0	0	0	1	1
Was the conflict of interest stated?	1	1	0	0	0	0	0
Total	7	8	4	6	4	9	4

status, methodological quality, language restrictions, and data analysis of individual patients. No study was based on the data analysis of individual patients. Each study included the published literature. Three studies (17-19) restricted the publication language, 2 of which only included English studies and 1 included English and Chinese studies. Three studies (4,18,22) included Chinese as part of their publication language. The methodological quality of the studies was evaluated by the 3 investigators, and the meta-analysis of more randomized controlled trials performed by Sun H et al (17) was chosen as having the best evidence quality. The outcome effects of the 7 studies are shown in Fig. 2. The Jadad decision algorithm is shown in Fig. 3.

Sun H et al (17) reported that unilateral kyphoplasty required less surgical time (MD = -23.19, $P < 0.00001$), less cement usage (MD = -2.07, $P < 0.00001$), reduced cement leakage (RR = 0.59, $P < 0.05$) and improved short-term general health (MD = 1.48, $P < 0.05$) compared with that of bilateral kyphoplasty. They found no significant difference between unilateral and bilateral kyphoplasty in the Visual Analog Scale (VAS)

scores (short-term and long-term), Oswestry Disability Index (ODI) scores (mid-term and long-term), degree of kyphotic angle reduction, restoration rate of anterior vertebral height, vertebral height loss rate, the number and incidence rate of postoperative adjacent-level fractures, or in other assessments made for the 36-Item Short Form Health Survey (SF-36) parameters (short-term and long-term) .

Discussion

Meta-analyses and systematic reviews were confirmed as the evidence with the highest quality in evidence-based medicine (23). Seven meta-analyses (4,17-22) were available to compare the outcome effect and safety between the unilateral and bilateral kyphoplasty for OVCFs, but they proposed different conclusions. For example, 2 meta-analyses (4,17) concluded that the unilateral approach reduced the cement leakage, while the others (18-22) disagreed with the significant difference between the 2 approaches in the cement leakage. These controversial conclusions confused the clinical decision makers and did not standardize the therapy effectively (11).

Jadad et al (11) proposed the sources of discordance among the meta-analyses as follows: the clinical question, study selection and inclusion criteria, data extraction, assessment of study quality, assessment of the ability to combine studies and statistical methods for

Table 6. *The heterogeneity and GRADE level of every outcome effect in the meta-analyses.*

Author/Year	The Outcome Effects		Heterogeneity	GRADE
Sun H (17) 2016	operative time		$P = 0.002$ $I^2 = 77\%$	High
	cement volume		$P = 0.43$ $I^2 = 0\%$	High
	short-term VAS scores		$P = 0.08$ $I^2 = 55\%$	Very Low
	long-term VAS scores		$P = 0.33$ $I^2 = 13\%$	Low
	mid-term ODI scores		$P = 0.45$ $I^2 = 0\%$	Low
	long-term ODI scores		$P = 0.37$ $I^2 = 0\%$	Low
	cement leakage		$P = 0.28$ $I^2 = 22\%$	Low
	postoperative adjacent-level fracture		$P = 0.50$ $I^2 = 0\%$	Moderate
	kyphotic angle reduction		$P =$ - c $I^2 = 93\%$	Very Low
	anterior vertebral height restoration		$P =$ - $I^2 = 88\%$	Very Low
	vertebral height loss		$P =$ - $I^2 = 68\%$	Very Low
	36-Item Short Form Health Survey parameters (short-term)	PF	$P = 0.76$ $I^2 = 0\%$	Low
		RP	$P = 0.08$ $I^2 = 67\%$	Very Low
		BP	$P = 0.59$ $I^2 = 0\%$	Low
		GH	$P = 0.36$ $I^2 = 0\%$	Low
		VT	$P = 0.50$ $I^2 = 0\%$	Low
		SF	$P = 0.96$ $I^2 = 0\%$	Low
		RE	$P = 0.29$ $I^2 = 9\%$	Low
		MH	$P = 0.72$ $I^2 = 0\%$	Low
	36-Item Short Form Health Survey parameters (long-term)	PF	$P = 0.87$ $I^2 = 0\%$	Low
		RP	$P = 0.12$ $I^2 = 58\%$	Very Low
		BP	$P = 0.54$ $I^2 = 0\%$	Low
		GH	$P = 0.97$ $I^2 = 0\%$	Low
		VT	$P = 0.20$ $I^2 = 38\%$	Low
		SF	$P = 0.98$ $I^2 = 0\%$	Low
		RE	$P = 0.77$ $I^2 = 0\%$	Low
		MH	$P = 0.85$ $I^2 = 0\%$	Low

