International Journal of Spine Surgery Publish Ahead of Print, published on March 11, 2021 as doi:10.14444/8049

International Journal of Spine Surgery, Vol. 00, No. 00, 0000, pp. 000–000
https://doi.org/10.14444/8049
©International Society for the Advancement of Spine Surgery

Practice Patterns of Spine Surgeons Regarding Osteoporosis: An International Survey

RICARDO DÍAZ-ROMERO, MD,[1,2] MANUEL SOSA HENRÍQUEZ, PhD,[1,3] KEVIN ARMAS MELIÁN, MD,[2] CLAUDIA BALHEN-MARTIN, MD[4]

[1]Universidad de Las Palmas de Gran Canaria, Spain, [2]Department of Neurosurgery of Hospital Insular of Las Palmas of Spain Neurosurgery, [3]Department Bone Metabolism and Osteoporosis of Hospital Insular of Las Palmas , and [4]Department of Radiology, Hospital Perpetuo Socorro, Las Palmas de Gran Canaria, Spain

ABSTRACT

Background: Osteoporosis (OP) represents a great challenge for the spine surgeon. Despite having effective pharmacological treatments for OP and surgical technical innovations, the awareness of spine surgeons regarding OP seems low. The purpose of this research was to assess practice patterns on the diagnosis and treatment of spine surgeons regarding OP.

Methods: An electronic survey of ten multiple-choice questions was administered to members of the European Association of Neurosurgical Societies (EANS). The survey asked about the specialty, the workplace, and practice patterns and attitudes regarding OP and spine fusion surgery, pseudoarthrosis, and vertebral compression fractures (VCF).

Results: A total of 122 surgeons completed the survey. In patients with suspected OP, 31.4% of surgeons would refer the patient to the OP specialist before surgery and 21.5% chose to perform the surgery without additional studies. A 66.4% of respondents would modify the surgical strategy in the case of OP. The most popular surgical techniques elected were cemented augmented screws (77.9%) and long-segment instrumentation (45.1%). Regarding pseudoarthrosis, 29.5% of surgeons opted to refer to the OP specialist, and 23.8% didn't consider any additional studies Concerning VCF management, 41.32% of respondents would refer the patient for treatment of OP, and the most common therapeutic strategy was conservatively treatment for 4 to 6 weeks and vertebroplasty or kyphoplasty if no improvement (55.74%).

There was a higher proportion of surgeons that would not consider preoperative studies or referring patients with suspected OP for spine surgery ($\chi^2 = 4.48$, p =0.03) and pseudoarthrosis ($\chi^2 = 9.5$, p =0.002) compared to VCF.

Conclusions: There was a greater awareness regarding optimizing OP management in VCF compared to patients with suspected OP for spine arthrodesis or pseudoarthrosis. There still opportunities for improvement for the timely diagnosis and treatment of OP in spine surgery patients.

Other & Special Categories

INTRODUCTION

The population worldwide is aging fast, and the increase in life expectancy has raised the number of patients with osteoporosis (OP) and degenerative spine conditions.[1] Osteoporosis has affected more than 75 million people in the United States, Europe, and Japan.[2] Over the next 25 years, the proportion comprising the elderly in Europe will increase by 56% in men and by 41% in women.[2] Some reports have suggested that the prevalence of OP in women over 50 years old with spine surgery is higher than in the general population and can reach up to 46%.[3]

A low bone mineral density (BMD) is associated with spinal instrumentation failure and poor bone fusion, influencing both clinical and radiological results in spine surgery.[1,4] Despite having effective pharmacological treatments for improving BMD[1,4–6] and the development of technical innovations in spine surgery for osteoporotic patients,[5] a lack of awareness in spine surgeons regarding OP has been found.[7,8] In addition, low referral rates for treatment following a vertebral compression fracture (VCF) have been reported.[9]

Currently, there are few reports that have explored the attitudes and practice patterns of spine surgeons regarding OP in fusion surgery.[8,10,11] Likewise, the specific surgical techniques applied by spine surgeons when operating on patients with OP have been poorly described.

The objective of this study was to evaluate practice patterns and attitudes of spine surgeons regarding the diagnosis and treatment of OP related to spinal arthrodesis, pseudoarthrosis, and VCF as

Copyright 2021 by International Society for the Advancement of Spine Surgery.

Table 1. Practice patterns and attitudes of spine surgeons regarding OP and fusion surgery.

