



Practice Patterns of Percutaneous Vertebroplasty: A Survey of Neurosurgeons

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ABSTRACT

AIM: To characterize current vertebral augmentation practices among neurosurgeons in Türkiye, with particular emphasis on patient selection, procedural approaches, complication experience, and postprocedure osteoporosis management.

MATERIAL and METHODS: A national, cross-sectional, anonymous, web-based survey was conducted among neurosurgeons practicing in Türkiye. Data on clinician and institutional characteristics, indications and timing for vertebral augmentation, technical preferences, perceived complications, and approaches to secondary fracture prevention were collected using a questionnaire. Data were analyzed descriptively.

RESULTS: Most respondents reported routinely performing vertebral augmentation at their centers, and many indicated substantial cumulative procedural experience. Clinical decision-making was primarily guided by pain severity and MRI-based fracture acuity. Support for vertebroplasty or kyphoplasty was highest for acute or subacute painful osteoporotic fractures refractory to conservative treatment. In contrast, support was lower for patients with chronic and traumatic fractures without neurologic deficit. Technical practice was relatively uniform, most commonly involving unilateral transpedicular access, local anesthesia with sedation, and single C-arm fluoroscopy. Cement leakage and adjacent-level fractures were frequently reported as lifetime experiences. Only a small minority of respondents reported having a written postprocedure osteoporosis protocol, and routine use of antiresorptive or anabolic therapy was limited.

CONCLUSION: Vertebral augmentation is widely used by neurosurgeons in Türkiye in a selective, patient-centered manner. Although technical practice is relatively consistent, structured secondary fracture prevention after vertebral augmentation is uncommon, highlighting an important opportunity to improve long-term outcomes.

KEYWORDS: Vertebroplasty, Kyphoplasty, Compression fractures, Osteoporosis, Surveys and questionnaires

INTRODUCTION

Vertebral compression fractures (VCFs) are among the most common fragility fractures in older adults and constitute an important source of pain, disability, and health care use. Epidemiologic analyses based on Global Burden of Disease data indicate that vertebral fractures remain a substantial worldwide problem in aging populations, with millions of incident and prevalent cases and a meaningful contribution to years lived with disability (13). Clinically, symptomatic

VCFs may lead to severe back pain, reduced mobility, loss of independence, and increased risk of subsequent fractures. These consequences underscore the need for timely and effective pain control and secondary fracture prevention (23).

Percutaneous vertebroplasty (VP) is a minimally invasive vertebral augmentation procedure in which a fractured vertebral body is injected with polymethylmethacrylate (PMMA) cement. The intended goals of the procedure are to stabilize micromotion within the vertebrae and reduce pain. VP has been widely



used for osteoporotic VCFs and selected pathologic fractures related to malignancy or benign vertebral lesions to reduce pain and promote vertebral restoration. Although anesthesia is frequently used during the procedure, the anesthesia, surgical technique, and method of application vary among surgeons. Consensus statements and practice parameters have been issued by professional societies addressing indications, procedural techniques, and safety considerations, reflecting the procedure's established role in contemporary spine care and emphasizing careful patient selection and the avoidance of complications (1).

The efficacy of VP in osteoporotic fractures has been debated for more than a decade despite its broad use. Two randomized, sham-controlled trials published in 2009 reported no significant advantage of VP over a simulated procedure for painful osteoporotic VCFs, raising concern that observed improvements might reflect placebo effects and challenging routine use in unselected populations (2,10). Later trials and analyses have reported heterogeneous results. This variability may be related to differences in fracture acuity, baseline pain severity, active fracture imaging confirmation, and intervention timing. The VAPOUR trial, published in 2016, reported that VP provided superior pain reduction compared with placebo in patients with acute painful osteoporotic fractures, defined as less than 6 weeks in duration, suggesting potential benefit in carefully defined early-presenting subgroups with severe symptoms (3). In contrast, other sham-controlled studies, including the multicenter VERTOS IV trial published in 2018, did not demonstrate a significant long-term pain benefit of VP over sham in patients with acute osteoporotic fractures (8). Updated systematic reviews continue to indicate that many trials comparing VP with nonsurgical management report symptomatic improvement, whereas placebo-controlled trials often fail to show clear superiority. These findings reinforce the importance of strict definitions of acute painful fracture and the central role of patient selection (6,11).

Real-world practice patterns may also vary substantially across regions and specialties. Differences in indications such as acute or subacute osteoporotic fractures, chronic fractures, malignant fractures, hemangioma, and trauma can be observed. Variation may also occur in thresholds for contraindications, including posterior wall disruption, canal compromise, and infection. Technical decisions may differ regarding unilateral or bilateral transpedicular access, cement viscosity and volume, and approaches to limiting cement leakage. Additional differences include anesthesia, antibiotic prophylaxis, postoperative mobilization, and secondary fracture-prevention strategies. Surveys in spine care have further shown inconsistency in osteoporosis assessment and treatment practices among surgeons, which may influence refracture risk after an index VCF and after vertebral augmentation (5).

