Risk Factors for Recollapse of the Augmented Vertebrae After Percutaneous Vertebral Augmentation: A Systematic Review and Meta-Analysis

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Key words
- Cement distribution pattern
- Intravertebral cleft
- Meta-analysis
- Osteoporotic vertebral compression fractures
- Percutaneous vertebral augmentation
- Recollapse of the augmented vertebrae

Abbreviations and Acronyms
BMD: Bone mineral density
CCT: Case-control trail
CI: Confidence interval
IVC: Intravertebral cleft
LKA: Local kyphotic angle
OR: Odds ratio
OVCF: Osteoporotic vertebral compression fracture
PKP: Percutaneous kyphoplasty
PMMA: Polymethylmethacrylate
PVA: Percutaneous vertebral augmentation
PVP: Percutaneous vertebroplasty
SMD: Standardized mean difference
VCR: Vertebral compression rate
VHR: Vertebral height restoration

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BACKGROUND AND OBJECTIVE: **Recollapse of the augmented vertebrae after percutaneous vertebral augmentation treatment for osteoporotic vertebral compression fractures has obtained much attention. Although many potential risk factors have been proposed, they are still disputed. The aim of our study was to identify the characteristics of the augmented vertebrae that had undergone a recollapse according to a systematic review from the earliest available records up to August 2017 and then conduct a meta-analysis based on eligible studies to assess significant potential risk factors for recollapse of the augmented vertebrae.**

METHODS: **Fourteen studies were identified for investigating recollapse of the augmented vertebrae. Of those studies, 9 studies were eligible for meta-analysis.**

RESULTS: **Pooled results showed that 5 primary factors were associated with recollapse of the augmented vertebrae, including preoperative intravertebral cleft, the affected vertebrae in the thoracolumbar region, preoperative severe kyphotic deformity, solid lump cement distribution pattern, and higher vertebral height restoration. It was possibly another risk factor that the distance between PMMA and superior end plate was relatively large.**

CONCLUSIONS: **Careful observation of patients with these risk factors and reasonable intervention could be useful to prevent deterioration of their clinical course.**

INTRODUCTION

Percutaneous vertebral augmentation (PVA) refers to percutaneous vertebroplasty (PVP) and percutaneous kyphoplasty (PKP). It is a minimally invasive technique for treating painful osteoporotic vertebral compression fractures (OVCFs). Numerous clinical studies[1-3] have shown that the treatment rapidly relieved the pain of patients, restored vertebral height partially, and provided biomechanical stability by injecting bone cement into fractured vertebrae. However, in the light of previous reports, many studies[4-18] have reported recollapse of the augmented vertebrae with significant vertebral height loss and aggravation of kyphotic deformity after a postoperative follow-up period, which usually requires further treatment. Thus, it is important to clarify risk factors for recollapse of the augmented vertebrae after PVA treatment for OVCFs.

To the best of our knowledge, previous studies have reported many risk factors for recollapse of the augmented vertebrae after PVA treatment for OVCFs, such as wedge fracture,[13] preoperative intravertebral cleft (IVC),[5,6,8-13,15] preoperative high local kyphotic angle (LKA),[7,9] small volume cement injection,[16,17] solid lump cement distribution pattern,[5,12,14] more vertebral height restoration (VHR),[5,8,10-12] lesser LKA restoration,[12] and non–polymethylmethacrylate (PMMA)–end plate–contact.[9,18] However, these studies were limited by either a small sample size or because a limited number of potential risk factors were investigated. Some of the results were conflicting. For example, most researchers[5,6,8-13,15] suggested that preoperative IVC could increase the risk of recollapse of the augmented vertebrae, whereas a study by Kang et al.[7] concluded that preoperative IVC was not correlated with the development of recollapse. Hence, we first reviewed the characteristics of patients who underwent recollapse of the augmented vertebrae and then identified those risk factors by undertaking a meta-analysis for all eligible studies.

METHODS

Search Strategy

We systematically searched PubMed, EMBASE, and the Cochrane Library for studies published up to August 2017. The

keywords for the study object (MeSH [Medical Subject Headings] words or free words) included ("the treated vertebrae" or "the augmented vertebrae" or "previous vertebrae") AND ("recollapse" or "recompression" or "refracture" or "subsequent vertebral fracture" or "recurrent fracture" or "gradual height decrease" or "vertebral height loss"). For the intervention strategy, the keywords were "vertebroplasty" or "kyphoplasty," or "vertebral augmentation." The reference lists of selected articles and reviews were manually reviewed for potentially relevant citations until no additional articles were found. When required, the authors of the articles were contacted. All analyses were based on previous published studies; thus, no ethical approval and patient consent were required.