Parameter	Value, % (n)
Q1. In patients with SUSPECTED osteoporosis and candidates for spinal arthrodesis, what strategy do you usually apply before surgery?	
Check routine bone densitometry	29.75 (36)
Check routine metabolic bone profile (vitamin D, parathyroid hormone, calcium)	1.65 (2)
Check both tests a and b	15.7 (19)
Refer the patient to the specialist for osteoporosis work-up before surgery	31.4 (38)
Proceed with the surgery on a regular basis	21.5 (26)
Other	0 (0)
Total	121
Q2. In patients with OSTEOPOROSIS WITHOUT TREATMENT and candidates for spine arthrodesis, what strategy do you usually apply before surgery?	
Proceed with surgery on a regular basis	8.20 (10)
Proceed with surgery and then refer the patient for treatment of osteoporosis	34.4 (42)
Refer to the specialist for the treatment of osteoporosis before surgery	36.1 (44)
Give treatment for osteoporosis and then proceed with surgery	16.4 (20)
Conservative treatment	2.46 (3)
Other (specify)	2.46 (3)
Total	122
Q3. In patients with OSTEOPOROSIS WITH TREATMENT who will undergo spine arthrodesis, what strategy do you usually follow?	
Alter my surgical plan to enhance bone fusion	66.4 (81)
Proceed with surgery on a regular basis	30.3 (37)
Other (specify)	3.3 (4)
Total	122
Q4. What surgical strategy do you use to improve fusion in patients with osteoporosis? Mark ONE OR MORE OPTIONS	
Long segment instrumentation and increase points of fixation	45.1 (55)
Cemented screws	77.9 (95)
Expandable screws	14.75 (18)
Modification of the technique; pedicle screws with bicortical fixation, conical screws. minimize tapping, sublaminar hooks	36.1 (44)
Do not change my surgical strategy	5.7 (7)
Other (specify)	7.4 (9)
Total	122

well as to report the most common surgical techniques used in osteoporotic patients.

METHODS

An electronic survey of 10 self-answered multiple-choice questions (Q) was administered to members of the European Association of Neurosurgical *S*ocieties (EANS) who treated spine pathologic conditions and had at least 5 years of practicing experience. There was an option for additional comments to avoid information gaps.

Questionnaire Development

The survey (Tables 1 and 2) asked about the specialty and the workplace, then was divided into 3 parts:

1. Spine surgeons' practice patterns and attitudes regarding OP and spine fusion surgery (4 questions): This part assessed the role of the neurosurgeon in the diagnostic approach in patients with suspected or confirmed OP without treatment. Suspected OP was defined by the presence of risk factors such as advanced age, being postmenopausal, family history of osteoporosis, previous fracture, current smoking, and long-term treatment with corticosteroids. It also explored the modifications in the surgical plan and the most popular surgical techniques used in patients with OP.
2. Perception of the influence of OP in the development of pseudoarthrosis (2 questions): Part 2 evaluated the surgeon's opinions or perceptions of the influence of OP in the development of pseudoarthrosis and the preoperative management pseudoarthrosis in case of a revision surgery.
3. Trends and management patterns of spine surgeons with respect to osteoporotic VCF (2 questions): This part assessed diagnostic, referral and treatments patterns of spine surgeons regarding VCF.

Administration of the Survey

The survey was integrated into the online survey platform SurveyMonkey and was sent by email to the members of EANS. An invitation to participate

Table 2. Perception of the influence of OP in the development of pseudoarthrosis and management patterns of spine surgeons concerning osteoporotic VCF.

Parameter	Value, % (n)
Q5. In patients who develop pseudoarthrosis following spinal surgery, what strategy do you usually apply?	
Check routine bone densitometry	15.57 (19)
Check routine metabolic profile (vitamin D, parathyroid hormone, calcium)	4.9 (6)
Check both tests a and b	22.95 (28)
Refer the patient to the specialist for osteoporosis work-up before surgery	29.5 (36)
Proceed with the surgery without further studies	27 (33)
Other (specify)	0 (0)
Total	122
Q6. What influence do you think osteoporosis has on the development of pseudoarthrosis?	
No clear influence	18 (22)
Little	10.7 (13)
Some	27.05 (33)
Quite	29.5 (36)
A lot	13.9 (17)
Other (specify)	0.82 (1)
Total	122
Q7. In patients who develop a low-energy vertebral compression fracture, what strategy do you usually follow?	
Check routine bone densitometry	19 (23)
Check routine metabolic profile (vitamin D, parathyroid hormone, calcium)	4.9 (6)
Check both tests a and b	22.3 (27)
Refer the patient to the specialist for osteoporosis work-up	41.3 (50)
I don't consider any specific diagnostic studies	11.6 (14)
Other (specify)	0.82 (1)
Total	121
Q8. In patients who present with a low-energy acute vertebral compression fracture, what therapeutic strategy do you consider to be most useful?	
Conservative treatment only	4.1 (5)
Conservative treatment for 4–6 weeks; if no improvement proceed with vertebroplasty or balloon kyphoplasty	55.7 (68)
Vertebroplasty	16.4 (20)
Balloon kyphoplasty	13.9 (17)
Percutaneous fixation with pedicle screws + vertebral reinforcement techniques	4.9 (6)
Other (specify)	4.9 (6)
Total	122

Abbreviations: OP, osteoporosis; VCF, vertebral compression fracture.

in the survey and 2 more reminders were sent. Answers were collected through SurveyMonkey and then transferred to a database (Excel spreadsheet).