Table 6 con't. *The heterogeneity and GRADE level of every outcome effect in the meta-analyses.*

Author/Year	The Outcome Effects		Heterogeneity	GRADE
Feng H (18) 2015	short-term VAS scores		$P = 0.84$ $I^2 = 0\%$	-
	mid-term VAS scores		$P = 0.82$ $I^2 = 0\%$	-
	long-term VAS scores		$P = 0.73$ $I^2 = 0\%$	-
	short-term ODI scores		$P = 0.21$ $I^2 = 36\%$	-
	operative time		$P = 0.33$ $I^2 = 14\%$	-
	cement volumn		$P = 0.11$ $I^2 = 44\%$	-
	kyphotic angle reduction		$P = 0.001$ $I^2 = 85\%$	-
	Cobb's angle recovery		$P = 0.11$ $I^2 = 50\%$	-
	vertebral height loss		$P = 0.85$ $I^2 = 0\%$	-
	vertebral height restoration		$P < 0.00001$ $I^2 = 94\%$	-
	short-term anterior vertebral height restoration		$P = 0.84$ $I^2 = 0\%$	-
	long-term anterior vertebral height restoration		$P = 0.30$ $I^2 = 18\%$	-
	short-term middle vertebral height restoration		$P = 0.97$ $I^2 = 0\%$	-
	long-term middle vertebral height restoration		$P = 0.85$ $I^2 = 0\%$	-
	cement leakage		$P = 0.50$ $I^2 = 0\%$	-
	postoperative adjacent-level fracture		$P = 0.49$ $I^2 = 0\%$	-
	36-Item Short Form Health Survey parameters (short-term)	PF	$P = -$ $I^2 = 0\%$	-
		RP	$P = -$ $I^2 = 67\%$	-
		BP	$P = -$ $I^2 = 9\%$	-
		GH	$P = -$ $I^2 = 0\%$	-
		VT	$P = -$ $I^2 = 0\%$	-
		SF	$P = -$ $I^2 = 0\%$	-
		RE	$P = -$ $I^2 = 9\%$	-
		MH	$P = -$ $I^2 = 0\%$	-
	36-Item Short Form Health Survey parameters (long-term)	PF	$P = -$ $I^2 = 0\%$	-
		RP	$P = -$ $I^2 = 62\%$	-
		BP	$P = -$ $I^2 = 0\%$	-
		GH	$P = -$ $I^2 = 0\%$	-
		VT	$P = -$ $I^2 = 15\%$	-
		SF	$P = -$ $I^2 = 0\%$	-
		RE	$P = -$ $I^2 = 0\%$	-
		MH	$P = -$ $I^2 = 0\%$	-
Chen H (4) 2014	short-term VAS scores		$P = 0.58$ $I^2 = 0\%$	Low
	long-term VAS scores(1 year)		$P = 0.98$ $I^2 = 0\%$	Low
	long-term VAS scores(2 year)		$P = 0.50$ $I^2 = 0\%$	Low
	short-term ODI scores		$P = 0.06$ $I^2 = 72\%$	Very Low
	long-term ODI scores		$P < 0.0001$ $I^2 = 91\%$	Very Low
	anterior vertebral height Restoration		$P = 0.54$ $I^2 = 0\%$	Low
	middle vertebral height Restoration		$P = 0.25$ $I^2 = 25\%$	Low
	kyphotic angle reduction		$P = 0.08$ $I^2 = 42\%$	Low
	operative time		$P = 0.13$ $I^2 = 32\%$	Low
	cement volumn		$P = 0.10$ $I^2 = 38\%$	Low
	cement leakage		$P = 0.23$ $I^2 = 27\%$	Low

