Meta Analysis

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Relationship between use of screws and acetabular cup stability in total hip arthroplasty: a meta-analysis

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Abstract

Objective: The relationship between the use of screws and acetabular cup stability in total hip arthroplasty (THA) remains controversial. We evaluated cup stability in THA with and without the use of screws.

Methods: We performed a systematic literature search to identify studies on cup stability relative to the use of screws in patients undergoing THA before October 2018. Methodological quality assessment and data collection were performed by two individual reviewers. Meta-analysis was performed using Review Manager version 5.3.5.

Results: We included seven trials involving 1402 patients (1469 THAs): 767 patients (809 THAs) with screws and 635 patients (660 THAs) without screws. The findings of meta-analysis indicated that uncemented acetabular component fixation with the use of additional screws was not correlated with migration of the cup, migration on roentgen stereophotogrammetry, or reoperation after THA. Moreover, operation time was not significantly different according to whether screws were used. There was no relationship between use of additional screws and osteoporosis or Harris Hip Score; however, THA with or without the use of screws might be related to bone sclerosis in the C1 region.

Conclusion: Currently, limited evidence shows that the use of screws during THA may not improve cup stability.

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Keywords

Total hip arthroplasty, cup stability, screws, meta-analysis, reoperation, uncemented acetabular component fixation

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Introduction

Total hip arthroplasty (THA) is among the most successful orthopedic procedures worldwide. For acute and chronic hip diseases, THA can relieve joint pain, correct deformities, and restore and improve hip function.[1] Despite the initial use of cemented fixation, which remains satisfactory in many cases, uncemented fixation has gained popularity owing to improvements in metal implants and surface treatments. However, a variety of complications may lead to failure of THA.[2]

Loosening and migration of the acetabular cup are the main reasons for THA failure.[3] Saito et al. reported cup loosening rates of 42% in the first 8 years after THA and 60% after 8 years.[4] Recently, with the detailed design of acetabular cups and emergence of new materials,[5] cups are widely used clinically, especially those with a porous coating and hemispherical design, which ensure good stability and durability of the press-fit cup.[6,7] In a study of 4289 patients who underwent THA with uncemented acetabular cups, the results suggested that patients with the highest 15-year survival rate were those who used press-fit cups.[8] Nevertheless, some studies have shown that press-fit cups made of new materials still have a possibility of aseptic loosening among less than 5% of patients in 10 years.[9] Therefore, some scholars have proposed that uncemented acetabular component fixation can be supported by the use of screws, particularly in osteopenic bone.[10,11] However, there are no data regarding significant advantages of the use of screws; thus, the usefulness of this approach remains uncertain.

We proposed the following hypothesis: additional screw fixation can improve initial stability of the acetabular cup and reduce the occurrence of cup migration. We examined the findings of evidence-based medicine to investigate the effect of uncemented acetabular component fixation with or without additional screw fixation on cup stability, to provide evidence for clinical applications.

Methods

Inclusion criteria

In this study, the inclusion criteria were as follows. 1) Research type: Randomized controlled trials (RCTs) or observational studies (OSs, including cohort studies and case-control studies). 2) Research participants: Adult patients (age > 18 years) with unilateral or bilateral osteoarthritis, traumatic arthritis, or avascular necrosis of the femoral head requiring initial THA; patients undergoing revision surgery were excluded. 3) Intervention measures: Patients with THA were divided into a screw-fixed group and a non-screw-fixed group; the former group included patients with screw-fixed press-fit cups whereas no screws were used in the latter group. 4) Measurement indexes: Migration of the cup, all-cause reoperation, operative time, postoperative bone changes, and Harris Hip Score (HHS) among patients with THA in both groups; short-term bone changes after surgery include osteosclerosis and decreased bone density.

Search strategy

According to the Cochrane Handbook for Systematic Reviews of Interventions, we searched PubMed, Embase, and the Cochrane Library using the following terms: "arthroplasty, replacement, hip", "hip replacement", "hip arthroplasty", "screw", "press-fit", and "cup". We also searched for "hip replacement, hip arthroplasty, screw, acetabulum cup" in SinoMed, China National Knowledge Infrastructure (CNKI), and Chongqing VIP Information Co., Ltd (CQVIP). The search timeline was from database inception to October 2018. There were no other restrictions on the search process, and we included studies published in English and Chinese language.