The investigation was authorized by the research ethics committee from our hospital and from the research committee of the EANS.

Statistical Analysis

Data were compiled in Excel spreadsheet files, and statistical testing analysis was performed in conjunction with SPSS software, version 25.0 (SPSS Inc, Armonk, NY). The study sample was described by calculating the frequencies and percentages for categorical variables, which were subsequently compared using χ^2 testing. Statistical significance was established at a 2-sided α level of .05 ($P = .05$).

RESULTS

A total of 122 EANS members completed the questionnaire, with a rate of response of 38.1%. The workplaces of the survey participants from Europe and the rest of the world are summarized in Figure 1.

1. The results of the first section of the survey on respect spine surgeons' practice patterns regarding OP (Table 1) were:
   - Q1. In patients with a suspected OP, the most frequent answer (34% of surgeons) was to refer the patient to the specialist for diagnosis and treatment of OP before surgery; whereas, 21.5% of surgeons would perform the surgery without additional diagnostic studies.
   - Q2. Regarding patients with OP without treatment who were scheduled for a spine arthrodesis, 36.1% of surgeons considered referring the patient to the OP specialist prior to surgery; 34.4% after the surgery; and 8.2% would proceed with the surgery without considering any treatment for OP.
   - Q3. In patients with OP with treatment, the tendency in most respondents (66.4%) was to modify or alter the surgical strategy; whereas, 30.3% opted to operate without any modifications.

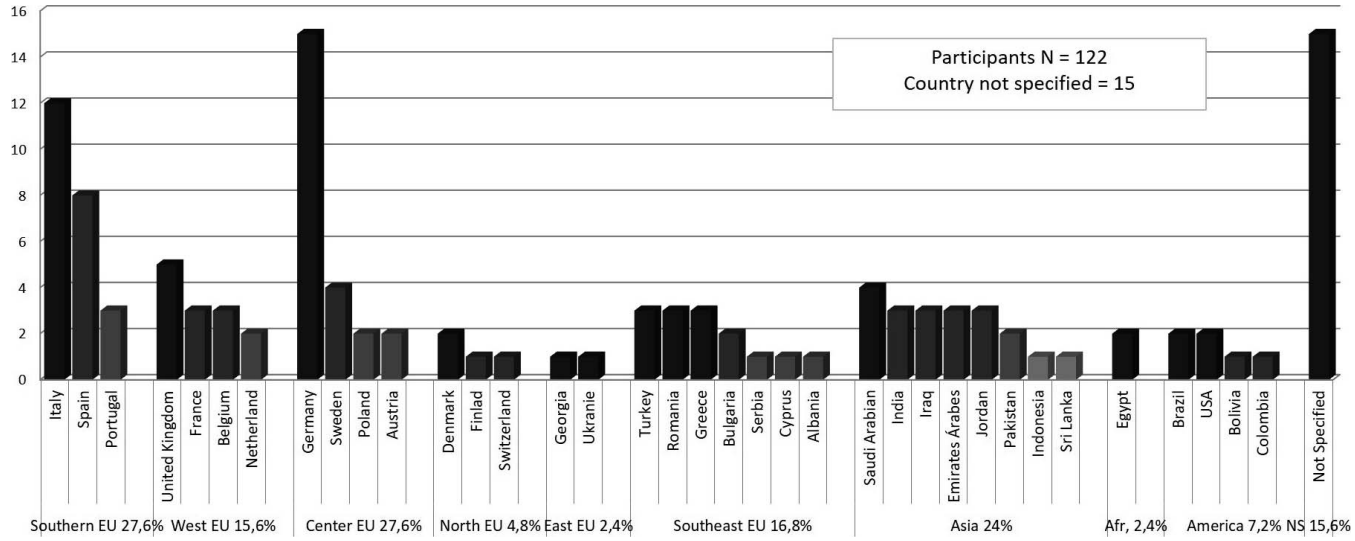

Figure 1. Participants in the survey who were members of European Association of Neurosurgical Societies (EANS), by countries.

Q4. The most frequent surgical techniques for patients with OP were cemented augmented screws (77.9%), long-segment instrumentation (45.1%), and modification of the surgical technique (eg, bicortical screws, conical screws, and minimizing tapping; 36.1%).

2. In the case of the spine surgeon's perception of the influence of OP in the development of pseudoarthrosis, the results were (Table 2):
   Q5. In the case of patients who developed pseudoarthrosis, 29.5% of surgeons would refer the patient to the OP specialist for diagnosis and treatment optimization; whereas, 23.8% did not consider additional studies even in the case of a reoperation.
   Q6. About the perception of the influence of OP in the development of pseudoarthrosis, 29.5% considered it to have quite an influence, and 27.05% reported some influence.
3. Finally, the results about the management patterns of spine surgeons concerning osteoporotic VCF were:
   Q7. In the case of osteoporotic VCF, it was found that 41.3% of surgeons preferred to refer the patient to a specialist, and 22.3% would request dual-energy x-ray absorptiometry (DXA) and a metabolic bone profile (MBP).
   Q8. With respect to the treatment of VCF, the majority (55.74%) of respondents chose conservative treatment for 4–6 weeks and vertebroplasty in case of refractory medical treatment, and only 4.1% opted for conservative treatment.

