Prevalence of Poor Bone Quality in Patients Undergoing Spine Surgery: A Comprehensive Approach

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Abstract

Study Design: A cross-sectional study.

Objectives: To investigate the prevalence of poor bone quality in patients requiring spine surgery through comprehensive evaluation with bone mass density (BMD), trabecular bone score (TBS), FRAX, and vitamin D status.

Methods: we prospectively recruited patients of > 50 years old candidates for lumbar or cervical spine fusion surgery at our institution. Recorded data were: demographic, body mass index (BMI), risk factors for osteoporosis, daily calcium intake, FRAX score, disability index for lumbar and cervical spine, and VAS for pain. Serum 25 OH vitamin D, BMD using DXA, and TBS was also evaluated.

Results: A total of 104 patients were recruited, osteoporosis by BMD was detected in 9.6%, and osteopenia in 34.6% of patients. 69.4% of patients with osteopenia had a degraded or partially degraded bone microarchitecture by TBS. Low levels of vitamin D were detected in 79.8% of patients. Increased pain was associated with low BMD levels. Adding TBS to BMD for the determination of bone strength resulted in 33.7% of patients with poor bone quality. Lastly, the combination of BMD, TBS, and FRAX revealed 37.5% of patients with poor bone quality.

Conclusions: Poor bone quality and low vitamin D levels are quite common among patients aged ≥ 50 years undergoing spine surgery. DXA alone seems not enough for preoperative identification of impaired bone quality cases. FRAX is useful for identifying high-risk patients and TBS is a valuable complement to DXA by adding the dimension of bone quality.

Keywords
osteoporosis, spine surgery, trabecular bone score, bone mineral density, Fracture Risk Assessment Tool, FRAX

Introduction

As the population ages, the number of patients at risk for low bone mineral density (BMD) who are also undergoing spine surgeries will increase as well.1

Osteoporosis is a disease that involves reduced bone density and quality, leading to a weakness of the skeleton and an increased risk of fracture. The standard criterion for the diagnosis of osteoporosis in postmenopausal women and older men is a T-score of ≤−2.5 at any skeletal site by BMD testing. Additionally, the National Bone Health Alliance (NBHA) recommended to formally expand the criteria for allowing a diagnosis of osteoporosis to include the presence of an elevated fracture risk using the Fracture Risk Algorithm (FRAX), even without a T-score of −2.5 or lower.2

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The presence of osteoporosis poses great challenges to spine surgeons because of several complications related to low BMD, such as pedicle screw loosening, non-union, proximal junctional kyphosis, and adjacent segment fractures. Despite the major impact of this disease on surgical outcomes, there are limited data concerning the prevalence of osteoporosis in spine fusion patients.³

Dual-energy x-ray absorptiometry (DXA) has been the gold standard for assessing BMD. However, DXA can result in spuriously elevated BMD measurements in patients with degenerative disease,⁴ and several reports suggested that BMD evaluation alone is insufficient in determining the bone status of patients.⁵,⁶

Bone strength is determined not only by bone mass but also by bone quality. Recently trabecular bone score (TBS) was introduced as a novel modality to assess trabecular bone quality easily and it is related to bone microarchitecture and fracture risk.⁶

Additionally, TBS provides information independent of BMD and is not influenced by degenerative changes of the lumbar spine.⁷-⁹ Significantly TBS also discriminates better than BMD for the prediction of vertebral fractures in patients with normal BMD or osteopenia.⁵,⁶,⁹

To date, most of the studies for the prevalence of osteoporosis in spine surgery patients have used DXA without bone quality assessment or applied CT Hounsfield Units (HU) measurement with contradictory results.¹,³,¹⁰-¹²

This study aimed to investigate the prevalence of poor bone quality in patients requiring spine surgery through a complete clinical evaluation, DXA BMD in combination with TBS, FRAX calculation and vitamin D status determination.