Data extraction and quality assessment

Two trained professional reviewers independently read the full text of articles that met the inclusion criteria and extracted the specific details of study design and measurement index data. Quality of the included RCTs was assessed using the criteria provided in the Cochrane Handbook, including adequate random sequence generation, allocation concealment, blinding, incomplete outcome data, selective reporting bias, and other bias. Assessment of the quality of OSs was done using the Newcastle–Ottawa Scale (NOS),[12] including population selection, population comparability, exposure assessment, and outcome assessment.

All analyses in this work were based on previously published studies; therefore, no ethics approval or patient consent were required.

Statistical analysis

Statistical analysis was performed using Review Manager (RevMan) Version 5.3.5. We used the odds ratio (OR) and mean difference (MD) to indicate the effect size of count data and continuous variables, respectively, and calculated the 95% confidence interval (CI). Fixed-effects model analysis was used when the statistical heterogeneity among the studies was small ($P > 0.1$, $I^2 < 50\%$). When statistical heterogeneity among the studies was large ($P < 0.1$, $I^2 > 50\%$), then the possible sources of heterogeneity and possible interference factors were analyzed. If there was only statistical heterogeneity but no clinical heterogeneity, the random-effects model was used with pooled data.[13] If there were small probability events or the data could not be analyzed, general description was used for qualitative evaluation. A P value < 0.05 was used to indicate statistical significance.

Results

Literature search and results

A total of 376 studies were identified in the database search. After excluding 104 duplicated studies, the reviewers read the titles and abstracts of the remaining studies, and then excluded 244 unrelated studies such as reviews, animal experiments, and biomechanical analyses, leaving 28 studies. After reading the full text and excluding 21 studies with no indicators of interest, seven studies were finally included.[14–20]

General information of the included studies

Among the seven included studies,[14–20] one article was published in Chinese;[20] three were RCTs[16,17,19] and the remaining four were OSs.[14,15,18,20] These studies were published from 2000 to 2012. The studies included 1402 patients (1469 THAs) with a baseline comparable between the groups in each study: 767 patients (809 THAs) in the screw-fixed group and 635 patients (660 THAs) in the non-screw-fixed group. The age range of patients was 32 to 89 years old. The number of screws (mostly one to three) used for fixing the cup varied between studies. Follow-up was from 2 to 9 years after THA. Specific baseline information for the included studies is shown in Table 1.

Quality assessment

Among RCT studies, Thanner 2000[19] used random grouping, but did not report the generation of sequences, allocation concealment, and blinding; Rohrl 2004[17] used sealed envelopes for allocation concealment, but did not mention blinding; Pakvis 2012[16] used a computer randomization sequence and sealed envelopes to conceal the allocation scheme, as well as blinding. The other bias in these RCTs was low risk. In quality assessment of OSs using the NOS, the scores for Roth 2006,[18] Iorio 2010,[15] Liang 2011,[20] Garcia-Rey 2012[14] were 7, 6, 4, and 8, respectively.

Clinical efficacy

Cup migration. The overall heterogeneity of the included studies was high ($I^2 = 53\%$). After random-effects model analysis, we found no significant difference in the occurrence of acetabular cup migration between the screw-fixed and non-screw-fixed groups (OR = 0.83; 95% CI: 0.23–3.04). In other words, the use of screws may not influence cup migration (Figure 1). Similarly, the difference was not significant (OR = 1.19; 95% CI: 0.38–3.75), after removing Pakvis 2012,[16] and the heterogeneity was low ($I^2 = 42\%$).

