

Vitamin D Supplementation and Spinal Fusion Success: A Meta-Analysis

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Poor bone mineralization and various musculoskeletal disorders have been linked to Vitamin D deficiency, especially osteoporosis and fractures.^{1,2} Recently, interest has grown in the potential effects of vitamin D on spinal fusion outcomes; however, clinical evidence supporting its benefit remains inconclusive.

Objective: This meta-analysis aims to evaluate the effect of vitamin D supplementation on spinal fusion success rates in patients undergoing spinal fusion surgery.

Methods: We conducted a systematic literature search in PubMed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Eligible studies included randomized controlled trials and prospective and retrospective cohort studies reporting spinal fusion outcomes in patients receiving vitamin D supplementation.³ **Results:** Three studies met the inclusion criteria, including one randomized controlled trial and two prospective cohort studies, involving 270 patients (170 in the vitamin D group and 100 in the control group). Pooled analysis demonstrated no statistically significant difference in fusion success between groups (risk ratio = 1.01; 95% CI = 0.72–1.41; $p > 0.05$). We observed high heterogeneity ($I^2 = 89\%$), and risk of bias ranged from low to moderate across studies.

Conclusion: Vitamin D supplementation did not significantly improve spinal fusion success rates.

Keywords: Preoperative Vitamin D, Spinal Fusion

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Introduction

Vitamin D is essential for bone health. Vitamin D deficiency has been linked to poor bone mineralization and various musculoskeletal disorders, especially osteoporosis and fractures.^{1,2} Recently, interest has grown in the potential effects of vitamin D on spinal fusion surgery outcomes. Spinal fusion surgery is a procedure

that treats various spinal pathologies. These include degenerative spine diseases, deformities, and fractures. Although surgical techniques and instrumentation have advanced, nonunion and pseudoarthrosis remain major concerns for spine surgeons.⁴ This meta-analysis reviews and analyzes evidence on the relationship between

vitamin D supplementation and spinal fusion success.

2. Methodology

We searched PubMed to identify relevant studies. We applied inclusion and exclusion criteria to select appropriate papers. We extracted data from each paper and compiled them in a table. The inclusion criteria are (1) papers published in English, (2) papers with vitamin D supplementation as the intervention, (3) papers that provide fusion rate, and (4) randomized controlled trials (RCTs), prospective, or retrospective cohort studies. Exclusion criteria of this study are (1) papers published in languages other than English, (2) papers that do not provide data regarding vitamin D levels or don't provide fusion rate information, (3) literature reviews, narrative reviews, systematic reviews, or meta-analyses, (4) commentaries or letters to the editor, (5) case reports or case series, and (6) in vivo or in vitro studies.

Types of studies and participants

This meta-analysis includes clinical trials, prospective studies, and retrospective studies. The studies must mention vitamin D supplementation as the intervention.

Types of outcome measure

The primary objective of this research is to compare spinal fusion success between patients who take vitamin D and those who do not.

Search methods for identification of studies

This research used an online literature search following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. We conducted searches in PubMed with the following keyword: Preoperative Vitamin D AND Spinal Fusion

Data collection and analysis

Selection of studies

We initially filtered search results by title relevance, then by abstract relevance. Non-English publications were automatically excluded. All authors then evaluated full-text articles to identify potentially eligible studies. We documented and reported exclusion reasons.

Data extraction and management

We extracted data and presented them in a table. We also reported the vitamin D dose and levels, if mentioned. The table also presents the types of surgery in each included study.

Assessment of risk of bias

All authors evaluated the risk of bias. We assessed the biases outlined in the Cochrane Collaboration Tool for Assessing Risk of Bias in Randomized Trials, published in 2011.(3) We evaluated non-clinical trials using Cochrane's ROBINS-I tool.(5) We visualized the risk-of-bias assessment using the RobVis tool.(6)

Statistical analysis

Statistical analysis was performed using Review Manager (RevMan) 5.4 and Open Meta-Analysis(7) Results are presented as forest plots.

Assessment of heterogeneity

We evaluated heterogeneity using the I² value during forest plot construction in RevMan 5.4. If the I² value is 50% or higher, the studies are deemed heterogeneous, and thus the statistical model is adjusted to a random-effects model.(3)