Regarding trends of preoperative screening of OP (DXA or MBP or both) or referring patients to the OP specialist, there was a statistically significant greater proportion of respondents who did not consider preoperative screening studies or referring patient to a specialist in the case of suspected OP ($\chi^2 = 4.48$, $P = .03$) and pseudoarthrosis ($\chi^2 = 9.5$, $P = .002$) compared with a VCF (Figure 2).

DISCUSSION

The present report displays the results of the first European survey among spine surgeons from all over the world regarding clinical decision-making for spinal fusion, management of pseudoarthrosis, and VCF in patients with OP and includes specific details regarding technical nuances of the spine surgery.

Spine Surgeons' Practice Patterns and Attitudes Regarding OP and Spine Fusion Surgery

In our survey, in the case of suspected OP, 47.1% of the surgeons considered obtaining a DXA and/or MBP, 31.4% opted for referring to a specialist, and 21.5% would proceed with the surgery without additional studies (Table 3). Similar studies reported

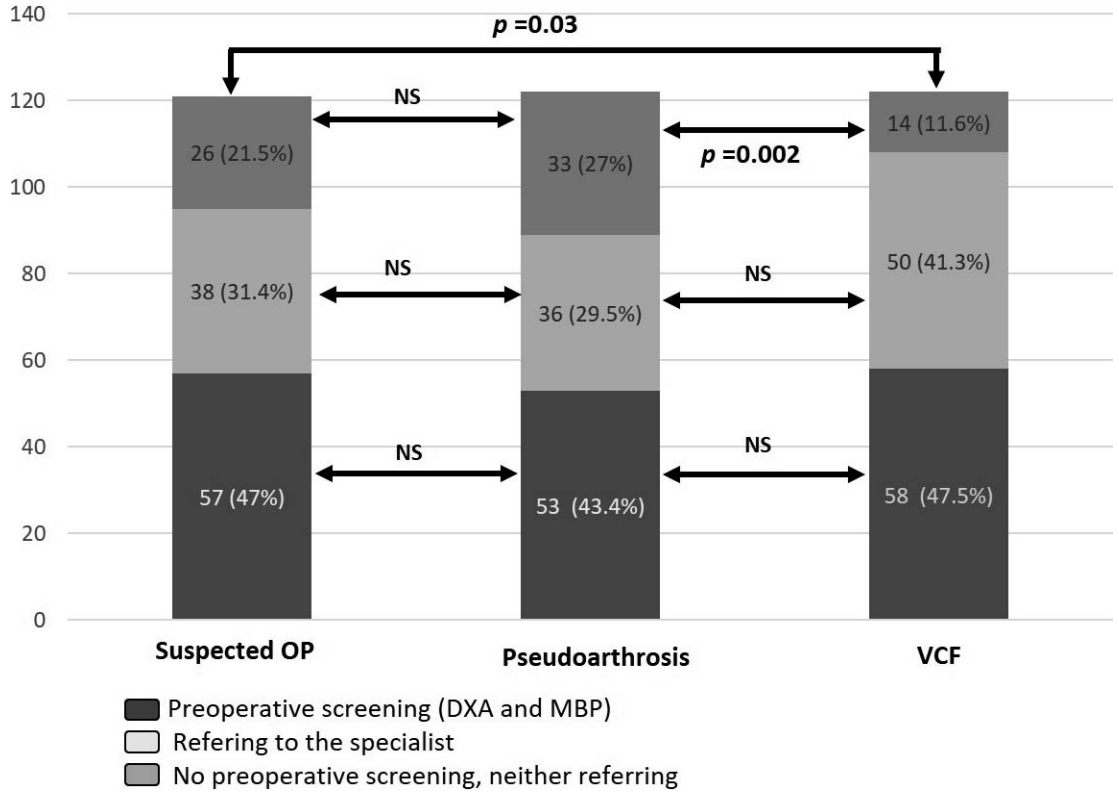

Figure 2. Comparative analysis on trends between suspected osteoporosis (OP), pseudoarthrosis and vertebral compression fracture (VCF). *$P < .05$. NS, nonsignificant statistically.

a trend to proceed with the surgery without additional studies in suspected OP; namely, 41% in the Dipaola et al[8] report, 32.5% in the Spain Society of Neurosurgery (SENEC) survey,[10] and 24.5% in the AOSpine Latin America survey.[11]

There was a small proportion of surgeons (8.2%) who would prefer to proceed with the surgery without any additional studies or treatment in untreated osteoporotic patients. However, a significant proportion of participants (34.4%) preferred to refer the patient after surgery, which entailed fewer risks for the timely management of OP.[6]

Currently, there is no widely accepted consensus for a preoperative work-up for osteoporosis in the case of spinal fusion surgery.[1,8] According to the American College of Radiology, besides the risk factors for OP, BMD measurement is indicated when a clinical decision would be influenced by test results.[1] A *de novo* diagnosis of OP prior to spinal surgery should stimulate improvements in terms of timely treatment and lead to pertinent surgical plan modifications.