Türkiye has an active spine and neurosurgical community and a growing population of older adults. However, national-level

data describing VP practice patterns, peri-procedural management, and postprocedure osteoporosis care remain limited in the peer-reviewed literature. Establishing a contemporary picture of how VP is applied in routine practice may help identify common practices and areas of divergence that mirror the mixed trial evidence. Such information may also support consensus-building and targeted education. Therefore, we conducted a nationwide survey among neurosurgeons in Türkiye to characterize current VP utilization, patient-selection criteria, technical preferences, complication experience, osteoporosis management practices, and attitudes toward the evidence base.

■ MATERIAL and METHODS

Study Design and Setting

We conducted a national, cross-sectional, anonymous, web-based survey to describe the current practice patterns of vertebroplasty/kyphoplasty in Türkiye. The survey targeted neurosurgeons involved in vertebral augmentation procedures and collected data on respondent characteristics, institutional context, procedural volume, clinical decision-making, technical preferences, complications, osteoporosis management, and attitudes toward the evidence base. The study protocol was approved by the Aydın Adnan Menderes University Non-Interventional Clinical Research Ethics Committee (Decision No. 17, Protocol No. 2025/369; meeting date December 04, 2025; approval date December 10, 2025). Participation was voluntary. Completion of the survey indicated informed consent.

Eligible participants were neurosurgeons practicing in Türkiye (specialists and academic staff) who performed or participated in vertebroplasty and/or kyphoplasty. The survey link was distributed electronically through professional networks (e.g., email and messaging platforms) to maximize geographic reach. No personal identifiers were collected.

Survey Instrument and Variables

A structured questionnaire was developed to assess vertebroplasty/kyphoplasty practice across the following domains (reflecting the final item set):

1. Respondent characteristics: sex (Q1), professional title (Q2), years of post-specialty experience (Q3), type of institution (Q4), and proportion of spine surgery in daily practice (Q5).
2. Training background: sources of vertebroplasty/kyphoplasty training (multi-response) (Q6).
3. Center practice and procedure volume: whether vertebral augmentation is routinely performed at the respondent's institution (Q7), number of vertebroplasties performed in the last 12 months (Q8), and lifetime vertebroplasty experience (Q9).

4. Indications and clinical decision-making: mandatory conservative-treatment duration before deciding on vertebroplasty in painful osteoporotic fractures (Q10); procedure tendency ratings for predefined clinical situations using a 5-point Likert scale (1 = “definitely would not perform” to 5 = “almost always would perform”) (Q11); perceived absolute contraindications (multi-response) (Q12); and key determinants of treatment decision-making (multi-response) (Q13).
5. Technical practice patterns: preferred access approach (Q14), dominant hand (Q15), side preference for unilateral approach (Q16), anesthesia modality (Q17), imaging guidance (Q18), typical PMMA cement volume per vertebra (Q19), determinants of cement viscosity selection (Q20), most common stopping rule for cement injection (Q21), routine technique to reduce cement leakage (Q22), uppermost treated level (Q23), anatomical regions treated (multi-response) (Q24), maximum number of levels treated in one session (Q25), use of vertebroplasty for kyphosis correction (Q26), and biopsy practice and instruments used (Q27).
6. Complications and related beliefs: lifetime experience of predefined complications (multi-response), including cement leakage, neurological symptoms, pulmonary embolism, infection, and adjacent-level fracture (Q28); and belief about the association between adjacent-level fractures and vertebroplasty (Q29).
7. Osteoporosis management: perceived responsibility for diagnosis and treatment of osteoporosis in patients undergoing vertebroplasty (Q30), availability of a post-vertebroplasty osteoporosis protocol (Q31), and routine post-procedure recommendations (multi-response) including DXA, calcium/vitamin D, antiresorptive/anabolic therapy, bracing, and exercise (Q32).
8. Special situations: approach to patients using anticoagulants/antiplatelets (Q33), and approach in suspected infection (Q34).
9. Malignancy-related practice: frequency of vertebroplasty use for malignant lesions across three specific aims using a 5-point Likert scale (Q35).
10. Clinical scenarios: management preference for three standardized scenarios (Q36–Q38) with planned oncologic therapy reflecting acute severe osteoporotic fracture, chronic osteoporotic fracture, and painful malignant fracture.
11. Knowledge, attitudes, and educational needs: awareness of sham-controlled randomized trials (Q39), overall opinion regarding the effectiveness of vertebroplasty (Q40), self-assessment of personal utilization frequency (Q41), and the most needed educational topic (Q42).

Data Collection and Management

The questionnaire was administered through an online survey platform (WhatsApp and email groups). Responses were exported to a spreadsheet format for analysis. Duplicate identification was not performed because no personal identifiers were collected; however, incomplete submissions (if present) were retained and handled as missing data at the item level.

Statistical Analysis

All analyses were descriptive. Categorical variables were summarized as counts and percentages. Likert-scale items were reported as the distribution of responses across the five categories. Multi-response items (e.g., training sources, contraindications, complications, and routine recommendations) were summarized as the number and percentage of respondents selecting each option; percentages were calculated using the total number of respondents as the denominator unless otherwise stated. Missing responses were reported when applicable. Statistical analyses were performed using standard statistical software.