Roentgen stereogrammetric analysis (RSA) evaluation. Three studies used RSA to measure the spatial position and rotation of the cup. The RSA evaluation system measures cup medial–lateral, distal–proximal, anterior–posterior displacements and rotation of the prosthesis according to the transverse, longitudinal, and sagittal axes; the heterogeneity was $I^2 = 0\%$ for all measures. Fixed-effects model analysis indicated that the displacement and angle change of the cup in the above six directions or planes were as follows: (MD = −0.06; 95% CI: −0.31–0.19), (MD = −0.14; 95% CI: −0.27–0.00), (MD = 0.05; 95% CI: −0.22–0.32), (MD = 0.23; 95% CI: −0.20–0.66), (MD = 0.46; 95% CI: −0.27–1.18), and (MD = −0.06; 95% CI: −0.55–0.44), respectively. RSA measurement suggests that screw fixation may not be associated with displacement (Figure 2).

All-cause reoperation rate. Among five of the included studies, Roth 2006[18] and Thanner 2000[19] reported no reoperation during the follow-up period in either group. Owing to the low heterogeneity, meta-analysis using the fixed-effects model revealed that there was no significant difference (OR = 0.82; 95% CI: 0.40–1.68) in the occurrence of reoperation between the screw-fixed and non-screw-fixed groups (Figure 3). To verify stability of the results, we conducted a sensitivity analysis: after removing the most weighted study, that of Iorio 2010,[15] the results showed no significant difference in the occurrence of reoperation between the screw-fixed and non-screw-fixed group (OR = 1.96; 95% CI: 0.57–6.66) and the heterogeneity was low ($I^2 = 0\%$).

Table 1. Specific baseline information for included studies.

Study	Type	Number of hip joints	Age (years)	Inclusion criteria	Surgical approach	Composition of artificial hip joint	Screw usage	Follow-up time (years)
Thanner 2000								
Screw-fixed group	RCT	30	56 (32–75)	Patients requiring THA	Modified Hardinge approach	Trilogy cup; cemented and uncemented femoral stem	1–3 screws	2
Non-screw-fixed group		34	56 (32–75)				0	
Rohrl 2004								
Screw-fixed group	RCT	22	56 (40–65)	Primary or secondary osteoarthritis	Posterior approach	Polyethylene liner cup, 28-mm femoral head	–	5
Non-screw-fixed group		21	56 (36–65)				0	
Pakvis 2012								
Screw-fixed group	RCT	18	64 ± 8	Primary osteoarthritis	Posterolateral approach	RM Pressfit Cup (Switzerland); CLS femoral stem; 32-mm ceramic polyethylene articulation head	2 screws	2
Non-screw-fixed group		19	62 ± 6				0	
Roth 2006								
Screw-fixed group	OS	110	61–72	Patients requiring THA	Posterior approach	DURALOC cup	1–3 screws	5
Non-screw-fixed group		101	61–72				0	
Iorio 2010								
Screw-fixed group	OS	509	67.16 (32–89)	Patients with osteoarthritis or traumatic arthritis	–	Press-Fit Condylar, DURALOC, Pinnacle cup; cemented and uncemented femoral stem; 28-mm and 32-mm femoral head	109 hips using 1 screw; 335 hips using 2 screws; 59 hips using 3 screws; 6 hips using 4 or more screws	6.32
Non-screw-fixed group		266	66.68 (39–88)				0	6.9
Liang 2011								
Screw-fixed group	OS	32	50.25 ± 10.85	Patients requiring THA	Anterolateral approach	DURALOC cup	1–2 screws	2
Non-screw-fixed group		30	50.06 ± 11.33				0	
Garcia-Rey 2012								
Screw-fixed group	OS	88	47.9 ± 15.9	Osteoarthrosis, developmental traumatic arthritis, inflammatory arthritis, avascular necrosis of the femoral head	Posterolateral approach	Cerafit Triradius press-fit cup (France); Cerafit Multicone femoral stem; 28-mm and 32-mm femoral head	2 screws	8.9
Non-screw-fixed group		189	51.9 ± 12.3				0	

Abbreviations: RCT, randomized controlled trial; OS, observational study.