A review of surgical complications in patients over 65 years old reported an overall rate of early complications of 13%, which included pedicle fractures and VCFs, and a 26% rate of late complications such as pseudoarthrosis with instrumentation failure, adjacent-level disc degeneration, and progressive junctional kyphosis.[12]

In recent decades considerable advances have been made in the treatment of OP. Several clinical trials have investigated the impact of pharmacological treatment on bone fusion in spinal surgery with alendronate,[13] zoledronic acid,[14] and teriparatide.[15] Most of them showed an 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.[6]

In addition, it has been estimated that between 40% and 90% of adults suffer from decreased serum levels of vitamin D, which could influence both clinical and radiological results of spine surgery.[16–18] It is very likely that providing the needed supplementation of vitamin D in the perioperative period will improve symptoms and may also aid in promoting bone fusion and reducing pseudoarthrosis.[1,6]

Table 3. Comparative of all the published reports studying practice patterns and attitudes of spine surgeons regarding OP.

	Trends in Spine Surgery Arthrodesis and OP					
Publications	**Preoperative Management Suspected OP**	**Modification of Technique**	**Surgical Strategy**	**Pseudoarthrosis and OP**	**VCF Referral and Diagnosis of OP**	**VCF Management**
Dipaola et al[8]	DXA 44% laboratories 12%	Surgeons alter surgical plan 74% depending on DXA results	Not investigated	• DXA 19% • Metabolic bone labs 20% • Refer to specialist before surgery 63.3%	• DXA 60% • Metabolic bone labs 39% • Refer to specialist 25,2%	Not investigated
SENEC[10]	• Pre-op screening* (DXA/MBP) 32.5% • Refer 32.5% • No additional studies 32.5%	Modified or alter surgical plan 48.7%	• Cement-augmented screws 70.1% • Modification of technique bicortical fixation 31.2% • Long-segment instrumentation 29.9%	• Pre-op screening* (DXA/MBP) 14.3% • Refer 27.6% • No additional studies 46.1%	• Preop screening* (DXA/MBP) 23.4% • Refer 59.7% • No additional studies 6.5%	• Conservative treatment if no improvement vertebroplasty or kyphoplasty 66.2% • Conservative 3.9%
AOSpine Latin America[11]	Risk factors for OP • DXA 64.9% • Vit D 44.5% • Refer 81%	Unplanned modification of the surgery 67.4%	• Extend the instrumentation 65% • Cement injection associated with instrumentation 63% • Fenestrated screws 41.4%	Not investigated	Not investigated	Not investigated
Present study EANS	• Pre-op screening[a] (DXA/MBP) 47.1% • Refer 31.4% • No additional studies 21.5%	Modified or alter surgical plan 66.4%	• Cement-augmented screws 77.9% • Modification of technique bicortical fixation 36.1% • Long-segment instrumentation 45%	• Pre-op screening[a] (DXA/MBP) 43.4% • Refer 29.5% • No additional studies 23.8%	• Pre-op screening[a] (DXA/MBP) 47.5% • Refer 41.3% • No additional studies 11.6%	• Conservative treatment if no improvement vertebroplasty or kyphoplasty 55.7% • Conservative 4.1%

Abbreviations: DXA, dual-energy x-ray absorptiometry; EANS, European Association of Neurosurgical Societies; MBP, metabolic bone profile; OP, osteoporosis; Pre-op, preoperative; SENEC, Spain Society for Neurosurgery; VCF, vertebral compression fracture; Vit, vitamin.
[a]DXA or MBP or both DXA and MBP.

Therefore, the percentages of study participants who considered MBP (only 17.35% of respondents in the present report, 12% in the case of Dipaola et al,[8] and 10.4% in the SENEC study[10]) seem insufficient given the high prevalence of hypovitaminosis D and the chance of its relatively rapid correction.

Surgical Strategies and Techniques in Osteoporotic Patients

Concerning the pertinent modifications of the surgical plan in the case of patients with OP, in this report, 66.4% of surgeons would alter the surgical plan to enhance fusion. Dipaola et al[8] found that 74% of the surgeons who reported obtaining a preoperative DXA would alter their surgical plan depending on the result; moreover, the SENEC survey[9,10] participants opted for altering the surgical plan in 48.7% of cases; and finally, in the AOSpine Latin America survey, 67.4% of respondents recognized unplanned modifications of the surgery in OP patients.[11]

In the present survey, cement-augmented screws were a good option for 77.9% of participants, versus 70% of the surgeons in the SENEC survey.[10] In the AOSpine Latin survey, 63% preferred the option of cement injection associated with instrumentation.[11]

The surgical strategy of extending instrumentation was valid in 65% of participants of the AOSpine Latin survey.[11] In addition, long-segment instrumentation was identified as a good option by almost 30% of participants of the SENEC survey[10] and by 45.1% of surgeons in the present report.