RESULTS

A total of 172 respondents were included in this study. The sample was predominantly male (156 respondents), with nearly half (82) specialists and substantial representation of professors (38) and associate professors (29). The post-specialty experience was broad, with the largest group reporting 0–5 years (62) and a notable proportion with ≥ 21 years (43). Participants worked across diverse settings, most commonly in private hospitals and private practice (57), university hospitals (43), and training and research hospitals (42). Spine surgery comprised a high proportion of daily practice for most respondents, with 89 reporting $>75\%$ spine workload. Regarding training, the most frequently reported source was residency/fellowship-based observation and hands-on experience (90), whereas 29 reported formal cadaver courses, 29 reported mentor-based in-house training, and 23 reported no specific training (Table I).

Most respondents reported that vertebroplasty/kyphoplasty was routinely performed at their institution (123/172), 41/172 indicated that it was performed only in selected cases, and 7/172 reported that it was not performed. In the past 12 months, the most common self-reported procedural volume was 1–10 cases (73/172), followed by 11–25 cases (45/172); 10/172 reported performing none. Regarding cumulative experience, 85/172 respondents reported involvement in more than 100 vertebroplasty procedures over their career, indicating a substantial proportion of high-experience operators (Table II).

In painful osteoporotic compression fractures, respondents most commonly reported no fixed, mandatory conserva-

Table I: Participant Characteristics and Training Background

Variable	Category	n (%)
Sex (Q1) (valid n=171)	Female	15 (8.8)
	Male	156 (91.2)
Current position (Q2) (valid n=170)	Specialist	82 (48.2)
	Assistant Professor	21 (12.4)
	Associate Professor	29 (17.1)
Years in practice after specialty (Q3) (valid n=170)	Professor	38 (22.4)
	0–5 years	62 (36.5)
	6–10 years	16 (9.4)
	11–15 years	24 (14.1)
	16–20 years	25 (14.7)
Institution type (Q4) (valid n=170)	≥21 years	43 (25.3)
	University hospital	43 (25.3)
	Training and research hospitals	42 (24.7)
	State hospital	25 (14.7)
	Private hospital/private practice	57 (33.5)
Proportion of patients un- dergoing spine surgery in daily practice (Q5) (valid n=171)	Foundation/research center	3 (1.8)
	<25%	5 (2.9)
	25%–50%	20 (11.7)
	51%–75%	57 (33.3)
Training sources for vertebroplasty/ kyphoplasty (Q6)*	>75%	89 (52.0)
	Formal course/cadaver course	29
	Residency/fellowship observation & hands-on	90
	In-house training with a mentor	29
	No specific training required	23

tive-treatment duration before vertebroplasty, indicating that timing was frequently individualized (43.3%). When asked about procedural tendency, the highest agreement was found for subacute (6–12 weeks) osteoporotic fractures refractory to conservative therapy (Likert 4–5: 76.9%), followed by acute (<6 weeks) fractures with severe pain (Likert 4–5: 64.5%). In contrast, enthusiasm decreased for chronic (>3 months) osteoporotic fractures (Likert 4–5: 33.5%) and was lowest for traumatic fractures without neurological deficit (Likert 4–5: 26.8%). For painful malignant fractures, the responses clustered toward moderate-to-high use (Likert 4–5: 55.3%). The most frequently cited absolute contraindication was infection (82.6%), and the most influential decision driver was pain severity (VAS) (82.6%), followed by MRI-based fracture acuity (71.5%) (Table III).

Table II: Center Practice and Procedural Volume

Variable	Category	n (%)
Periodic vertebroplasty/ kyphoplasty at your center (Q7) (valid n=171)	Yes, routinely performed	123 (71.9)
	Only in selected cases/rarely	41 (24.0)
	No, not performed	7 (4.1)
Number of vertebroplasties personally performed/ participated in during the last 12 months (Q8) (valid n=171)	0	10 (5.8)
	1–10	73 (42.7)
	11–25	45 (26.3)
	26–50	30 (17.5)
	>50	13 (7.6)
Approximate lifetime number of vertebroplasties performed/ participated in (Q9) (valid n=171)	0	0 (0.0)
	1–20	15 (8.8)
	21–50	31 (18.1)
	51–100	40 (23.4)
	>100	85 (49.7)

Most respondents reported using a unilateral transpedicular approach as their primary access technique (111/171, 64.9%), whereas 31.6% (54/171) preferred a bilateral transpedicular approach; parapedicular/costotransverse access was uncommon (3.5%, 6/171). The procedure was most often performed under local anesthesia with monitored sedation (111/171, 64.9%); 15.8% (27/171) reported using general anesthesia, and 9.9% (17/171) indicated that the choice of anesthesia varied by case. Fluoroscopic guidance predominated, with single C-arm fluoroscopy used by 155/170 (91.2%) respondents; biplanar fluoroscopy (5.9%) and hybrid angio suites (2.4%) were rarely reported, whereas CT guidance was exceptional (0.6%) (Table IV).

Regarding cement delivery, the most frequently reported PMMA volume per vertebra was 2–4 mL (69/171, 40.4%), followed by 4–6 mL (54/171, 31.6%); 22.2% (38/171) stated that the injected volume varied by vertebral level and fluoroscopic appearance. In most cases (62.4%, 106/170), cement viscosity was dynamically adjusted based on leakage risk under fluoroscopy, whereas 21.8% (37/170) used the manufacturer's standard method. The most common stopping rule during injection was suspected posterior leakage (85/171, 49.7%), followed by cessation after reaching the target volume (62/171, 36.3%) and stopping due to sudden pain or neurological symptoms (18/171, 10.5%) (Table IV).