Methods

Study Design

This is a cross-sectional, with prospective recruitment of consecutive patients waiting to undergo lumbar or cervical spine fusion surgery between January to December 2019 at our Institution.

Patient Population

Inclusion criteria: 1) Patients > 50 years old of both sexes. 2) candidates for lumbar and cervical fusion surgery with the diagnosis of degenerative lumbar spinal stenosis, lumbar disc herniation, degenerative lumbar spondylolisthesis, cervical disc herniation, cervical spinal stenosis 3) patients that accepted to participate in the study with signed informed consent.

Exclusion criteria included: candidates for spine surgery without fusion or arthrodesis or patients with degenerative deformities or scoliosis that required more than 5 segments of fixation, prior surgery with spinal instrumentation, individuals with BMI < 15 or >37 kg/m² since TBS is not recommended in extreme body sizes and those who did not agree to participate in the study.

Data Acquisition

Within a 3-month range, prior surgery patients were cited for consultation at the Bone Metabolic Unit. Each patient completed a questionnaire recording demographic data, body mass index (BMI), risk factors for osteoporosis, daily calcium intake, the calculation of the percentage of probability of major osteoporotic fracture (MOF) and hip fracture at 10 years using the FRAX corrected version by TBS.

Disability scales were obtained: Oswestry disability index (ODI) for the lumbar spine, neck disability index (NDI) for cervical spine cases and the visual analog scale (VAS) for axial back or cervical pain. A serum 25 OH vitamin D was ordered.

Bone Mineral Density Evaluation

DXA scans (Discovery densitometers, Hologic Inc, Bedford, MA, USA) were performed at the lumbar spine (L1-4) and hips (femoral neck and total hip) of every patient. T-scores were derived using reference ranges for our population. Patients were diagnosed with osteoporosis according to the World Health Organization criterion: T-score of ≤−2.5 at any skeletal site. Also, the lowest T-score between −2.5 and −1.0 was the criterion for osteopenia, and T-score at −1.0 or above was the criterion for normal BMD.¹³,¹⁴

Trabecular Bone Score Evaluation

Lumbar spine TBS was calculated at the same regions of interest used for BMD measurements using TBS iNsight software (Version 2.1, Med- Imaps, Bordeaux, France). Lumbar spine TBS was calculated as the mean value of the individual measurements for vertebrae L2–L4. Study subjects were categorized by established criteria⁸ into 3 groups according to their TBS values: above 1.350 was considered as normal; TBS between 1.200 and 1.350 partially degraded microarchitecture; and TBS ≤ 1.200 partially degraded microarchitecture.

Poor bone quality was defined by the presence of either osteoporosis by densitometric criteria and/or osteopenia plus a degraded or partially degraded bone microarchitecture by TBS⁷,⁸ and/or the presence of high-risk patients for MOF or hip fracture by FRAX.²

Ethics

The study protocol was approved by the Ethics Committee of our Hospital before study commencement. Declaration of Helsinki was followed concerning privacy and confidentiality of patient data and all patients gave informed written consent.
Table 1. Demographics, Risk Factors for Osteoporosis and Medications of Study Subjects.

| Demographics N = 104 |       |               |
|---------------------|-------|---------------|
| Age in years        | 60.9 ± 7.61 |
| Sex female (%)      | 57 (54.8%) |
| Body mass index in kg/m² (range) | 31 (18.5-34) |

**Risk factors**
- Parent fractured hip: 9 (8.7%)
- Current smoking: 37 (35.6%)
- Alcohol: 8 (7.7%)
- Physical activity sedentarism: 55 (52.9%)
- Rheumatoid arthritis: 5 (4.8%)
- Asthma: 8 (7.7%)
- Oral corticoid use*: 10 (9.6%)
- Antiepileptics: 11 (10.6%)

**Medications**
- Calcium intake mg/day (IQR): 834 ± 272
- Vitamin D supplementation: Vitamin D 10 (9.6%), Multivitamins 10 (9.6%)
- Antidepressants: 33 (31.7%)
- Benzodiazepines: 10 (9.6%)

*Data are mean ± SD or n ± (%).
*If the patient is currently exposed has been exposed to oral glucocorticoids for more than 3 months at a dose of prednisone of 5mg daily or more (or equivalent doses of other glucocorticoids).