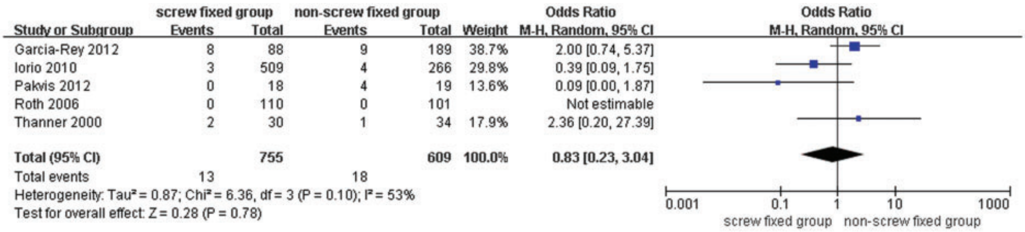

Figure 1. Forest plot of cup migration in screw-fixed and non-screw-fixed groups.
M-H, Mantel–Haenszel.

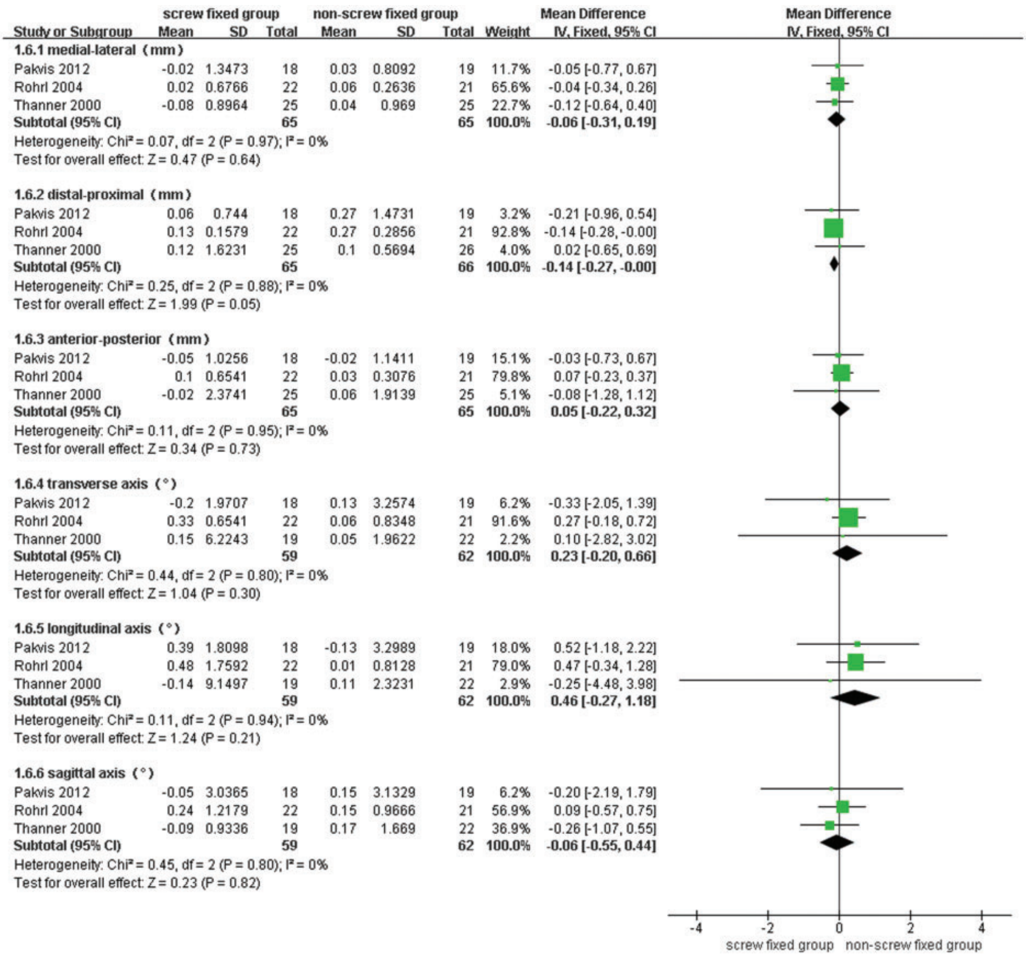

Figure 2. Forest plot of roentgen stereogrammetric analysis between screw-fixed and non-screw-fixed groups.
IV, inverse variance.