In terms of treated regions (multi-response), vertebroplasty was most frequently performed in the lumbar (169/172, 98.3%) and thoracic (158/172, 91.9%) spines, with lower rates for sacral (38/172, 22.1%) and cervical (10/172, 5.8%) levels.

Table III: Indications and clinical decision-making for vertebroplasty

Variable	Category	n (%)	Variable	Category	n (%)
Q10. Mandatory conservative treatment duration before VP (painful osteoporotic VCF) (valid n=171)	<2 weeks	24 (14.0)	Q11E. Tendency to perform VP: Painful fracture due to malignant vertebral lesion (valid n=168)	Likert 1	13 (7.7)
	2–4 weeks	47 (27.5)		Likert 2	26 (15.5)
	4–6 weeks	19 (11.1)		Likert 3	36 (21.4)
	>6 weeks	7 (4.1)		Likert 4	53 (31.5)
	Varies by clinical status/no fixed duration	74 (43.3)		Likert 5	40 (23.8)
Q11A. Tendency to perform VP: Acute (<6 weeks) osteoporotic VCF with severe pain (valid n=169)	Likert 1	10 (5.9)	Q12. “Absolute” contraindications to VP (multi-response; n=172)	Infection (spondylodiscitis/sepsis)	142 (82.6)
	Likert 2	21 (12.4)		Posterior wall defect + spinal canal compression	128 (74.4)
	Likert 3	29 (17.2)		Presence of neurological deficit	128 (74.4)
	Likert 4	45 (26.6)		Severe coagulopathy/inability to stop anticoagulants	87 (50.6)
	Likert 5	64 (37.9)		Excessive clinical/anesthetic risk	49 (28.5)
Q11B. Tendency to perform VP: Subacute (6–12 weeks) osteoporotic VCF, pain despite conservative care (valid n=169)	Likert 1	3 (1.8)	Q13. Most influential factors for VP decision (multi-response; n=172)	Other	4 (2.3)
	Likert 2	8 (4.7)		Pain severity (VAS)	142 (82.6)
	Likert 3	28 (16.6)		Fracture age (MRI findings)	123 (71.5)
	Likert 4	55 (32.5)		Degree of vertebral collapse (radiologic)	91 (52.9)
	Likert 5	75 (44.4)		Presence of severe osteoporosis	69 (40.1)
Q11C. Tendency to perform VP: Chronic (>3 months) osteoporotic VCF with persistent pain (valid n=170)	Likert 1	19 (11.2)		Patient's mobilization status	63 (36.6)
	Likert 2	45 (26.5)		Other	1 (0.6)
	Likert 3	49 (28.8)			
	Likert 4	30 (17.6)			
	Likert 5	27 (15.9)			
Q11D. Tendency to perform VP: Traumatic compression fracture without neurological deficit (valid n=168)	Likert 1	27 (16.1)			
	Likert 2	56 (33.3)			
	Likert 3	40 (23.8)			
	Likert 4	25 (14.9)			
	Likert 5	20 (11.9)			

(Likert 1 = Definitely would not use, Likert 5 = Use very frequently)

The maximum number of vertebral levels treated in a single session was most commonly three (74/170, 43.5%), followed by two (29.4%); 10.6% reported treating ≥ 5 levels in a single session. Vertebroplasty was used to correct kyphosis in 37.1% (62/167) of respondents. Routine biopsy practices varied: 40.8% (69/169) did not routinely obtain biopsies, whereas 47.3% (80/169) reported obtaining biopsies using instruments within the vertebroplasty set; smaller proportions used dedicated biopsy sets (4.1%) or biopsy forceps (7.7%) (Table IV).

Across respondents' cumulative experience, the most frequently reported vertebroplasty-related event was asymptomatic cement leakage (149/172, 86.6%). New adjacent-level fractures were also commonly encountered (87/172, 50.6%). Less commonly reported complications included radicular

pain or new neurological deficit (39/172, 22.7%), pulmonary embolism (17/172, 9.9%), and infection (discitis/osteomyelitis) (15/172, 8.7%). Regarding the attribution of adjacent-level fractures, most respondents considered an association with vertebroplasty to be possible in selected cases (112/170, 65.9%), 17.6% (30/170) believed the relationship was frequently present, and 16.5% (28/170) viewed adjacent fractures as mostly independent of the procedure (Table V).