3. Results

Figure 1 illustrates the exclusion process, following PRISMA guidelines

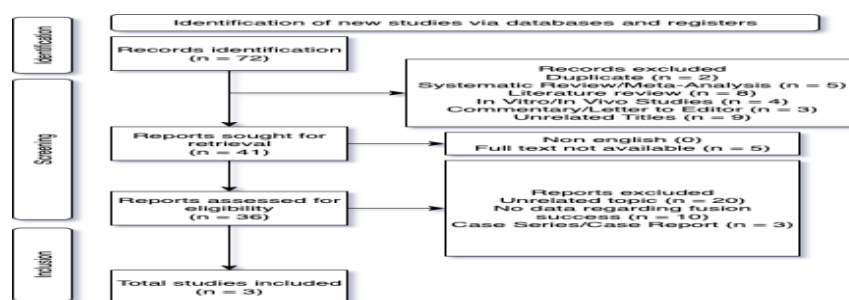


Figure 1. Studies exclusion process

Included studies

We included three studies. Two were prospective studies, and one was an RCT. Table II provides detailed data from each included study. Hu and colleagues conducted an RCT on 34 patients. Twenty-one patients were enrolled in the intervention group, and the rest were treated as controls. They did lumbar interbody fusion surgery with 95.2% fusion success in the intervention group.⁸ Wang and colleagues did a prospective study on patients who underwent lumbar interbody fusion. Thirty-six patients were assigned to the intervention group and 35 to the control group. The fusion success was 91.67% and 74.29% in the intervention and control groups, respectively.⁹ Tao Shi et al. did a prospective cohort study on osteopenic and osteoporotic patients who underwent lumbar interbody fusion and found a lower fusion rate compared to control (73.45% vs 96.15%).¹⁰

Table 2. Summary of findings

Author	Population	Surgical Procedure	Outcome
Hu, 2022(8) RCT	Intervention group (n = 21) Age 64 ± 11.1 Vit D 26.8 ± 8.8	Lumbar Interbody Fusion	Intervention group (6mo) Fused 20 (95.2%) Vit D 31.6 ± 8.2
	Control (n = 13) Age 56.1 ± 15 Vit D 26.4 ± 12.9		Control (6mo) Fused 11 (84.6%) 27.4 ± 12.9
Wang, 2025(9) Prospective Cohort	Intervention group (n = 36) Age 54.7 ± 8.2 Vit D n/a	Lumbar Interbody Fusion	Intervention group Fused 33 (91.67%)
	Control (n = 35) Age 55.2 ± 9.4 Vit D n/a		Control Fused 26 (74.29%)
Tao Shi, 2023(10) Prospective Cohort	Intervention (Osteopenia and Osteoporosis; n = 113) Vit D Osteopenia 15.8 ± 6.6 Vit D Osteoporosis 16.7 ± 7.1	Lumbar Interbody Fusion	Intervention (6 mo) Fused 83 (73.45%) Vit D Osteopenia 36.9 ± 3.9 Vit D Osteoporosis 27.3 ± 2.1
	Control (n = 52) Vit D 37.8 ± 4.2		Control (6 mo) Fused 50 (96.15%) Vit D (6mo) 36.9 ± 3.9

Risk of bias

One study was a clinical trial (8), and we evaluated its risk of bias using Cochrane’s ROBINS-I tool. We judged the study’s risk of bias to be low, due to its complete explanation on each bias domain (Figure 2). We assessed the remaining studies’ biases using the ROBINS-I tool. Wang’s study (9) had a moderate risk of bias and a serious risk of bias in the confounding and classification intervention domains, respectively. The reason to this was unclear preoperative vitamin D level and the presence of another supplementation in addition to vitamin D, respectively. Although

preoperative vitamin D level was not the point of interest in this study, we considered failure to report it a possible source of bias because it may have included vitamin D-deficient subjects; therefore, this condition should have been reported. Tao Shi’s study (10) was considered to have serious risk and moderate risk in the confounding and missing-data domains, respectively. The serious risk of confounding bias was because they included osteoporotic patients, which clearly would affect the end result.