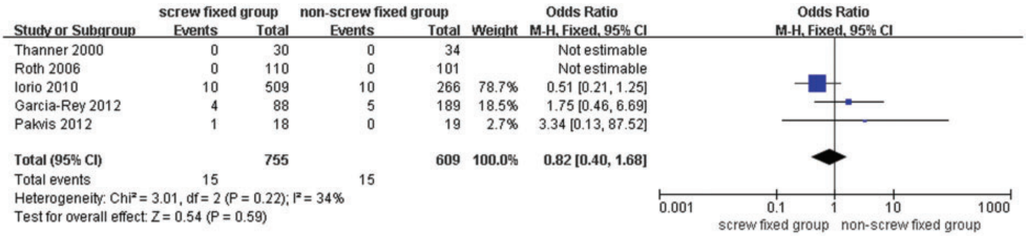

Figure 3. Forest plot of reoperation in screw-fixed and non-screw-fixed groups.

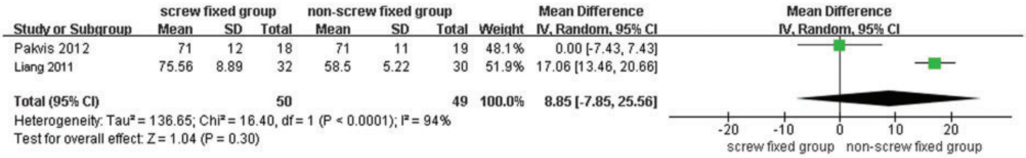

Figure 4. Forest plot of operative time in screw-fixed and non-screw-fixed groups.

Operative time. Two studies compared operation time between the two groups, but the heterogeneity was high ($I^2 = 94\%$, $P < 0.0001$). After verification, no significant clinical heterogeneity was found between the two groups. The pooled results from the random-effects model suggested no significant difference in the length of operation time between the two groups (MD = 8.85; 95% CI: −7.85–25.56), as shown in Figure 4.

Postoperative bone change. Four studies reported postoperative hip bone changes in both groups. The heterogeneity of bone density reduction around the cup was low ($I^2 = 0\%$), and the results suggested that whether screws are used is not related to bone density reduction around the cup (OR = 1.36; 95% CI: 0.48–3.86). Additionally, heterogeneity of osteosclerosis in the C1 region of the DeLee and Charnley zone was high ($I^2 = 62\%$). Verification showed that Liang 2011[20] and Roth 2006[18] both reported that bone sclerosis in the C1 region occurred within 5 months after operation; the former study used one to two screws and the latter used one to three screws. The results of random-effects model analysis suggested that screw fixation may be related to bone sclerosis in the C1 region (OR = 3.62; 95% CI: 1.09–12.08; $P = 0.04$), as shown in Figure 5.

HHS functional score. Three studies evaluated the HHS of hip function in the two groups. The heterogeneity was high ($I^2 = 57\%$), probably owing to differences in the time of postoperative evaluation. The results from the random-effects model suggested that screw fixation may not be related to the HHS (MD = −1.03; 95% CI: −3.58–1.53), as shown in Figure 6.

Discussion

In THA, doubts remain as to whether the press-fit acetabular component should be fixed with screws.[18] Additional screws may damage important nerves and blood vessels,[21] and wear of the screws may lead to osteolysis.[22] To assess the relationship between the use of screws and cup stability, we conducted the present meta-analysis and

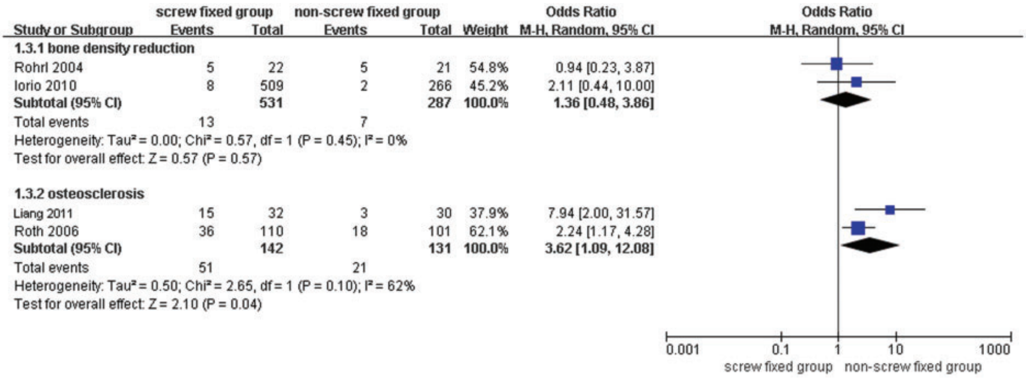

Figure 5. Forest plot of bone changes in screw-fixed and non-screw-fixed groups.

