



Vitamin D Status and Supplementation in Spine Surgery: A Narrative Review of the Current Evidence

Dr. Nishant

M.S. Ortho, D-Ortho, F.A.G.E.,
Assistant Professor in Orthopaedic Surgery RDJM Medical College, Muzaffarpur, Bihar, India
Email: nishantspine@gmail.com
ORCID: 0000-0002-6206-7732

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Abstract

Bone quality is now recognized as an important factor in spinal fusion success. Since vitamin D helps the body absorb calcium, supports bone cells, and aids muscle function, improving vitamin D levels around surgery seems logical. A systematic review and meta-analysis available as a medRxiv preprint registered with PROSPERO in 2026 examined 13 studies on vitamin D in spine surgery patients. However, the review's conclusions were more cautious than the biological reasoning suggests. Vitamin D supplements did not clearly reduce pain after surgery or improve fusion rates. Some early analyses hinted at possible benefits for disability scores, bone quality, implant stability, and fracture risk, but these findings were based on a small number of studies, showed a lot of variation, and were influenced by removing certain studies. This review summarizes the current evidence, explains what is known and still uncertain about vitamin D supplements in spine fusion, and notes that while the biological reasons are strong, clinical proof is still lacking.

Key words: Vitamin D, supplementation, spine surgery

1. Introduction

Vitamin D deficiency is common in adults with osteoporosis and other conditions that weaken bones, making it especially important for people having spinal surgery. Today, spine surgery focuses more on improving bone health before the operation, since poor bone quality can weaken how well implants hold, affect graft healing, and disturb the conditions needed for successful fusion. In this context, vitamin D is seen as something that can be improved because it clearly helps with calcium balance, bone repair, muscle function, and nerve-muscle coordination. [1,2]

Even though there is a strong biological reason to focus on vitamin D, its real effect in spine surgery is still unclear. Some studies have connected low vitamin D levels to worse recovery, slower fusion, more implant problems, and higher fracture risk, but studies on supplements have shown mixed results. Differences in patients' starting vitamin D levels, surgery types, supplement plans, other osteoporosis treatments, and how results are measured make it harder to understand the research. [3,4]

This review examines the current evidence on vitamin D levels and supplements in people having spine surgery, focusing on pain after surgery, fusion results, disability, implant stability, bone quality, fracture risk, and recovery. It also discusses the limits of the research and considers whether the evidence supports regularly fixing vitamin D deficiency as part of overall bone health care.

2. The Reason Why Vitamin D Is a Plausible Target in Spine Surgery

Osteoporosis is common in older adults and is seen more often in people needing spinal fusion. Lower bone density has been linked to higher risks of implants loosening, cages sinking, delayed healing, failed fusion, problems where bones join, and the need for more surgery. Successful fusion depends on several biological steps, including new bone growth, graft healing, mineral buildup, and remodeling at the fusion site. All of these can be affected by poor bone renewal or not enough calcium and vitamin D. Vitamin D works by interacting with its receptor to help the intestines absorb calcium, control parathyroid hormone release, support bone-building cells, and affect bone-resorbing cells. Vitamin D also helps muscle strength, balance, and nerve-muscle coordination, which are important for recovery after surgery, fall risk, and how the new implants handle stress. Because of this, fixing vitamin

D deficiency is a sensible, low-cost, and low-risk approach to improving bone health around surgery. The main question this review looks at is whether clinical trial evidence supports this idea. [1,2]

The systematic review and meta-analysis available as a medRxiv preprint (registered with PROSPERO and following PRISMA 2020 guidelines) searched five major databases up to mid-January 2026, with no language limits. Out of about 3,800 records, 13 studies were included after full review: six randomized controlled trials, five cohort studies, one nonrandomized comparative study, and one case-control study. These studies came from Iran, Taiwan, South Korea, Poland, Ukraine, China, the United States, and Germany. The surgeries covered included lumbar decompression, different types of lumbar and cervical fusion, and general stabilization procedures. [5]

One strength of the review was that it clearly separated studies where patients actually took vitamin D supplements from those that only compared people with different starting vitamin D levels or included other treatments like denosumab. This matters because comparing initial vitamin D levels is a different question than testing supplements directly. Mixing these types of studies can make treatment effects seem bigger than they really are. The review focused on studies of actual supplements for its main results and used the broader combined analyses to suggest new ideas. For pain after surgery (main outcome), four trials where patients took vitamin D supplements, with a total of 177 patients, were combined to look at pain using the Visual Analog Scale. There was no significant difference between the vitamin D and control groups, and the studies disagreed a lot about how big or which way the effect went. A broader analysis of five studies, including one that combined bone status and denosumab treatment, also found no significant results. Interestingly, if one trial involving women with already good vitamin D levels was removed, the results became significant in favor of vitamin D. The authors saw this as a sign that supplements might help mostly people who are deficient to start with, rather than proof that vitamin D reduces pain for everyone. [5]

Fusion rate (secondary outcome): Three studies where patients took vitamin D, covering 128 patients, showed a risk ratio that slightly favored vitamin D, but the result was not statistically significant. The range of

possible effects was wide, meaning the true effect could be anything from no benefit to a real benefit. A broader analysis of four studies, including one with bone status and denosumab, was also unclear, and most of the apparent benefit came from that one unique comparison, not from vitamin D alone. [5]

Disability (secondary outcome): Three studies with 277 patients were combined to look at Oswestry Disability Index scores. This analysis found a significant benefit for the vitamin D group. However, it mixed studies of direct supplements with those comparing starting vitamin D levels, showed very high differences between studies, and the result depended on one key trial. If that trial was removed, the result was no longer significant. The authors emphasized that this should be seen as a possible link, not strong proof of benefit. [5]