**Statistical Analysis**

Descriptive statistics were performed with measures of proportion. Numerical variables were analyzed with measures of central tendency and dispersion for numerical variables.

Contrast tests were carried out to verify (in the case of the dependent numerical variables); the homogeneity of variances (Levene’s test) and normal distribution (Kolmogorov-Smirnov normality tests), for the relevance of applying parametric or non-parametric tests.

Inferential statistics. For the analysis of 2 independent groups, the T-Test was used and for association between categorical variables Chi-square χ² test were applied.

For bivariate analysis for numerical variables the Pearson correlation test, and for the correlation of ordinal variables the Spearman’s Rho test.

A significant P < 0.05, with 95% confidence intervals, is considered. The data were analyzed using IBM SPSS Statistics V23.

**Results**

A total of 104 patients were recruited, the median age was 60.9 ± 7.61 and 54.8% were women. The median BMI body mass index was 31 kg/m². The main risk factors were current smoking in 35.6% and sedentarism with 52.9%. The mean daily calcium intake was 834 ± 272 mg/day, 9.6% of patients received supplementation with vitamin D and 9.6% multivitamins. A 31.7% of the patients took antidepressants and 9.6% benzodiazepines (Table 1).

Regarding clinical parameters, the mean VAS was 7.5 ± 1.7/10, and the disability index was 46.8 ± 15.8. A 69.2% (72/104) of patients suffered lumbar spine and 30.8% (32/104) cervical spine disease (Table 2). The specific diagnosis was: spondylolytic lumbar stenosis 56 (53.8%), degenerative spondylolisthesis 16 (15.3%), herniation of cervical disc 17 (16.3%), and cervical spondylotic stenosis with myelopathy 15 (14.4%).

The BMD and TBS data are also summarized in (Table 2).

Patients with a FRAX of ≥ 20% for MOF was 4(3.8%), FRAX of ≥ 3% for hip fracture was 9 (8.7%).

Regarding serum vitamin D the mean value was 24.2 ng/mL, insufficiency of vitamin D was detected in 42.3% (44/104) patients and deficiency in 37.5% (39/104) (Table 2).

Osteoporosis by densitometric WHO criteria was evident in 9.6% (10/104), osteopenia in 34.6% (36/104) of the patients, and normal in 55.8% (58/104). TBS consistent with degradated microarchitecture was registered in 12.5% (13/104), and with a partially degradated microarchitecture in 47.1% (49/104) of the patients. A 69.4% of patients with osteopenia, had a degradated or partially degradated bone microarchitecture by TBS.

Adding TBS to BMD for the determination of bone strength resulted in 33.7% (35/104) patients with poor bone quality, and the combination of BMD, TBS, and FRAX for the assessment of bone health status, revealed a 37.5% (39/104) of patients with poor bone quality (Table 3). In this group bone health optimization prior to spine surgical intervention was done by the osteoporosis specialist and consisted in supplemental calcium and vitamin D and antiresorptive medication if needed.

Table 2. Results of Clinical Data, BMD, TBS, FRAX and Vitamin D.