Table 6 con't. *The heterogeneity and GRADE level of every outcome effect in the meta-analyses.*

Author/Year	The Outcome Effects		Heterogeneity	GRADE
Huang Z (19) 2014	short-term VAS score		$P = 0.77$ $I^2 = 0\%$	Low
	long-term VAS score		$P = 0.97$ $I^2 = 0\%$	Low
	mid-term ODI scores		$P = -$ $I^2 = -$	Very Low
	long-term ODI scores		$P = -$ $I^2 = -$	Very Low
	cement leakage		$P = -$ $I^2 = -$	Low
	adjacent-level fractures		$P = 0.20$ $I^2 = 39\%$	Low
	operation time		$P = 0.61$ $I^2 = 0\%$	High
	kyphosis angle reduction		$P = -$ $I^2 = 85\%$	Low
	anterior vertebral body height restoration		$P = -$ $I^2 = 91\%$	Very Low
Lin J (20) 2013	pre-operative VAS scores		$P = 0.17$ $I^2 = 46\%$	-
	short-term VAS scores		$P = 0.93$ $I^2 = 0\%$	-
	long-term VAS scores		$P = 0.63$ $I^2 = 0\%$	-
	operative time		$P = 0.27$ $I^2 = 17\%$	-
	cement volume		$P = 0.86$ $I^2 = 0\%$	-
	cement leakage		$P = 0.16$ $I^2 = 45\%$	-
Yang L (21) 2013	operative time		$P = 0.39$ $I^2 = 0\%$	-
	short-term VAS scores		$P = 0.62$ $I^2 = 0\%$	-
	long-term VAS scores		$P = 0.61$ $I^2 = 0\%$	-
	adjacent-level fractures		$P = 0.22$ $I^2 = 34\%$	-
	cement leakage		$P = 0.25$ $I^2 = 28\%$	-
	vertebral height loss		$P = 0.08$ $I^2 = 68\%$	-
Li L (22) 2013	pre-operative VAS scores		$P = -$ $I^2 = 0\%$	-
	short-term VAS scores (≤3 months)		$P = -$ $I^2 = 0\%$	-
	long-term VAS scores (≥1 year)		$P = -$ $I^2 = 0\%$	-
	pre-operative ODI scores		$P = 0.09$ $I^2 = 57.3\%$	-
	short-term ODI scores (≤3 months)		$P = -$ $I^2 = -$	-
	long-term ODI scores (≥1 year)		$P = -$ $I^2 = -$	-
	Cement volume		$P = 0.13$ $I^2 = 50.4\%$	-
	operative time		$P = 0.00$ $I^2 = 94.7\%$	-
	preoperative kyphosis angle		$P = 0.46$ $I^2 = 0.0\%$	-
	kyphosis angle reduction		$P = 0.89$ $I^2 = 0.0\%$	-
	kyphosis angle restoration		$P = 0.00$ $I^2 = 94.3\%$	-
	cement leakage		$P = -$ $I^2 = 39.9\%$	-

c: "-"means that this data was not mentioned in the reviews. VAS,Visual Analog Scale; ODI,Oswestry Disability Index; PF, physical function; RP, role physical; BP, bodily pain; GH, general health; VT, vitality; SF, social function; RE, role emotional; MH, mental health

data synthesis. They also offered a decision algorithm to select the best evidence reviews from discordant reviews (11), which were commonly used in selecting meta-analyses and systematic reviews (24-29). We applied the algorithm in 7 meta-analyses. Feng H et al (18), Chen H et al (4) and Li L et al (22) included trials written in Chinese, which were published locally in China, reducing publication bias and random error (11) for inclusion of more studies to some extent. However, these 3 studies (4,18,22) were assessed as level II according to the Oxford Levels of Evidence (15). Although the AMTASR scores of Yang L et al were the highest among