5. The findings outside the three pooled outcomes

Apart from the main meta-analyses, some individual studies in the review suggest areas where vitamin D could be important, even if the combined statistics are not clear:

Time to fusion: One randomized trial found that adding vitamin D to calcium did not change the fusion rate after one year, but it did shorten the average time to fusion by about two weeks. This could affect how long a patient needs to limit activity and how long the implants are under stress, even if the final fusion result is the same. [6] **Implant stability and revision surgery:** An observational study looked at fixing vitamin D, vitamin K, and omega-3 deficiencies in patients having spinal stabilization. Those whose deficiencies were not fixed had more screw loosening, cage movement, and revision surgeries, while those with fixed deficiencies had fewer implant problems. However, since the treatment included three supplements and was not randomized, the benefit cannot be linked to vitamin D alone. [7] **Vertebral fracture risk:** In a large study of over 13,000 adults with osteoporosis having their first lumbosacral fusion, those prescribed vitamin D had about a 22% lower risk of sacral fracture after surgery, even after accounting for other factors. However, the study could not confirm if patients actually took the vitamin D or reached good blood levels. [8] **Vertebral bone quality and dosing:** A case-control study found that patients who developed fragile vertebrae after fusion were taking lower daily doses of vitamin D than those who did not have this

problem. Doses below about 2,000 IU per day were linked to higher risk. An estimated cutoff of around 1,900 IU/day best separated the groups, but this comes from one retrospective study and should not be seen as a firm clinical guideline. **Muscle biology, and rehabilitation:** Smaller trials reported that taking vitamin D before surgery was linked to lower levels of inflammatory markers like C-reactive protein and interleukin-6, positive changes in muscle signaling related to less muscle loss, and earlier or better improvements in balance and posture during recovery after lumbar and cervical fusion. While these findings fit with vitamin D's known role in muscle health, they are based on indirect markers or small sample sizes rather than clear clinical results. [9-11]

6. The reasons why the pooled results are weaker than what the individual studies indicate

There are several reasons why a treatment that makes sense biologically ended up with unclear results when the studies were combined: only three to five studies were included, which is not enough for a meta-analysis to reliably balance out random differences between trials, and makes each individual study have too much influence on the combined result. [5] **Large differences between studies:** The studies on pain and disability were very different from each other in patients' starting vitamin D levels, supplement types and doses, comparison groups, surgery types, and when results were measured. Combining such different studies into one result can hide the real effects instead of making them clearer. [5] **Other treatments confuse results:** Some studies gave vitamin D along with other treatments, like denosumab or vitamin K and omega-3. This makes it impossible to say if the benefits were due to vitamin D or the combination. In more than one analysis, statistical significance appeared or disappeared depending on whether a single trial was included, which is a common sign that the combined result is fragile rather than strong. [5,7] **Risk of bias varied:** Of the 13 studies, only two were rated as low risk of bias, eight were moderate, and three were high risk. Common problems included unclear randomization, no blinding, and not controlling for other factors, especially in observational studies. bias could not be assessed. With fewer than ten studies contributed to Publication bias could not be assessed: Since fewer than ten studies contributed to any single outcome, the

authors felt that methods to check for publication bias were not reliable enough to give clear answers. An earlier systematic review focused specifically on vitamin D deficiency in elective spinal fusion patients, which similarly found associations between deficiency and worse functional outcomes but concluded the evidence on supplementation, fusion, and pseudarthrosis was too heterogeneous and limited to draw firm conclusions. The newer review adds value mainly by explicitly separating direct-supplementation evidence from the broader, noisier literature that mixes in baseline status and co-interventions — a distinction that makes clear the case for supplementation is weaker once the analysis is restricted to cleaner comparisons. The findings on muscle and balance outcomes are also broadly consistent with older evidence in non-surgical older-adult populations suggesting vitamin D can support muscle strength and balance, without establishing that supplementation reliably prevents falls in every population studied. [4,5,12]

8. Clinical Implications

Overall, the evidence does not support vitamin D supplements as a proven, stand-alone way to reduce pain after surgery or reliably improve fusion rates in all spine surgery patients, especially those who are not deficient. However, the review still supports finding and fixing significant vitamin D deficiency as part of standard care, especially for patients with osteoporosis, fragile fractures, poor nutrition, or those having complex fusions. In these cases, the risks of supplements are low, and possible benefits like better bone quality, fewer implant problems, and lower fracture risk are still possible, though not yet proven by strong studies. Fixing vitamin D should be one part of a full bone-health plan that also checks calcium, kidney function, fall risk, nutrition, and, when needed, uses osteoporosis medicines. [1,2,4–6]

9. Limitations and Future Prospects

The limitations of this review are similar to those in the wider field: there were only a few studies for each outcome, many differences between studies, other treatments that make it hard to know what caused the effects, mixed risk of bias, and results that changed depending on which studies were included. The authors call for larger, well-designed randomized trials that group patients by their starting vitamin D

levels and osteoporosis severity, use standard supplement types and doses, report blood vitamin D levels, use clear and blinded methods to judge fusion, and report both time to fusion and final fusion rates. Future research using individual patient data, not just summary statistics, may be needed to find out which groups of patients benefit most from supplements. Vitamin D supplements do not clearly reduce pain after surgery or improve fusion rates following spine surgery, despite strong biological reasons. While early analyses and individual studies suggest possible benefits for disability scores, bone quality, implant stability, and fracture risk, these findings are based on small, varied datasets and are not enough to support firm clinical recommendations. Fixing significant vitamin D deficiency remains a reasonable, low-risk part of bone-health care around surgery, especially for patients with osteoporosis or nutritional risk, but should be seen as an addition rather than a proven way to improve fusion outcomes until larger, well-designed trials are done. [4,5]

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