Most respondents favored shared/multidisciplinary responsibility for osteoporosis diagnosis and treatment in patients undergoing vertebroplasty (65/171, 38.0%), followed by referral to physical medicine and rehabilitation (51/171, 29.8%) and endocrinology (34/171, 19.9%); 12.3% (21/171) believed osteoporosis management should be led primarily by the neu-

Table IV: Technical practice patterns for vertebroplasty

Variable	Category	n (%)	Variable	Category	n (%)
Q14. Most commonly used approach (valid n=171)	Unilateral transpedicular	111 (64.9)	Q21. Most common reason to stop injection (valid n=171)	Suspected posterior leakage	85 (49.7)
	Bilateral transpedicular	54 (31.6)		Lateral venous leakage	4 (2.3)
	Parapedicular/costotransverse	6 (3.5)		Sudden pain/neurological symptoms	18 (10.5)
Q15. Dominant hand (valid n=175)	Right	135 (77.1)		Target volume reached	62 (36.3)
	Left	5 (2.9)		Other	2 (1.2)
	Both	35 (20.0)	Q22. Routine technique to reduce cement leakage (n=119)	High-viscosity cement injection with slow, incremental delivery under frequent fluoroscopic control	56 (47.1)
Q16. Preferred entry side in unilateral VP (valid n=185)	Right-sided entry	34 (18.4)		Anterior placement of cement within the vertebral body (often starting in the anterior one-third)	34 (28.6)
	Left-sided entry	43 (23.2)		None	10 (8.4)
	Depends on vertebral morphology	107 (57.8)		T4	18 (11.5)
	Other	1 (0.5)		T5	18 (11.5)
Q17. Usual anesthesia (valid n=171)	Local anesthesia + sedation (monitored)	111 (64.9)	Q23. Highest vertebral level treated (n=157)	T6	16 (10.2)
	Local anesthesia only	16 (9.4)		Cervical	10 (5.8)
	General anesthesia	27 (15.8)		Thoracic	158 (91.9)
	Depends on case	17 (9.9)	Q24. Regions treated (multi-response) (n=172)	Lumbar	169 (98.3)
Q18. Imaging guidance (valid n=170)	Single C-arm fluoroscopy	155 (91.2)		Sacral	38 (22.1)
	Biplanar fluoroscopy	10 (5.9)		Coccyx	2 (1.2)
	Hybrid angio suite	4 (2.4)		1	5 (2.9)
	CT-guided	1 (0.6)	Q25. Maximum number of levels treated in one session (valid n=170)	2	50 (29.4)
Q19. Average PMMA volume per vertebra (valid n=171)	<2 mL	2 (1.2)		3	74 (43.5)
	2–4 mL	69 (40.4)		4	23 (13.5)
	4–6 mL	54 (31.6)		≥5	18 (10.6)
	>6 mL	8 (4.7)	Q26. Use VP for kyphosis correction (valid n =167)	Yes	62 (37.1)
	Varies by level and imaging appearance	38 (22.2)		No	105 (62.9)
Q20. How cement viscosity is determined (valid n=170)	Standard per manufacturer instructions	37 (21.8)	Q27. Routine biopsy during VP / instrument used (valid n=169)	No routine biopsy	69 (40.8)
	Dynamic adjustment based on leakage risk under fluoroscopy	106 (62.4)		Yes, dedicated biopsy set	7 (4.1)
	Based on fracture morphology/acuity (acute–subacute–chronic)	12 (7.1)		Yes, using instruments within VP set	80 (47.3)
	No clear standard	15 (8.8)		Yes, biopsy forceps	13 (7.7)

rosurgeon. Importantly, a standardized post-vertebroplasty osteoporosis protocol was uncommon: only 3.5% (6/171) reported having a written protocol and 22.2% (38/171) reported having a verbal/team-based protocol, whereas 74.3%

(127/171) indicated that each physician followed an individual approach (Table VI).

Regarding routine postprocedure recommendations (multi-response), the most frequently selected measures were calci-

Table V: Complications and related beliefs

Variable	Category	n (%)
Q28. Complications encountered during career (multi-response) (n=172)	Asymptomatic cement leakage	149 (86.6)
	Radicular pain/new neurological deficit	39 (22.7)
	Pulmonary embolism (cement or thromboembolism)	17 (9.9)
	Infection (discitis/osteomyelitis)	15 (8.7)
	New adjacent-level fracture	87 (50.6)
Q29. Do you attribute new adjacent-level fractures to vertebroplasty? (valid n=170)	Yes, frequently associated	30 (17.6)
	May be associated in some cases	112 (65.9)
	No, mostly independent	28 (16.5)

Table VI: Osteoporosis management practices after vertebroplasty

Variable	Category	n (%)
Q30. Who should take responsibility for osteoporosis diagnosis and treatment in patients undergoing vertebroplasty? (valid n=171)	Neurosurgeon	21 (12.3)
	Physical medicine and rehabilitation	51 (29.8)
	Endocrinology	34 (19.9)
	Shared/multidisciplinary follow-up	65 (38.0)
Q31. Is there a standard post-vertebroplasty osteoporosis treatment protocol in your clinic? (valid n=171)	Yes, written protocol	6 (3.5)
	Yes, verbal/team-based (not written)	38 (22.2)
	No, each physician applies their own approach	127 (74.3)
Q32. Routine recommendations after vertebroplasty (multi-response) (n=172)	DXA (bone mineral density assessment)	96 (55.8)
	Calcium + vitamin D supplementation	115 (66.9)
	Antiresorptive/anabolic therapy (bisphosphonate, denosumab, teriparatide, etc.)	53 (30.8)
	Brace use	113 (65.7)
	Regular exercise/mobilization program	77 (44.8)
	No specific recommendation	8 (4.7)

um/vitamin D supplementation (115/172, 66.9%) and brace use (113/172, 65.7%), followed by DXA assessment (96/172, 55.8%) and a regular exercise/mobilization program (77/172, 44.8%). Antiresorptive/anabolic therapy was routinely recommended by 30.8% (53/172) of respondents, whereas 4.7% (8/172) reported no specific routine recommendation (Table VI).