Longer fusion constructs for surgical stabilization can provide increased points of fixation that help protect against junctional or segmental failure.[6] Authors recommended surgeons avoid starting or ending the constructs at the cervicothoracic or thoracolumbar junction and to extend the instrumentation at least 3 fixation points above and below the apex of a deformity.[12,19,20]

Hybrid posterior constructs that use pedicle screws, sublaminar wires, and laminar hooks may increase pull-out strength in osteoporotic bone and improve fixation secondary to the relative preservation of cortical bone in the lamina.[6]

Several observational studies in patients with OP have shown that cement augmentation of pedicle screws and expandable pedicle screws can improve fusion rates and decrease complications related to OP.[5]

Polymethyl methacrylate augmentation of pedicle screws has been proven to increase pull-out strength by 119%–250%, but high polymerization temperature and leakage are among some of the risks associated with its use.[19,21,22]

Alternatively, expansive pedicle screws have comparable pull-out strength to standard screws augmented with polymethyl methacrylate and 42.7% greater force than screws augmented with a calcium-based cement.[19,21]

Pseudoarthrosis and Osteoporosis

Regarding spine surgeons' attitudes toward pseudarthrosis, Dipaola et al[8] found that only 19% of surgeons requested a DXA and 20% asked for a bone metabolic profile in patients with pseudoarthrosis. In the SENEC report,[10] 46.1% of respondents did not consider conducting any additional studies for the diagnosis of OP even in the case of reintervention, and only 27.6% would refer the patient to an OP specialist. In our survey, 23.8% of participants would proceed with a reintervention without any additional studies or treatment, and almost 30% opted to refer to a specialist in OP.

The decrease in BMD is an independent risk factor related to the failure of instrumentation in lumbar fusion surgery.[20] If revision surgery becomes necessary for an established symptomatic pseudarthrosis, it is recommended to rule out disorders that may deteriorate bone quality, such as OP, smoking, malnutrition, hyperparathyroidism, rheumatoid arthritis, and other systemic inflammatory diseases.[23,24] Consequently, it is reasonable (depending on the clinical context) to make the effort to diagnose and treat a potential risk factor such as OP before revision surgery in a patient with a pseudarthrosis.

Trends and Management Patterns of Spine Surgeons Concerning Osteoporotic VCF

Regarding the participation of spine surgeons in the case of VCF, Dipaola et al[8] found that 60% of spine surgeons would request a DXA and 39% would ask for metabolic bone laboratory test results after a VCF. In the SENEC study,[10] respondents would improve OP management either by referring the patient to a specialist for medical management (59.7%) or by performing a diagnostic test to confirm OP (24%). In the present survey, 88.4%

of surgeons considered referring the patient for treatment or obtaining DXA and metabolic laboratory test results.

It has been seen that any intervention to evaluate osteoporosis in patients sustaining fragility fractures significantly increased the likelihood of treatment of OP.[7] On the basis of previous reports and this study, it appears that spine surgeons have registered a greater awareness and active participation in the case of VCF related to OP. In our survey, more spine surgeons would agree to screen for OP or refer patients in the case of VCF than with a suspected OP in spine surgery or pseudoarthrosis.

Although VCF, spondylarthrosis, and pseudoarthrosis can be considered different entities with different surgical treatments, it is also true that osteoporotic VCFs are merely a symptom of an underlying metabolic bone disease, and referral for OP treatment should be standard practice, as it is for candidates for spine surgery with risk factors for OP. Second, although not identical to fracture healing, fusion mass healing goes through stages of endochondral ossification and membranous bone healing[7]; the ultimate goal in the treatment of fractures and for fusion is to get them to heal as quickly as possible. Last, spine surgeons, who are frequently provide initial care, are in a unique position to recognize pathologic fractures or detect potential OP in patients scheduled for fusion surgery and institute proper therapy or referrals.[7,8]

Regarding the treatment patterns for patients with VCF, 66.2% of participants in the SENEC study[10] and 55.7% in the present report considered that the most appropriate treatment was vertebral augmentation after a 4–6 weeks of conservative treatment with no improvement. Nevertheless, 22.4% of respondents in the SENEC survey[10] and 30.3% in the present EANS survey opted for a vertebral augmentation technique (vertebroplasty or kyphoplasty) at the time of diagnosis.