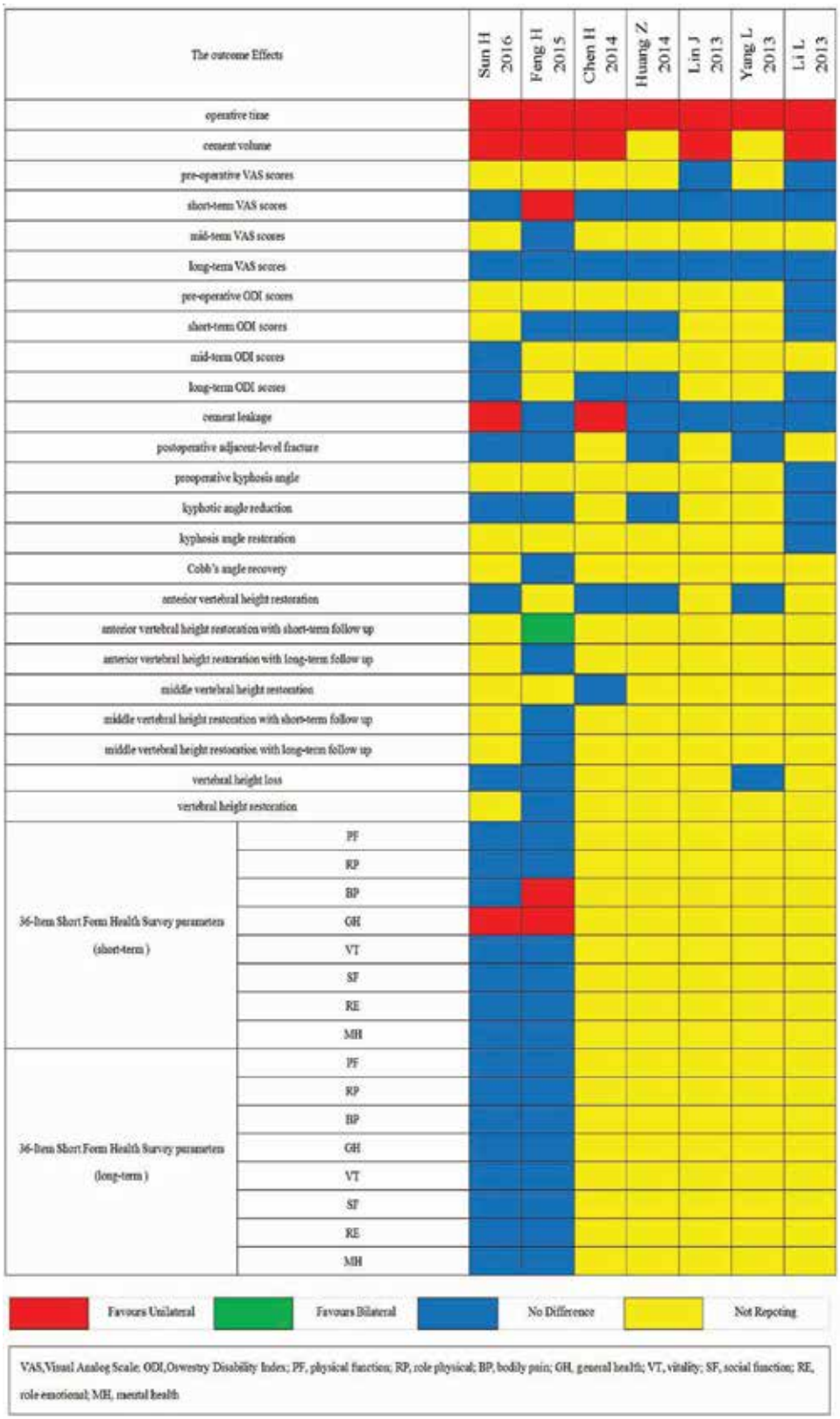

Fig. 2. *The outcome effects of the meta analyses.*

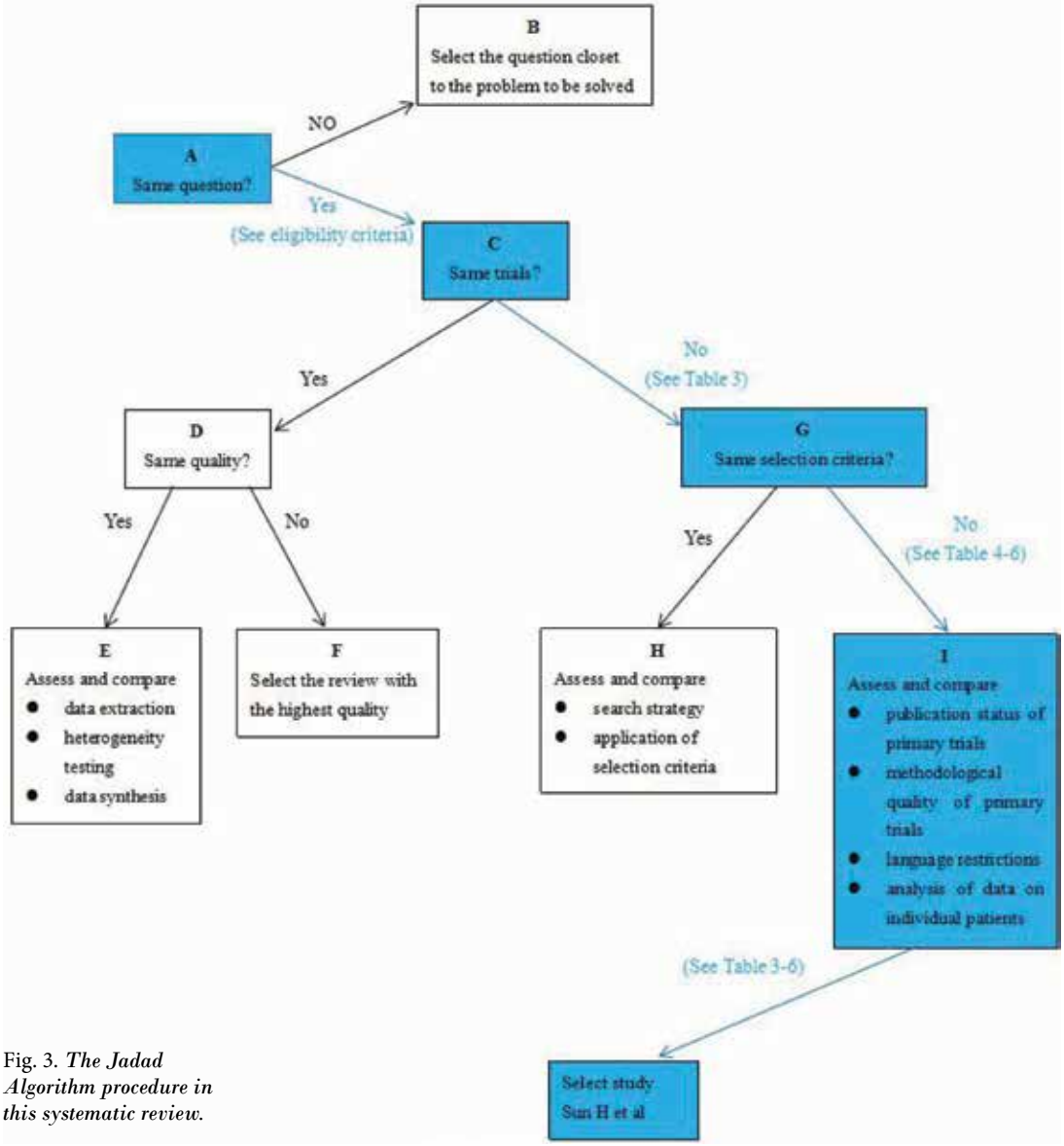

Fig. 3. *The Jadad Algorithm procedure in this systematic review.*

the studies, we finally selected the study of Sun H et al (17) as the study with the best evidence for the inclusion of more trials and providing the most current evidence.