| Clinical N = 104 |       |       |
|-----------------|-------|-------|
| Visual Analogue Scale | 7.5 ± 1.7 |
| Disability Index | 46.8 ± 15.8 |
| Spine disease | Lumbar 72 (69.2%), Cervical 32 (30.8%) |

| Densitometry and TBS |       |       |
|----------------------|-------|-------|
| BMD L2-L4 g/cm² | 1.095 ± 0.186 |
| T-score lumbar spine | 0.48 ± 1.66 |
| BMD femoral neck g/cm² | 0.837 ± 0.143 |
| T-score femur neck | −0.45 ± (1.35) |
| BMD total hip g/cm² | 1.000 ± 0.147 |
| T-score total hip | 0.54 ± 1.15 |
| Osteopenia (DXA) | 36 (34.6%) |
| Osteoporosis (DXA) | 10 (9.6%) |
| TBS L2-L4 | 1.352 ± 0.109 |
| TBS ≤ 1.2 degraded microarchitecture | 13 (12.5%) |
| TBS 1.2–1.35 partially degraded | 49 (47.1%) |

| FRAX 10-year risk of fracture (%) |       |
|----------------------------------|-------|
| FRAX MOF (range) | 6.2 (0.2-52.8) |
| FRAX hip (range) | 1.4 (0.1-4.9) |

| Bone metabolic profile |       |       |
|-----------------------|-------|-------|
| Serum value of Vitamin D | 24.2 ± 11.9 |
| Vitamin D status | Normal 21 (20.2%), Insufficiency 44 (42.3%), Deficiency 39 (37.5%) |

Data are mean ± SD or n ± (%).
*Oswestry disability index (ODI) for lumbar spine and neck disability index (NDI) for cervical spine cases.
† Determined as 25hydroxicholesterolcalciferol (2SHCC).
‡Vitamin D deficiency < 20 ng/mL and insufficiency 20–30 ng/mL. MOF = Major osteoporotic fracture 10-year risk (%).
The prevalence of osteoporosis and osteopenia in women was 14% (8/57) and 31.6% (18/57), and in men 4.3% (2/47) and 38.3% (18/47) respectively. Poor bone quality in females was 43.9% (25/57) and in males 29.8% (14/47), with non-statistically significant (NSS) differences ($\chi^2$ test, $P = 0.15$).

Regarding age, 74% of patients were younger than 65 years, poor bone quality in younger was 35.1% (27/77) and older of 65 yrs, 44.4% (12/27) with NSS difference ($\chi^2$ test, $P = 0.3$).

Nevertheless, there was a statistically significant correlation between age and BMD femoral neck ($r = -0.19, P = 0.05$), and TBS ($r = -0.25, P = 0.01$). In the other hand, NSS correlation was found between age and lumbar and hip BMD (Figure 1).

Considering the diagnosis, in patients with lumbar spine disease, 13.9% (10/72) have osteoporosis, 33.3% (24/72) osteopenia, and 40.3% (29/72) poor bone quality. In patients with cervical spine disease, there were no cases of osteoporosis, 37.5% (12/32) had osteopenia, and 31.3% (10/32) poor bone quality. Differences between lumbar and cervical groups didn’t reach statically significant difference ($\chi^2$ test, for DXA $P = 0.08$, and poor bone quality $P = 0.3$).

In the bivariate analysis, there was a statistically significant negative correlation between the VAS and BMD L2-L4, namely the lower the BMD the higher was the pain by VAS ($r = -0.25, P = 0.01$), the same was for TBS T-score and VAS ($r = -0.22, P = 0.03$). Non-significant correlation between vitamin D levels and other clinical (VAS o disability) or densitometric variables was founded.

Distribution of the TBS categories in DXA is summarized in Figure 2. In the group with osteopenia 58.3% of patients had partially degraded bone microarchitecture and 11.1% a degraded bone microarchitecture. An illustrative case of this integral approach is presented in Figure 3.

**Discussion**

Very few data exist for the prevalence of osteoporosis or poor bone quality in spine fusion patients, as a result, many spine surgeons lack awareness of preoperative screening and treatment for osteoporosis.\textsuperscript{1,15,16} This study assesses both the quantitative and qualitative of bone status, in patients over the age of 50 years requiring spine surgery. Through the combination of DXA, TBS, FRAX we were able to detect 37.5% of patients with poor bone quality. Therefore, authors propose an expanded definition for osteoporosis that not only included BMD DXA but a comprehensive evaluation to identify patients with potential poor bone health who could be considered for preoperative optimization.