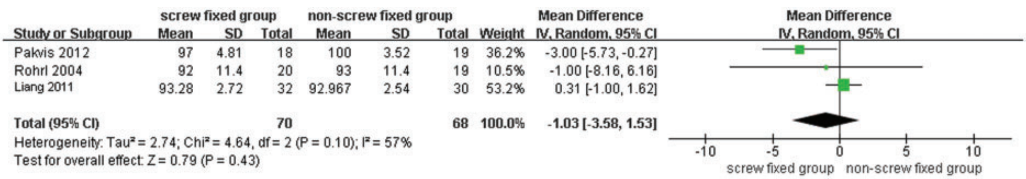

Figure 6. Forest plot of Harris hip scores in screw-fixed and non-screw-fixed groups.

found that additional screw fixation may not be associated with postoperative cup migration, RSA cup displacement or rotation, all-cause reoperation, length of operation, reduction of bone density around the cup, or HHS functional score, but use of additional screws may be associated with bone sclerosis in the C1 region of the hip.

The stability of the cup is an important index that reflects the outcome of THA. We analyzed the occurrence of cup migration and RSA evaluation and used OR, MD, and sensitivity analysis; we found that additional screw fixation had no significant effect on stability of the cup. The incidence of cup migration with screws was 1.72% (13/755) and that without screws was 2.96% (18/609). There are many factors affecting cup stability, including patient age, bone condition, cup surface coating, cup coverage rate, and cup placement.[23] However, degenerative changes in the bone around the cup are the direct cause of cup loosening.[24,25] Therefore, it is necessary to evaluate the patient's characteristics before surgery. In addition, screw fixation had no effect on all-cause reoperation. In this meta-analysis, the main causes of all-cause reoperation were loosening of the acetabular cup or femoral stem prosthesis, followed by joint dislocation and local infection. The all-cause reoperation rate was 1.98% (15/755) in the screw-fixed group and 2.46% (15/609) in the non-screw-fixed group. Only two studies provided a comparison of operative time, with a high heterogeneity, which may be related to operations conducted by different surgeons. The Harris hip functional score, an important indicator of life quality, did not show that additional screw fixation can improve the clinical prognosis of patients.

A problem requiring attention is that additional screw fixation may cause sclerosis of the C1 region in the DeLee and Charnley zone of the hip.[26] Roth et al. identified this phenomenon in the C1 region of the acetabulum after additional screw fixation. This phenomenon may be related to the unbalanced force exerted by the screws, as the fulcrum of acetabular prostheses,[18] which may lead to the hypothesis that additional screws are not conducive to cup stability. Screws may not only promote peripheral bone changes[22] but may also damage nerves and blood vessels;[21] only a few of our included studies mentioned this complication. Particularly for patients in whom multiple screws are used for fixation, greater attention should be paid to this potential problem. Thus, there is no direct evidence that additional screw fixation can improve the initial stability of the cup and reduce the occurrence of cup loosening after THA.

Our study has some limitations. First, the timing of the RCT and OS studies included in this study is inconsistent, and the internal design of each study also has varying degrees of deficiency; these factors will affect the authenticity of our results. Second, the question remains as to whether using screws to fix the acetabular cup is related to the quality and coverage of the autologous bone, however, none of the seven studies considered this factor. Third, older cups used in long-term studies often had a relatively smooth surface whereas modern cups have a much higher coefficient of friction. These differences influence the need for screws, and opinions about the use of screws will likely change in the future. These limitations suggest that a prospective large-sample RCT is needed, to clarify the causal relationship between screw fixation, cup stability, and patient prognosis.

We can conclude that currently, limited evidence shows that the use of screws during THA may not improve stability of the cup.

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Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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