This is the first systematic review of the overlapping meta-analyses to compare the unilateral approach to the bilateral approach in kyphoplasty for OVCFs. Sun H et al (17) was shown to represent the best evidence study. According to the meta-analysis of Sun H et al (17), we concluded that unilateral kyphoplasty could reduce the operation time, cement volume, and cement leakage rate compared to that of bilateral kyphoplasty, while there were no differences in VAS scores, ODI scores, radiographic assessment, adjacent-level fracture rate and most of the SF-36 subscale scores.

Osteoporosis is characterized by the systemic impairment of bone mass, strength, and microarchitecture, which increases the propensity of fragility fractures (30). OVCFs are very common in elderly people, causing intractable pain, kyphosis and greatly impairing the quality of a patient's life (1,2,4,31-33).

Balloon kyphoplasty is a minimally invasive operation used in the treatment of patients with OVCFs who have no improvement after 4 weeks of conservative therapy (34-36); it involves the insertion of the balloon plate into the vertebral body, followed by the injection of cement for the fixation of the vertebral body. Balloon kyphoplasty can provide rapid and constant pain relief, reduce the kyphosis deformity and improve the quality of life; thus, it has been regarded as one of the standard operations during the last decade (5,7,18,20,37,38). There are 2 approaches in balloon kyphoplasty, namely, unilateral and bilateral approaches (4,17-22,39,40). Steinmann et al (9) planned a cadaveric study comparing the biomechanics of unilateral kyphoplasty to bilateral kyphoplasty. The results indicated that there were no differences between the two approaches in the restoration of vertebral body strength, stiffness, and height in OVCFs. However, the complications between the 2 approaches were the main points that attracted the attention of those making the decisions. Cement leakage and adjacent vertebral fracture are very serious and common complications. The leakage rate was reported to be approximately 18.4% in percutaneous balloon kyphoplasty (41), and the adjacent vertebral fracture rate ranged from 7.9% to 24% (41,42). The excessive cement volume was also thought to be an important risk factor for the cement leakage and adjacent vertebral fractures (21,41,43), although Belkoff et al (44) proposed that only 2 mL of bone cement was adequate to restore strength. When the cement volume increased, the risk of cement leakage and the adjacent vertebral fractures increased (41). Lin et al (41) and Kolb et al (45) also proposed that the unilateral approach might cause the uneven distribution of the bone cement and change the biomechanics of the vertebral bodies resulting in increased compression of the adjacent vertebral bodies and cement leakage. In addition to the factors mentioned above, an intravertebral cleft, cortical disruption and low cement viscosity were also risk factors for cement leakage (43). These factors interacted with each other and affected the results between the 2 approaches. Our systematic review came to the final conclusion that the unilateral approach reduced the cement volume and cement leakage. Additionally, no significant difference was found in adjacent vertebral fractures between the 2 approaches. Our systematic review also found no significant differences in VAS scores, ODI scores, radiographic assessment, and most of the SF-36 subscale scores, which means the efficacy of the 2 approaches were comparable.

Some limitations existed in our systematic review. First, the AMTASR scores indicated that some of the included studies were of low quality. Most of the included studies did not provide the prior design and did not perform a comprehensive literature search, which could have resulted in failure to access the gray literature. Second, not all the studies used the GRADE level. Moreover, the level showed that most of the outcomes were associated with evidence of low quality.

Conclusion

This systematic review of overlapping meta-analyses indicated that unilateral kyphoplasty could reduce the operation time, cement volume and the cement leakage rate compared to that of bilateral kyphoplasty. This conclusion was the evidence of the best quality. On the basis of this outcome, we concluded that unilateral kyphoplasty was more advantageous than bilateral kyphoplasty in the efficacy and safety of OVCF treatment.

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