The updated Cochrane review included the analysis of 5 randomized trials that compared vertebroplasty with a placebo and concluded that there was high-quality evidence that percutaneous vertebroplasty conferred no clinically important benefits concerning pain, disability, or disease-specific quality of life.[25]

In addition, The American Society for Bone and Mineral Research (ASBMR) created a task force to address key questions on the efficacy and safety of vertebral for patients with acutely painful osteoporotic vertebral fractures. It was founded that percutaneous vertebroplasty provides no demonstrable clinically important benefits compared with placebo or sham procedures.[26]

However, the ASBMR task force recommendations have aroused many criticisms. One is that they completely discount the large body of literature on vertebral augmentation, and some authors argue that vertebral augmentation is demonstrably a lifesaving and life-prolonging procedure as it can statistically save a life for every 15 patients treated.[27,28] In addition, the task force report does not accurately reflect the evidence for vertebroplasty in patients with severe symptoms within 6 weeks of fracture onset. The VAPOUR trial is the only blinded trial to specifically assess this patient group and found vertebroplasty to be more effective than placebo in alleviating severe pain within 6 weeks.[29] Consequently, there is still controversy and no consensus regarding vertebral augmentation.

Regarding the limitations of our research, one was the limited number of key questions; consequently, some important information could not be evaluated. This was balanced by the fact that the rate of response was affected by the length of the survey. This survey was conducted with surgeon members of the EANS whose practices were representative of the neurosurgical community only, and this may have produced a selection bias.

On the basis of recent reports in the literature (Table 3), there is still significant need to improve spine surgeons' awareness and OP management, because between 21% and 41% of surgeons would proceed with spine surgery without additional studies in the case of suspected OP, and 60%–80% of spine surgeons polled appeared to not consider an osteoporosis work-up to be a routine part of a pseudoarthrosis work-up. Only 10%–17% of surgeons considered getting an MBP.[16,17]

Finally, the study of these practice patterns of spine surgeons gives valuable insight into the actual decision-making process in clinical practice and treatment strategy and may help in the creation of consensus guidelines. Bone mineral status measurement, MBP evaluation, and prompt referral if needed should be considered in patients older than 50 years, as a routine work-up for spine surgery, pseudoarthrosis patients, and after a VCF.

CONCLUSIONS

Spine surgeons have a key role in the proper preoperative diagnosis and treatment of OP in patients who require a spinal arthrodesis or suffer from a pseudoarthrosis or VCF.

A greater awareness of preoperative screening and increased rates of referral to the specialist in OP was found in the case of VCF compared with suspected OP or pseudoarthrosis.

There are still opportunities for improvement in the preoperative diagnosis of suspected OP and for optimization of untreated OP patients who would undergo spinal fusion surgery.

REFERENCES

1. Lubelski D, Choma TJ, Steinmetz MP, Harrop JS, Mroz TE. Perioperative medical management of spine surgery patients with osteoporosis. *Neurosurgery*. 2015;77(suppl 1);S92–S97.

2. Hernlund E, Svedbom A, Ivergård M, et al. Osteoporosis in the European Union: medical management, epidemiology and economic burden. *Arch Osteoporos*. 2013;8(1-2):136. doi:10.1007/s11657-013-0136-1

3. Chin DK, Park JY, Yoon YS, et al. Prevalence of osteoporosis in patients requiring spine surgery: incidence and significance of osteoporosis in spine disease. *Osteoporos Int*. 2007;18(9):1219–1224.

4. Goldstein CL, Brodke DS, Choma TJ. Surgical management of spinal conditions in the elderly osteoporotic spine. *Neurosurgery*. 2015;77(suppl 1):S98–S107.

5. Fischer CR, Hanson G, Eller M, Lehman RA. A systematic review of treatment strategies for degenerative lumbar spine fusion surgery in patients with osteoporosis. *Geriatr Orthop Surg Rehabil*. 2016;7(4):188–196.

6. Lehman RA Jr, Kang DG, Wagner SC. Management of osteoporosis in spine surgery. *J Am Acad Orthop Surg*. 2015;23(4):253–263.

7. Daffner SD, Karnes JM, Watkins CM. Surgeon specialty influences referral rate for osteoporosis management following vertebral compression fractures. *Global Spine J*. 2016;6(6):524–528.

8. Dipaola CP, Bible JE, Biswas D, Dipaola M, Grauer JN, Rechtine GR. Survey of spine surgeons on attitudes regarding osteoporosis and osteomalacia screening and treatment for fractures, fusion surgery, and pseudoarthrosis. *Spine J*. 2009;9(7):537–544.

9. Chami G, Jeys L, Freudmann M, Connor L, Siddiqi M. Are osteoporotic fractures being adequately investigated? A questionnaire of GP and orthopaedic surgeons. *BMC Fam Pract*. 2006;7(1):1–5.

10. Díaz-Romero RP, Sosa MH, Armas KM, Coloma GV. Trends and attitudes of spine surgeons regarding osteoporosis. *Neurocirugia (Astur)*. 2019;30(6):268–277.