**Table 3. Bone Health Status Assessment With BMD, TBS and FRAX n = 104.**

| DXA total T-score* | TBS range | Bone health status | DXA + TBS† | DXA + TBS + FRAX‡ |
|--------------------|-----------|--------------------|------------|--------------------|
| $> -1$             | 58 (55.8%) | Normal             | 42 (40.4%) | Normal bone quality |
| $-1$ to $-2.5$     | 36 (34.6%) | Partially degraded | 49 (47.1%) | Normal bone quality |
| $\leq -2.5$        | 410 (9.6%) | Degraded           | 13 (12.5%) | Poor bone quality  |

* Densitometric total result at lumbar spine or femoral neck or total hip.
† Defined by the combination of DXA, TBS range.
‡ Defined by the combination of DXA, TBS range and FRAX risk.
§ Bone microarchitecture.
Osteoporosis is a multifactorial disease that is often difficult to diagnose accurately. More diagnostic tools (FRAX, TBS) have been developed which, used judiciously, with BMD, can substantially improve the detection of poor bone quality patients.\textsuperscript{7}

To facilitate the combination of clinical and radiological data, the FRAX was developed, this tool calculates the probability of major fractures for a given person over 10 years.\textsuperscript{17} Additionally, NBHA made the recommendation to formally expand the criteria for diagnosing osteoporosis for individuals who have an elevated fracture risk based on FRAX.\textsuperscript{2}

The prevalence of osteoporosis in spine patients previously reported, depends on age and sex and it range from 10% to 40%.\textsuperscript{1,3,10,11,12,18,19} see Table 4, Most of them applied DXA BMD or CT HU measurements, and there is only one study that combined BMD and TBS for bone status assessment in only 28 patients.\textsuperscript{19}

Several reports suggested that BMD evaluation by DXA alone is insufficient for determining osteoporosis as it can result in a high incidence of false negatives cases, and therefore a missed opportunity to optimize patients for surgery.\textsuperscript{5,6}

Some imaging techniques have been developed to assess bone microarchitecture such as high-resolution CT and peripheral QCT, and MRI.\textsuperscript{5,20} However, their applicability in the routine clinical practice is still limited because, costs, radiation exposure, and availability.\textsuperscript{21} Despite the opportunistic utility of lumbar spine CT HU measurements in identifying osteoporosis, some reports did not find to be an effective screening tool for identifying low BMD.\textsuperscript{4,21}

Trabecular bone score (TBS) is a novel technique to assess trabecular bone quality easily, based on a bone texture analysis derived from the lumbar spine DXA image. It is related to bone microarchitecture and fracture risk independent of BMD,\textsuperscript{8,22} and discriminates better than lumbar spine BMD for prediction of vertebral fractures in patients with normal BMD or.