Nearly half of respondents reported strict adherence to guideline-recommended discontinuation intervals when planning vertebroplasty in patients receiving anticoagulant or antiplatelet therapy (77/170, 45.3%). Others reported proceeding without interruption or using bridging in high-thromboembolic-risk patients (44/170, 25.9%) or making flexible decisions based on personal clinical experience (42/170, 24.7%), whereas only 4.1% (7/170) stated they generally avoided vertebroplasty in such patients. In the setting of suspected spinal infection (spondylodiscitis or epidural abscess), the dominant approach was not to perform vertebroplasty (141/170, 82.9%). A minority would consider vertebroplasty under antibiotic therapy in selected cases (7.6%) or decide case by case without a fixed rule (9.4%). For malignant vertebral lesions, respondents reported moderate-to-high utilization of vertebroplasty, particularly for pain control, with 58.2% selecting Likert 4–5 (pain control-only item). Utilization was more conservative when vertebroplasty was considered in combination with radiotherapy (Likert 4–5: 40.3%) and augmentation after surgical decompression (Likert 4–5: 44.4%), indicating greater variability across oncologic scenarios (Table VII).

In the acute, severely painful osteoporotic fracture scenario (Scenario 1), 51.2% (87/170) of patients reported performing vertebroplasty, whereas 34.1% (58/170) preferred kyphoplasty; only 12.4% recommended extending conservative treatment to at least 4–6 weeks. In the chronic fracture scenario (Scenario 2), most respondents favored continued conservative management without surgery (57.3% [98/171]), whereas 33.9% (58/171) still considered vertebroplasty and 8.8% (15/171) considered other surgical options. For the malignant fracture scenario with planned oncologic therapy (Scenario 3), responses were split between performing vertebroplasty (45.9% [78/170]) and deferring the decision to case-by-case tumor board evaluation (45.9% [78/170]), with a few choosing radiotherapy/systemic therapy alone (7.1%) or decompression plus stabilization (1.2%) (Table VIII).

Most respondents reported at least some familiarity with sham-controlled randomized trials and other contemporary evidence on vertebroplasty: 55.0% (94/171) had partial knowledge, 23.4% (40/171) were familiar in detail, and 21.6% (37/171) were not aware of these trials. When asked to interpret the effectiveness of vertebroplasty in light of this evidence, the prevailing view was that it was beneficial in selected patients (52.7% [88/167]), whereas 37.1% (62/167) considered it broadly effective. Only 2.4% (4/167) of respondents perceived the evidence as weak or effectiveness as questionable, and

Table VII: Special situations and malignancy-related practice

Variable	Category	n (%)
Q33. Approach to vertebroplasty in patients using anticoagulants/ antiplatelets (valid n=170)	Strictly follow guideline-recommended discontinuation intervals	77 (45.3)
	Proceed without stopping/ with bridging in high thromboembolic risk	44 (25.9)
	Flexible decision based on personal clinical experience	42 (24.7)
	Avoid vertebroplasty in these patients	7 (4.1)
Q34. Vertebroplasty when infection is suspected (spondylodiscitis/ epidural abscess) (valid n=170)	Would not perform.	141 (82.9)
	Consider in selected cases under antibiotic therapy	13 (7.6)
	No specific rule; case-by-case decision	16 (9.4)
Q35A. Use of vertebroplasty in malignant vertebral lesions: for pain control only (Likert 1–5) (valid n=160)	Likert 1	8 (5.0)
	Likert 2	14 (8.8)
	Likert 3	45 (28.1)
	Likert 4	50 (31.3)
	Likert 5	43 (26.9)
Q35B. Use of vertebroplasty in malignant vertebral lesions: combined with radiotherapy (Likert 1–5) (valid n=139)	Likert 1	18 (13.0)
	Likert 2	24 (17.3)
	Likert 3	41 (29.5)
	Likert 4	38 (27.3)
	Likert 5	18 (13.0)
Q35C. Use of vertebroplasty in malignant vertebral lesions: augmentation after surgical decompression (Likert 1–5) (valid n=151)	Likert 1	11 (7.3)
	Likert 2	29 (19.2)
	Likert 3	44 (29.1)
	Likert 4	41 (27.2)
	Likert 5	26 (17.2)

(Likert 1 = Definitely would not use, Likert 5 = Use very frequently)

7.8% were undecided. In terms of self-reported utilization, 76.5% (130/170) believed that they used vertebroplasty at an appropriate frequency, 22.4% (38/170) felt that they used it less than warranted, and 1.2% (2/170) felt that they may have overused it. The top educational priority was osteoporosis treatment and fracture prevention (41.9%), followed by current literature and evidence (26.9%). Few respondents focused on indications/patient selection (12.6%), complication management (10.2%), or technical details (8.4%) (Table IX).