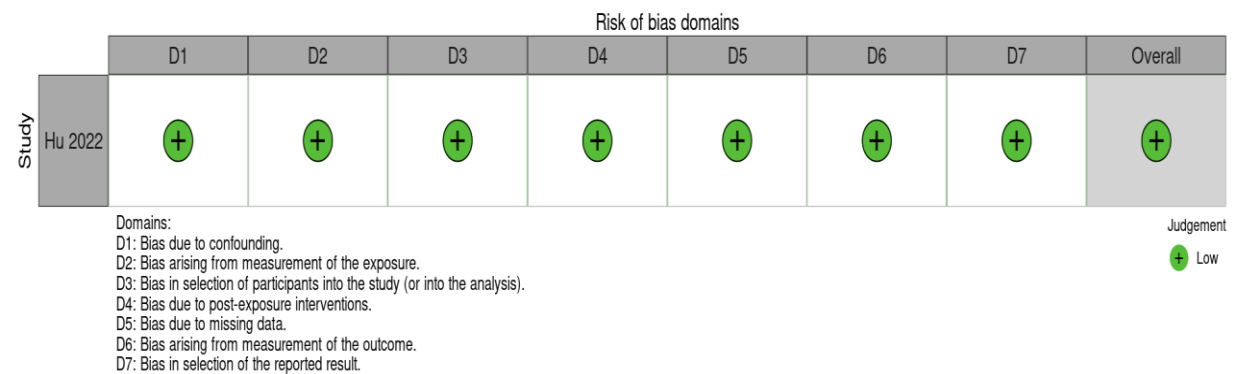


Figure 2. Assessment of risk of bias of the RCT study

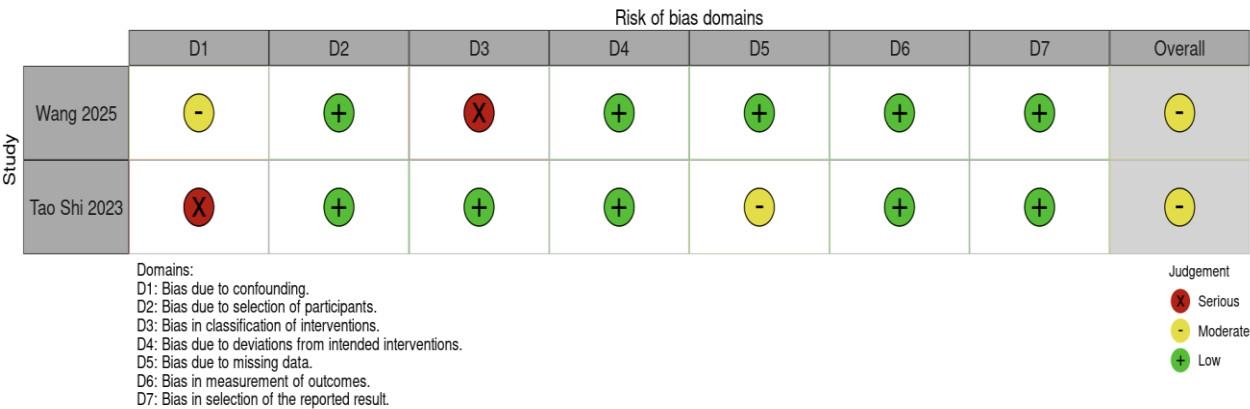


Figure 3. Assessment of risk of bias of the prospective studies

Summary of findings

Altogether, 3 studies were analyzed with a total of 170 subjects in the Vitamin D Supplement cohort and 100 subjects in the Control cohort. Based on the analysis using a random-effects model with the Mantel-Haenszel method to compare risk ratios, the cohorts did not differ significantly; the

overall risk ratio was 1.01 (95% CI: 0.72-1.41). The overall effect test did not show a significant effect. Significant heterogeneity was detected ($p<0.01$), suggesting inconsistent effects in magnitude and/or direction. The I^2 value indicates that 89% of the variability among studies arises from heterogeneity rather than random chance.

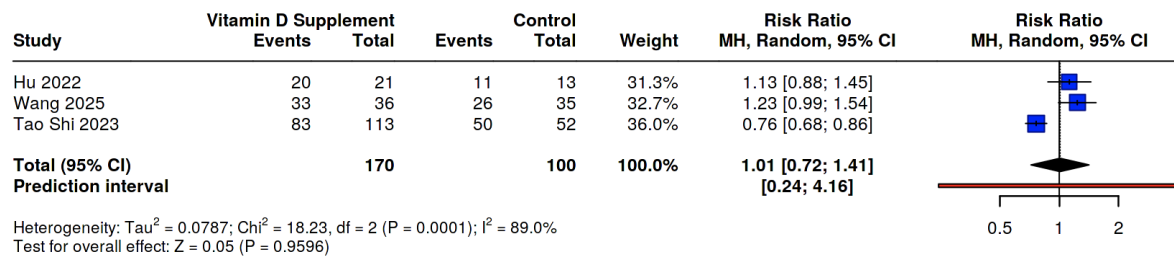


Figure 4. Forest plot of Meta-Analysis

Discussion

In spinal surgery, adequate bone health is crucial for fusion success, implant integration, and maintaining structural integrity. However, despite vitamin D's importance for bone health in general, the role of vitamin D status (deficiency vs normal) in spinal surgery outcomes has not been systematically consolidated.¹¹ That said, the benefits of vitamin D have also been mentioned several times.

Kerezoudis and colleagues found that low preoperative vitamin D would result in worse spinal fusion. Correcting vitamin D deficiency preoperatively would help maximize the success of spinal fusion.¹² Similarly, Xu and colleagues observed that patients with lower preoperative vitamin D had poorer short-term surgical outcomes after spinal fusion.¹³ No consensus exists on the optimal supplementation dose, timing (preoperative, perioperative, postoperative), or target serum levels for spinal surgery patients. Some suggested thresholds are borrowed (e.g. 25-hydroxyvitamin D > 30 ng/mL), but applicability to spinal fusion is not confirmed.¹¹

Despite varying results and statements in the literature, Vitamin D's role in bone metabolism is

well known. It is vital in supporting calcium absorption and bone mineralization. It is also essential for the immune system. Laboratory studies and epidemiological data have demonstrated a correlation between vitamin D deficiency and various conditions, including skeletal diseases, inflammatory bowel diseases, respiratory tract infections, and autoimmune disorders.¹⁴

This meta-analysis found no significant difference in spinal fusion between those who received vitamin D supplementation and those who did not. However, we identified several limitations that might have affected the results. First, follow-up duration may have differed. Using a single time point for fusion evaluation might yield a more consistent and significant result. Second, the study did not report preoperative vitamin D levels, and Tao Shi's study had a serious bias because the study population included osteoporotic subjects.

Cocnclusion

There is no significant difference in the success of spinal fusion between those who received vitamin D supplementation and those who didn't

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