Figure 3. An illustrative case of a 70-year-old female patient presented with neurogenic claudication and leg pain, Oswestry disability index (ODI) of 58 and VAS 9/10. A, Lumbar spine DXA, BMD was 0.824 g/cm\textsuperscript{2} with a T-score of $-2.1$ (osteopenia), but was may be invalid due to degenerative changes at L4–5 and L3-4. B, Sagittal T2 MRI of lumbar spine shows degenerative lumbar stenosis and spondylolisthesis at L4–5. C, TBS L2-L4 reveal a degraded microarchitecture of the patient’s lumbar spine. The serum value of vitamin D was deficient (16.1 ng/mL), and FRAX score for MOC was 5.3%. A diagnosis of poor bone quality was made, consequently, calcium/vitamin D and antiresorptive treatment were administered for 6 weeks before surgery by an osteoporosis specialist. Given the segmental instability and the poor bone quality of the patient, a technique for minimizing the pseudarthrosis rate was included by the addition of an interbody fusion technique. D, Postoperative lateral lumbar spine radiograph demonstrating pedicle screw and lumbar interbody fusion at L4-5 with posterior decompression.
| Author/year | Patients selection | Diagnosis method | Prevalence of osteoporosis |
|-------------|--------------------|------------------|---------------------------|
| Chin et al. 2007<sup>10</sup> | 676 patients ≥ 50 years candidates for spine surgery, excluding vertebroplasty. Retrospective (Korea) | BMD measured by DXA WHO criterion | -Female osteoporosis of 44.1%, and osteopenia of 46.7% -Male osteoporosis of 12.5% and osteopenia of 45.9% |
| Wagner et al. 2016<sup>1</sup> | 128 patients ≥ 50 years undergoing TLIF Retrospective (U.S) | BMD measured by DXA WHO criterion and CT HU measurement | CT HU values consistent with osteoporosis 19.5% and with osteopenia 29.7% |
| Burch et al. 2016<sup>3</sup> | 98 women with age from 50 years to 70 years for spinal fusion surgery. Retrospective (U.S) | -Trabecular BMD by CT-based measurement -Fragile bone strength by a finite element analysis -Poor bone quality (either osteoporosis or fragile bone strength) | -Osteoporosis 14% -Fragile bone strength 27% -Poor bone quality 29% |
| Schmidt et al. 2018<sup>12</sup> | 144 ≥ 50 years requiring spinal surgery Retrospective (Germany) | BMD measured by DXA WHO criterion and HR-pQCT in patients with T-score below −1.5 or vertebral fractures | -Osteoporosis 27.1%, -Osteopenia 43.8% -Inadequate vitamin D levels 73.6% |
| Bjerke et al. 2018<sup>18</sup> | 140 Consecutive patients >18 years who underwent posterior thoracolumbar or lumbar spinal fusion Retrospective (U.S) | BMD measured by DXA WHO criterion for spine and/or hip within 1 year of surgery | -Osteoporosis 10.0% -Osteopenia 58.6% -Normal 31.4% |
| Zou et al. 2019<sup>11</sup> | 479 patients aged ≥ 50 years undergoing lumbar fusion for lumbar degenerative disease Retrospective (China) | BMD measured by DXA WHO criterion of both lumbar and hip | -Osteoporosis 39.7% -Female 48.9% -Male 27.1% |
| Banse et al. 2019<sup>19</sup> | 28 patients over 50 years old prior to corrective surgery of the lumbar spine with osteosynthesis Retrospective (France) | BMD measured by DXA WHO criterion and TBS | -Osteoporosis 14.3% -Osteopenia 42.9% -TBS <1.2 50% of patients |
| Present study 2020 | 104 patients ≥ 50 years candidates for spine surgery (cervical and lumbar) Cross-sectional with prospective recruitment | -BMD measured by DXA WHO criterion -TBS for bone quality -FRAX for risk fracture -Poor bone quality (DXA, TBS, FRAX) | -Osteoporosis DXA 9.6% -Osteopenia DXA 34.6% -Poor bone quality 37.5% -TBS <1.2 12.5% Inadequate vitamin D levels 79.8% |

BMD: bone mineral density DXA: dual energy x-ray absorptiometry HR-pQCT: high-resolution peripheral quantitative computed tomography HU: Hounsfield units FRAX: Fracture Risk Algorithm TBS: trabecular bone score.
osteoopenia.9 Finally, conversely to lumbar spine BMD, TBS appears to be relatively unaffected by the presence of osteoarthritis changes.6,20,22

This study showed a relatively low prevalence of densitometric osteoporosis (9.6%). This is partially explained by the lower mean age of this cohort of patients compared to other series and the exclusion of degenerative deformity cases, as it has been shown that this last group have a higher prevalence of osteoporosis.11,23

On the other hand, 34.6% of the patients had osteopenia, TBS was able to discriminate patients with impaired bone quality in this group. Specifically, 69.4% of patients with osteopenia have a degraded or partially degraded microarchitecture.