Table VIII: Management preferences in standardized clinical scenarios

Variable	Category	n (%)
Q36. Scenario 1 (acute osteoporotic T12 VCF, VAS 9, refractory to 2 weeks of analgesics + brace, no deficit) (valid n=170)	I would perform vertebroplasty	87 (51.2)
	Continue conservative treatment for at least 4–6 weeks	21 (12.4)
	I would prefer kyphoplasty	58 (34.1)
	Other	4 (2.4)
Q37. Scenario 2 (chronic L1 VCF ~3 months, VAS 5, mobile, chronic MRI, no deficit) (valid n=171)	I would perform vertebroplasty	58 (33.9)
	Continue conservative treatment; no surgery	98 (57.3)
	Consider other surgical options (e.g., fusion)	15 (8.8)
Q38. Scenario 3 (metastatic breast cancer, multiple lesions, painful T10 VCF, radionuclide therapy planned) (valid n=170)	I would perform vertebroplasty	78 (45.9)
	Radiotherapy/systemic therapy only	12 (7.1)
	Surgical decompression + stabilization	2 (1.2)
	Case-by-case, tumor board decision	78 (45.9)

■ DISCUSSION

This nationwide survey of neurosurgeons in Türkiye suggests that vertebral augmentation is firmly integrated into routine spine practice. At the same time, clinical use appears to be strongly guided by patient selection, and the findings point to an important systems gap in structured secondary fracture prevention. Most respondents reported that vertebroplasty or kyphoplasty was routinely performed at their center, and many described substantial cumulative experience. Together, these responses indicate broad procedural availability and operator familiarity. Respondents most often prioritized pain severity and MRI features consistent with fracture acuity in clinical decision-making. Support for vertebroplasty was strongest in acute or subacute painful osteoporotic fractures that remain symptomatic despite conservative care. In contrast, endorsement was lower for chronic fractures and for traumatic fractures without neurologic deficit. This pattern is consistent with the clinical rationale for vertebroplasty as an intervention to control pain and provide mechanical stabilization in carefully selected cases. In many practices, imaging evidence of ongoing fracture activity, such as marrow edema, together with marked functional limitation, is considered central when estimating the likelihood of meaningful benefit.

Table IX: Knowledge, attitudes, and educational needs regarding vertebroplasty

Variable	Category	n (%)
Q39. Awareness of recent RCTs (e.g., sham-controlled NEJM/BMJ trials) (valid n=171)	Yes, in detail	40 (23.4)
	Partial knowledge	94 (55.0)
	Not aware	37 (21.6)
Q40. Summary of vertebroplasty based on these trials (valid n=167)	Effective and beneficial	62 (37.1)
	Beneficial in selected patients	88 (52.7)
	Effectiveness questionable/weak evidence	4 (2.4)
Q41. Self-assessment of vertebroplasty use in personal practice (valid n=170)	Undecided	13 (7.8)
	I use it less than warranted	38 (22.4)
	I use it at an appropriate frequency	130 (76.5)
Q42. Most needed education/information area in vertebroplasty (valid n=167)	I may be overusing it	2 (1.2)
	Indications and patient selection	21 (12.6)
	Technical details (approach, cement volume, etc.)	14 (8.4)
	Prevention and management of complications	17 (10.2)
	Osteoporosis treatment and fracture prevention	70 (41.9)
	Current literature/level of evidence	45 (26.9)

The interpretation of these practice patterns should be considered alongside the mixed evidence base, particularly sham-controlled randomized trials that substantially influenced the field. Two pivotal sham-controlled trials published in 2009 reported no significant benefit of vertebroplasty over sham in painful osteoporotic VCFs, raising concerns about placebo effects and routine use in broad, unselected populations (2,10). Subsequent studies have emphasized that timing and baseline symptom severity may be important. The VAPOUR randomized, double-blind, placebo-controlled trial reported benefit of vertebroplasty in patients with very acute fractures less than 6 weeks old and severe pain (3). However, uncertainty has persisted even in acute presentations, as illustrated by the sham-controlled VERTOS IV trial, which did not show a statistically significant difference in pain relief with vertebroplasty compared with sham over follow-up in acute osteoporotic fractures (8). Notably, most respondents in our survey did not endorse a fixed minimum duration of conservative treatment before proceeding to vertebroplasty. Instead, individualized decision-making was described based on clinical severity and

imaging findings. This approach is compatible with the view that benefit may be concentrated in specific acute or sub-acute phenotypes and limited in others, compared with placebo response and natural history. Contemporary consensus and guideline efforts similarly position vertebral augmentation as an option for selected patients and emphasize indications, outcomes, and awareness of complications rather than a uniform approach for all patients (15,18).

From a technical perspective, respondents described broadly similar workflows, with the predominant use of unilateral transpedicular access, local anesthesia with sedation, and single C-arm fluoroscopy. The reported complication experience aligns with published profiles in which cement leakage is common on imaging but often clinically silent. A large meta-analysis reported a cement leakage incidence of approximately 55% for percutaneous vertebroplasty, with lower rates for balloon kyphoplasty, indicating that leakage is frequently an imaging finding rather than a symptomatic event (17,21). The relatively frequent reporting of having ever encountered radicular pain or new neurologic deficit and pulmonary embolism likely reflects cumulative career exposure rather than per-procedure incidence. These responses nevertheless underscore why respondents commonly stop injections when posterior leakage is suspected and cement viscosity is adjusted in response to fluoroscopic leakage risk. Such behaviors are consistent with the principles for leakage risk mitigation described in meta-analytic work on cement leakage risk factors (20,21).