11. Pantoja S, Molina M. Surgeon management of osteoporosis in instrumented spine surgery: AOSpine Latin America Survey. *Global Spine J*. 2019;9(2):169–172.

12. DeWald CJ, Stanley T. Instrumentation-related complications of multilevel fusions for adult spinal deformity patients over age 65: surgical considerations and treatment options in patients with poor bone quality. *Spine*. 2006;31(19S):S144–S151.

13. Nagahama K, Kanayama M, Togawa D, Hashimoto T, Minami A. Does alendronate disturb the healing process of posterior lumbar interbody fusion? A prospective randomized trial. *J Neurosurg Spine*. 2011;14(4):500–507.

14. Chen F, Dai Z, Kang Y, Lv G, Keller ET, Jiang Y. Effects of zoledronic acid on bone fusion in osteoporotic patients after lumbar fusion. *Osteoporos Int*. 2016;27(4):1469–1476.

15. Ohtori S, Inoue G, Orita S, et al. Comparison of teriparatide and bisphosphonate treatment to reduce pedicle screw loosening after lumbar spinal fusion surgery in postmenopausal women with osteoporosis from a bone quality perspective. *Spine*. 2013;38(8):E487–E492.

16. Kim TH, Lee BH, Lee HM, et al. Prevalence of vitamin D deficiency in patients with lumbar spinal stenosis and its relationship with pain. *Pain Physician*. 2013;16(2):165–176.

17. Ravindra VM, Godzik J, Guan J, et al. Prevalence of vitamin D deficiency in patients undergoing elective spine surgery: a cross-sectional analysis. *World Neurosurg*. 2015;83(6):1114–1119.

18. Stoker GE, Buchowski JM, Bridwell KH, Lenke LG, Riew KD, Zebala LP. Preoperative vitamin D status of adults undergoing surgical spinal fusion. *Spine*. 2013;38(6):507–515.

19. Tomé-Bermejo F, Piñera AR, Alvarez-Galovich L. Osteoporosis and the management of spinal degenerative disease (I). *Arch Bone Joint Surg*. 2017;5(5):272.

20. Lattig F. Bone cement augmentation in the prevention of adjacent segment failure after multilevel adult deformity fusion. *Clin Spine Surg*. 2009;22(6):439–443.

21. Ponnusamy KE, Iyer S, Gupta G, Khanna AJ. Instrumentation of the osteoporotic spine: biomechanical and clinical considerations. *Spine J*. 2011;11(1):54–63.

22. Shea TM, Laun J, Gonzalez-Blohm SA, et al. Designs and techniques that improve the pullout strength of pedicle screws in osteoporotic vertebrae: current status. *Biomed Res Int*. 2014; 48:49. doi:10.1155/2014/748393

23. Ondra SL, Marzouk S. Revision strategies for lumbar pseudarthrosis. *Neurosurg Focus*. 2003;15(3):1–5.

24. Choma TJ, Rechtine G, McGuire RA, Brodke, DS. Treating the aging spine. *J Am Acad of Orthop Surg*. 2015;23(12):91–100.

25. Johnston RV, Rischin KJ, Homik J, et al. Percutaneous vertebroplasty for osteoporotic vertebral compression fracture. *Cochrane Database Syst Rev*. 2018(4): CD006349. doi:10.1002/14651858

26. Ebeling PR, Akesson K, Bauer DC, et al. The efficacy and safety of vertebral augmentation: a second ASBMR task force report. *J Bone Miner Res*. 2019;34(1):3–21.

27. Chen AT, Cohen DB, Skolasky RL. Impact of nonoperative treatment, vertebroplasty, and kyphoplasty on survival and morbidity after vertebral compression fracture in the Medicare population. *J Bone Joint Surg Am*. 2013;95(19):1729–1736. doi:10.2106/JBJS.K.01649

28. Hirsch JA, Chandra RV, Carter NS, Beall D, Frohbergh M, Ong K. Number needed to treat with vertebral augmentation to save a life. *Am J Neuroradiol*. 2020;41(1):178–182.

29. Clark W, Bird P, Gonski P, et al. Safety and efficacy of vertebroplasty for acute painful osteoporotic fractures (VA-

POUR): a multicentre, randomised, double blind, placebo-controlled trial. *Lancet*. 2016;388(10052):1408–1416.

Disclosures and COI: The authors received no funding for this study and report no conflicts of interest.

Corresponding Author: Ricardo Díaz-Romero, MD, Department of Neurosurgery, Hospital Insular of las Palmas, Plaza Doctor Pasteur, s/n, 35016, Las Palmas de Gran Canaria, Spain. Phone: 928494000; Fax: 928494782; Email: ricdrp@yahoo.com.

Published 0 Month 2021

This manuscript is generously published free of charge by ISASS, the International Society for the Advancement of Spine Surgery. Copyright © 2021 ISASS. To see more or order reprints or permissions, see http://ijssurgery.com.