The combination DXA with TBS allowed to detect 33.7% of patients with poor bone quality, and by adding FRAX in the diagnosis, the overall prevalence of patients with poor bone quality was 37.5%. Thus, we were able to identify additional patients who may be at risk of osteoporosis related complications.

Although we found a significant correlation between femoral neck BMD with TBS, and age, this quantification was not the same, for lumbar DXA BMD levels. As shown by other studies, this discrepancy confirm that degenerative spinal diseases are associated with spurious increased lumbar spine BMD measurements thereby limiting their utility in this region of interest.4,20

Significantly 80% of patients in this report had decreased vitamin D levels and of these 37.5% had deficiency, not surprising since it is estimated that between 40 and 90% of a spine surgery patients suffer from decreased serum levels of vitamin D, which could influence both clinical and radiological results.24,25

Several reports highlight an incomplete preoperative bone status workup in patients undergoing spine fusion surgery.21 Wagner et al. found that in patients in whom osteoporosis was retrospectively diagnosed at the time of surgery, 64% had not undergone any preoperative evaluation or workup.1 Schmidt et al. showed a deficient in postoperative medical management of patients underlying low BMD resulting in high prevalence of untreated osteoporosis ranging from 30 to 70%.12

Clinical interest in poor vertebral bone quality for spine fusion patients is driven by the need to optimize patient selection and surgical approaches to avoid complications, thus it is imperative to carry out more sensitive and specific preoperative tests.

Regarding treatment, there are some proposal of treatment based on DXA and TBS information (e.g. Delphi ranking),7 patients with osteopenia and degraded microarchitecture should be considered for anti-resorptive medication and calcium, vitamin D if needed and in patients with osteoporosis, added to the above, anabolic treatment can be considered.

In recent decades considerable advances have been made on the treatment of OP, several clinical trials have investigated the impact of pharmacological treatment on bone fusion in spinal surgery with alendronate,26 zoledronic acid,27 and teriparatide.28 Most of them showed increase in bone fusion rates and a reduced risk of screw loosening. Although there is no clear consensus, some authors recommended that antiresorptive treatment should be started at least 4–6 weeks before surgery and continued in the postoperative period under specialized supervision.29

In our study, preoperative bone health optimization was supervised by osteoporosis specialist and consisted mainly in supplemental calcium, vitamin D and antiresorptive medication.

Beside medical management, tailoring of the surgical technique should be considered by spine surgeons, there are several options to mitigate the risk of bone-related failure for fusion patients, some include using specialized pedicle screws, augmenting with PMMA, extending the number of instrumented levels or combining anterior and posterior approaches.

One of the limitations of this study was the need to exclude patients with extreme BMI values and cases of significant scoliosis.11 Consequently, a relatively limited number of patients could be recruited. Additionally, our results do not represent the population of patients with degenerative deformity or scoliosis candidates for long-segment instrumentation, which may benefit the most from the preoperative determination of poor bone health.

The positive side is the prospective condition of this investigation which enable us a better control of variables and to monitor the impact of the diagnosis and optimization of the patients with poor bone health who underwent spine surgery.

Further potential research should analyze if systematic application of bone health assessment and optimization to elective spine surgery populations resulted in better outcomes and less complications.

**Conclusion**

Poor bone quality and low vitamin D levels are quite common among patients aged ≥50 years undergoing spine surgery. DXA alone seems not enough for preoperative identification of impaired bone quality cases. TBS is a valuable complement to DXA by adding the dimension of bone quality and increasing the detection of poor bone quality, especially in patients with osteopenia. A comprehensive bone health assessment is recommended in patients requiring spinal fusion surgery.

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**Authors’ Note**

Informed consent was obtained from all individual participants included in the study. This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of University Hospital las Palmas Gran Canaria (08/15/2018. No CEIm-CHUMI-2017/929).

**Declaration of Conflicting Interests**

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.
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