

INPLASY

Cement Augmentation of Pedicle Screw Constructs as a Modifier of Hardware Failure Risk in Instrumented Metastatic Spine Surgery: A Systematic Review and Meta-Analysis

INPLASY202640045

doi: 10.37766/inplasy2026.4.0045

Received: 13 April 2026

Published: 13 April 2026

Corresponding author:

Ying-Ching Li

johnhunter0823@gmail.com

Author Affiliation:

Chang Gung Memorial Hospital,
Linkou Medical Center; Chang Gung
University.

Li, YC; Li, CY; Huang, SH; Wang, HK; Chen, KH; Kang, YP; Lu, YJ.

ADMINISTRATIVE INFORMATION

Support - Nil.

Review Stage at time of this submission - The review has not yet started.

Conflicts of interest - None declared.

INPLASY registration number: INPLASY202640045

Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 13 April 2026 and was last updated on 13 April 2026.

INTRODUCTION

Review question / Objective In adult patients with spinal metastases undergoing instrumented pedicle screw fixation, does cement-augmented pedicle screw fixation (CAPS) reduce hardware failure rates compared to conventional (non-augmented) pedicle screw fixation, and does the Spinal Instability Neoplastic Score (SINS) modify this effect?

Rationale Hardware failure (HF) after instrumented posterior fixation for spinal metastases remains a consequential complication, affecting 2–22% of patients. Despite widespread adoption of cement-augmented pedicle screw fixation (CAPS), no meta-analysis has quantified its effect on HF rates or examined the Spinal Instability Neoplastic Score (SINS) as a potential modifier. This systematic review and meta-analysis was conducted to address this critical evidence gap.

Condition being studied Hardware failure (screw loosening, pullout, rod fracture, cage migration,

progressive kyphosis) after instrumented posterior pedicle screw fixation for spinal metastases.

METHODS

Search strategy Five electronic databases were searched from inception through April 2026:

- PubMed/MEDLINE
- Embase
- Cochrane CENTRAL
- Web of Science
- Scopus

Three Boolean concept blocks were used: (1) population: spinal metastases; (2) intervention: cement-augmented pedicle screw fixation; (3) outcome: hardware failure terms.

Supplementary searching included backward citation tracking of all included studies and relevant review articles. No language or date restrictions were applied. Full search strategies are provided in Supplementary Appendix A.

Participant or population Inclusion: Adult patients (≥ 18 years) with spinal metastases undergoing instrumented pedicle screw fixation with reported hardware failure outcomes (symptomatic or radiographic).

Exclusion: Case reports ($n \leq 5$); studies restricted to pure vertebroplasty or kyphoplasty without pedicle screw constructs; studies where metastatic and non-metastatic populations were not separable; conference abstracts.

Intervention Cement-augmented pedicle screw fixation (CAPS): polymethylmethacrylate (PMMA) injected through fenestrated or cannulated pedicle screws to create a composite screw-cement-bone interface.

Comparator Conventional (non-augmented) pedicle screw fixation using standard solid screws without cement augmentation.

Study designs to be included Observational studies (retrospective and prospective cohort studies, case-control studies, case series). Both single-arm studies reporting hardware failure rates and direct comparative studies were eligible. Randomised controlled trials were eligible but none were identified.

Eligibility criteria Inclusion:

- Adult patients (≥ 18 years) with spinal metastases
- Instrumented pedicle screw fixation
- Reported hardware failure outcomes (symptomatic or radiographic)
- CAPS arm: PMMA injected through fenestrated or cannulated pedicle screws
- Conventional arm: standard solid screws without cement.

Information sources Five databases searched from inception through April 2026:

1. PubMed/MEDLINE
2. Embase
3. Cochrane CENTRAL
4. Web of Science
5. Scopus

Supplementary: backward citation tracking of included studies and relevant reviews. No date or language restrictions.

Main outcome(s) Hardware failure rate (pooled proportion with 95% CI) for cement-augmented and non-augmented arms, computed separately using the Freeman-Tukey double arcsine transformation with DerSimonian-Laird random-effects models.

Additional outcome(s) 1. Direct comparative OR of CAPS vs conventional fixation
2. Sensitivity analysis restricted to SINS-reporting studies
3. Exploratory meta-regression: SINS as effect modifier.

Data management Two independent reviewers extracted data using a pre-piloted standardised form. Disagreements resolved by a third reviewer.

Risk of bias: Newcastle-Ottawa Scale (NOS)

- Good: ≥ 7 stars
- Fair: 5–6 stars
- Poor: < 5 stars.

Quality assessment / Risk of bias analysis Risk of bias was assessed using the Newcastle-Ottawa Scale (NOS) for observational studies, with pre-specified quality thresholds:

- Good: NOS ≥ 7 stars
- Fair: NOS 5–6 stars
- Poor: NOS < 5 stars

Assessment was performed independently by two reviewers. Domains evaluated: selection, comparability, and outcome ascertainment.

Strategy of data synthesis Pooled hardware failure rates were computed separately for cement-augmented and non-augmented arms using the Freeman-Tukey double arcsine transformation with DerSimonian-Laird (DL) random-effects models. The Restricted Maximum Likelihood (REML) estimator was applied as a sensitivity check.

For direct comparative data, odds ratios were computed with continuity correction (0.5) where cells contained zero events.

Heterogeneity was quantified using I^2 , Cochran Q, and τ^2 . 95% prediction intervals were computed for all pooled estimates.

Publication bias: Egger's regression and Begg's rank correlation tests (applied when $k \geq 10$).

Certainty of evidence: GRADE framework, starting at low certainty for observational studies.

All analyses were performed in Python 3.12.

Subgroup analysis 1. Leave-one-out sensitivity analysis for the cement-arm pooled estimate
2. Sensitivity analysis restricted to studies with available SINS data

-
3. Exploratory weighted least-squares meta-regression of study-level mean SINS as a moderator of hardware failure rate
 4. SINS-stratified descriptive analysis (SINS 7–12 vs >12).

Sensitivity analysis Sensitivity analyses: leave-one-out; SINS-restricted.

Language restriction English.

Country(ies) involved Taiwan.

Keywords cement augmentation; hardware failure; meta-analysis; pedicle screw; SINS; spinal metastases; Spinal Instability Neoplastic Score; systematic review.

Dissemination plans Results will be submitted for publication in a peer-reviewed journal (target: European Spine Journal). Data extraction spreadsheet available from corresponding author upon reasonable request.

Contributions of each author

Author 1 - Ying-Ching Li - drafted the manuscript.

Email: johnhunter0823@gmail.com

Author 2 - Cheng-Yu Li - The author provided statistical expertise.

Email: mick791212@hotmail.com

Author 3 - Sheng-Han Huang - The author contributed to the development of the selection criteria, and the risk of bias assessment strategy.

Email: suntoryer@gmail.com

Author 4 - Hong Kai Wang - The author read, provided feedback and approved the final manuscript.

Email: cakekevin3211@hotmail.com

Author 5 - Kuan-Hung Chen - The author read, provided feedback and approved the final manuscript.

Email: khchenns@gmail.com

Author 6 - Yan-Po Kang - The author read, provided feedback and approved the final manuscript.

Email: mr1880@cgmh.org.tw

Author 7 - Yu-Jen Lu - The author read, provided feedback and approved the final manuscript.

Email: alexlu0416@gmail.com