Adjacent-level fracture risk remains a debated downstream issue, and our findings reflect this nuance. While many respondents reported encountering adjacent-level fractures, most believed that vertebroplasty may be related in some cases rather than being the cause. The literature is similarly heterogeneous. Some analyses suggest an increased risk of new vertebral fractures after vertebral augmentation compared with conservative treatment, particularly with longer follow-up. However, confounding at the study level remains difficult to eliminate (16). Other syntheses, especially those restricted to randomized trials, have reported comparable adjacent-level fracture risks between vertebroplasty, kyphoplasty, and the expected course without augmentation (7,9). Risk-factor meta-analyses also indicate that baseline osteoporosis severity, thoracolumbar junction fractures, intradiscal cement leakage, and cement volume may influence the risk of adjacent fractures, highlighting the interaction between patient factors and procedural mechanics (22). Overall, the respondents' cautious attribution appears reasonable. Vertebroplasty is not always causal, but it can play a role under certain biological or technical conditions, especially if osteoporosis is untreated.

The most actionable message from this survey is the lack of standardized management of osteoporosis after vertebroplasty. Only a small minority of patients reported having a written postprocedure osteoporosis protocol, and most indicated that management varies by physician. Although calcium

and vitamin D supplementation and bracing were frequently recommended, the routine recommendation of antiresorptive or anabolic therapy was comparatively low. This gap is clinically important because an index vertebral fracture strongly predicts subsequent fractures, and secondary prevention remains underimplemented in many settings. Reviews have described Fracture Liaison Services as a systems-based model that increases identification, evaluation, and treatment after fragility fractures, addressing the common reality that only a minority of patients receive osteoporosis therapy after an initial fracture (12,14). Evidence syntheses further suggest that Fracture Liaison Service interventions can reduce secondary fracture risk over time and improve the delivery of preventive care (4,19). In our survey, multidisciplinary follow-up was the most commonly preferred approach to ownership of osteoporosis care, which conceptually aligns with the Fracture Liaison Service pathway. However, the scarcity of written protocols suggests that this intent has not yet been consistently translated into standardized processes. Vertebroplasty and kyphoplasty encounters may represent a high-yield point of contact to trigger DXA evaluation, targeted laboratory assessment when appropriate, and initiation or coordination of evidence-based pharmacotherapy. Such an approach may reduce the risk of refracture, regardless of the ongoing debate about the magnitude of the incremental analgesic benefit of vertebroplasty across subgroups.

Several limitations warrant consideration. This was a self-reported survey and is therefore susceptible to recall bias, particularly for lifetime complication exposure, and selection bias if respondents with greater procedural volume or interest were more likely to participate. Item-level missingness also led to variable valid denominators. In addition, the survey responses reflect beliefs and reported practices rather than measured patient outcomes. Therefore, the results should be interpreted as describing practice patterns and perceived risk-benefit balance rather than demonstrating effectiveness. Another limitation is that inferential subgroup analyses comparing practice patterns according to sex, professional title, years of experience, or training background were not performed. Although such analyses may provide useful information for future educational planning, the present study was designed primarily as a descriptive nationwide survey, and some respondent subgroups were small or imbalanced, which could limit the reliability of exploratory subgroup comparisons. Moreover, the survey did not collect patient-level procedural or outcome data. Complications were recorded as self-reported lifetime experiences rather than procedure-level complication rates; therefore, they could not be reliably analyzed according to professional experience or procedural volume without risk of exposure-related bias. Similarly, the reported PMMA volume reflected the usual practice categories rather than the exact cement volume injected into individual vertebrae. Thus, the relationship between cement volume and adjacent-level fracture could not be assessed in a clinically valid manner. Future

prospective or registry-based studies, including patient-level data, exact cement volumes, procedural denominators, and longitudinal follow-up, are needed to identify the predictors of complications after vertebral augmentation. Even so, the survey helps identify domains where practice is relatively consistent, such as core technical workflows and contraindication awareness, and domains where variation is greater, including timing thresholds, antithrombotic strategies, and postprocedure osteoporosis pathways. These findings can inform targeted consensus efforts and quality improvement initiatives.

CONCLUSION

In conclusion, the practice of vertebroplasty and kyphoplasty among neurosurgeons in Türkiye is widespread and technically consistent. At the same time, clinical use is largely selective, favoring acute or subacute painful osteoporotic fractures, with individualized timing decisions. These patterns support a patient-selection framework rather than indiscriminate use when considered alongside sham-controlled trial data showing mixed results across populations and time points. The largest opportunity for improvement highlighted by this survey is the establishment of standardized, multidisciplinary secondary fracture-prevention pathways after vertebral augmentation. Such pathways are likely to deliver durable benefits in reducing refracture and long-term outcomes, regardless of the ongoing debate about short-term analgesic effect sizes in specific trial settings.

Declarations

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Availability of data and materials: The datasets generated and/or analyzed during the current study are available from the corresponding author by reasonable request.

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AUTHORSHIP CONTRIBUTION

Study conception and design: MOY, FH

Data collection: MOY, FH

Analysis and interpretation of results: MOY, FH

Draft manuscript preparation: MOY

Critical revision of the article: FH

Other (study supervision, fundings, materials, etc...): n/a

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