Selection Criteria

Two independent reviewers screened the titles and abstract of the studies to determine the relevance of each study to this review. All the studies that investigated recollapse of the augmented vertebrae after PVA treatment for OVCFs were collected to identify all possible risk factors of recollapse. Then, these studies were included in a meta-analysis if they met the following criteria: first, the study had to be conducted through case-control trial; second, the risk factors were investigated for recollapse of the augmented vertebrae after PVA (PVP or PKP) treatment for OVCFs; third, sufficient data were published to estimate an odds ratio (OR) or standardized mean difference (SMD) with 95% confidence interval (CI); fourth, the follow-up time of the patients was more than 12 months. The studies were excluded from our meta-analysis if publications were duplicated or from the same study population. Articles that did not report outcomes of interest were also excluded.

Data Collection and Assessment of Quality

The following data were extracted from eligible studies by 1 investigator (W.B.Y.) and reviewed by another (J.W.): first author and year of publication, country, study design, type of surgery, sample size, age, all included variables, mean length of follow-up, and comments. To assess the quality of the studies, the Newcastle-Ottawa Scale with a 9-point system[19] was used to assess each study with respect to the following 3 broad perspectives: the selection of the study groups (0–4 points); the comparability of the groups (0–2 points); and the determination of either the exposure or the outcome of interest (0–3 points). Studies with ≥7 points were considered high quality. Those 2 evaluators also independently performed methodological quality evaluations and then cross-validated the results. When disagreement occurred between the 2 evaluators, a third evaluator (W.X.X.) was involved.

The Variables of Potential Risk Factors

Twelve potential risk factors were evaluated in our meta-analysis results, including the age, sex, BMD (bone mineral density), fracture level (thoracolumbar vs. nonthoracolumbar), fracture type (wedge or nonwedge), preoperative IVC (Figure 1), preoperative vertebral compression rate (VCR), preoperative LKA, cement volume injected, cement distribution patterns (solid lump distribution pattern vs. interdigitated distribution pattern, Figure 2), the degree of VHR, the degree of LKA restoration, and cement leakage into disc space.

Meta-Analysis Methods

The STATA 11.0 software (Stata Corporation, College Station, Texas, USA) was used to analyze the data. The differences in dichotomous and continuous outcomes were expressed as OR with 95% CI and SMD with 95% CI, respectively. Before the original data were synthesized, the Q test and I^2 value calculations were adopted to assess the heterogeneity of the data. A random-effects model (DerSimonian-Laird method) was used as a meta-analysis when the P value was <0.1 and I^2 value >50%; otherwise, a fixed-effect model (Mantel-Haenszel method) was used for analysis. When significant heterogeneity was found in our study, a sensitivity analysis was performed to identify the trials that potentially biased the results. The publication bias was assessed using

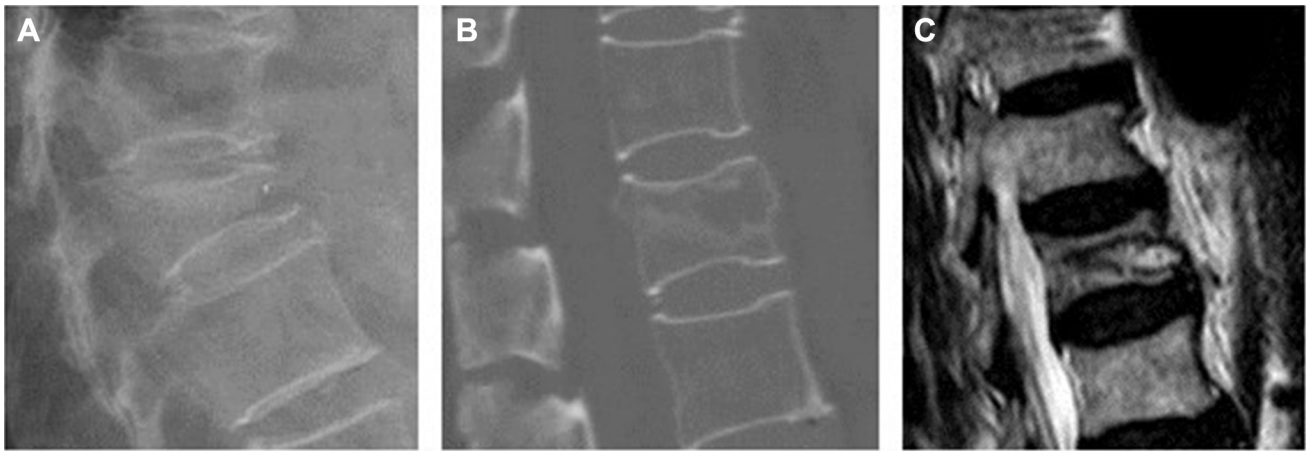

Figure 1. The imaging manifestation of preoperative intravertebral cleft. (**A**) Lateral radiograph shows radiolucent shadow in T12; (**B**) sagittal computed tomography demonstrates a T12 superior endplate intravertebral cleft; (**C**) Sagittal T2-weighted magnetic resonance imaging shows fluid within a T12 hypersign intravertebral cleft.