Vertebroplasty and Other Methods of Vertebral Augmentation

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Introduction

One in two women and one in five men over the age of 50 years will suffer a fracture due to osteoporosis. Vertebral compression fractures (VCFs) are the most common type of osteoporotic fracture, with 1.4 million new VCFs occurring worldwide every year. Some of these fractures are asymptomatic or result in tolerable symptoms, with only one-third of patients with a new fracture seeking medical attention. Acute back pain symptoms for most mildly symptomatic VCFs will generally subside over 6–8 weeks as the fracture heals. Patients with severe pain resulting in significant disability are a subset of patients with osteoporosis who may benefit from vertebroplasty.

Vertebroplasty is a minimally invasive, image-guided procedure that involves the injection of cement into the VCF (Fig. 95.1). The primary goal is reduction of back pain and disability. Vertebroplasty is also used for pathological fractures, particularly those caused by multiple myeloma or spinal metastasis. The spine is affected by osteolytic or osteopenic bone disease in 70% of those with multiple myeloma, with 30% of patients sustaining a VCF during the disease. Similarly, osteolytic metastases weaken bone integrity, leading to elevated VCF risk. Around one in eight patients who die of cancer has symptomatic spinal lesions during their illness. Vertebroplasty is used for pain relief for cancer patients with symptomatic pathological VCFs refractory to medical therapy. More recently, there is interest in combining vertebroplasty with adjunct procedures such as radiofrequency ablation and cryoablation to provide local tumor control.

This chapter will outline the background, uses and indications, evidence for efficacy and safety, and clinical pearls of the vertebroplasty procedure. Kyphoplasty and other methods of vertebral augmentation are reviewed in Chap. 99.

Background and Historical Perspective

Conservative Medical Therapy for Vertebral Compression Fractures

The key goals of conservative medical therapies are pain relief and improvement of mobility and function. For most

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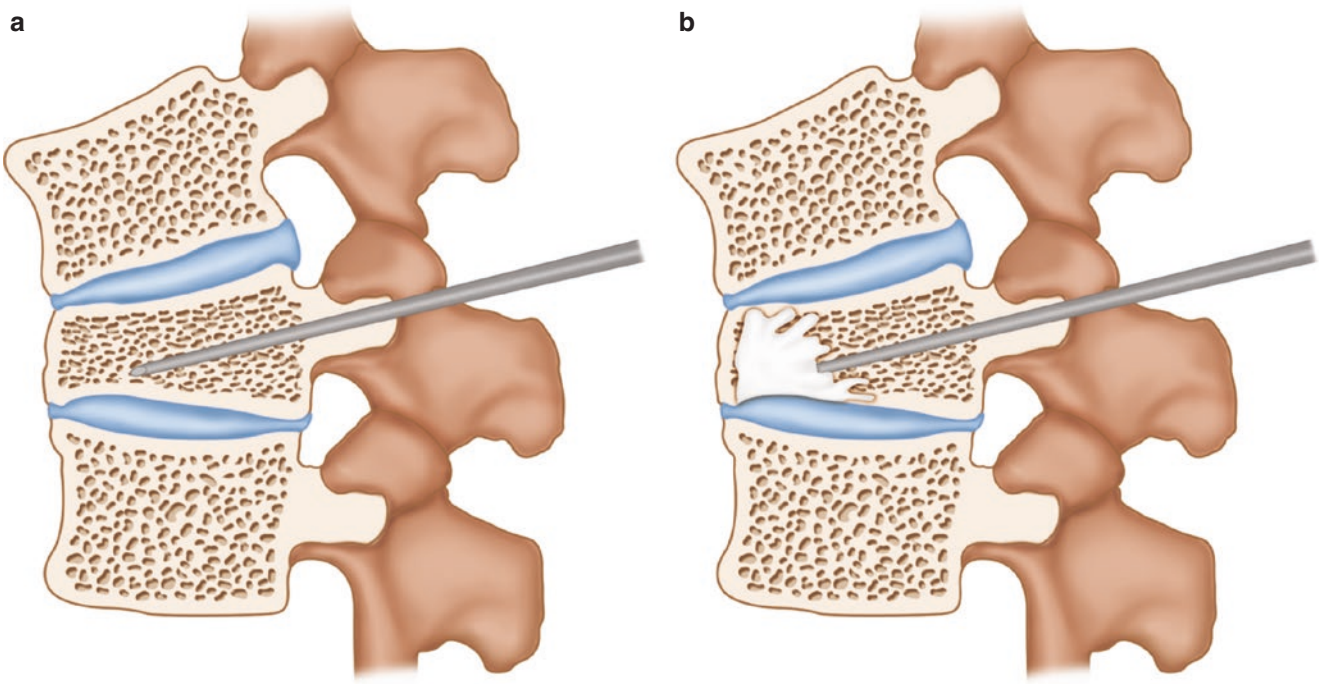

Fig. 95.1 The vertebroplasty procedure. (**a**) The initial steps of the vertebroplasty procedure involve the percutaneous insertion of a needle into the fractured vertebral body. (**b**) Cement is subsequently injected into the fractured vertebra

VCFs, medical management with combinations of analgesics, bed rest, orthosis, and physical therapy is the mainstay of treatment. For those with milder pain and no limitation of function, these measures may be sufficient. However, conservative treatment of those with more severe pain is not benign. In this cohort, medical management often involves a prolonged period of bed rest, which may result in loss of bone mass and muscle strength. Bone loss occurs at an estimated rate of 2% per week, while loss of muscle mass occurs at a rate of 10–15% per week. Furthermore, immobilization leads to an elevated risk of venous thromboembolic disease and decubitus ulceration. The addition of narcotic analgesia, and its associated side effects of sedation, confusion, addiction, and constipation, further complicates management and prolongs recovery. These ill effects are most pronounced in elderly patients.

Historical Perspective

Vertebroplasty was first described in literature in 1987 by Galibert et al., for the treatment of a vertebral hemangioma. Following this, vertebroplasty was introduced to the United States in 1993 by Dion and colleagues. In 1997, they published their treatment results from 29 patients with 47 painful osteoporotic VCFs. Almost all (90%) patients reported improvement of both pain and mobility within 24 hours. Since these early experiences, larger observational series, prospective open-label randomized controlled trials, and double-blind multicenter randomized controlled trials have followed further examining the efficacy and safety of vertebroplasty.

Use and Indications

The decision to proceed with vertebroplasty should be based on a thorough pre-procedural workup, involving history, examination, imaging, and appropriate laboratory investigations. Evaluation of potential candidates should identify those most likely to benefit and assess for contraindications.

Indications

- Acute (<6 weeks) symptomatic VCFs causing severe pain.
- Symptomatic osteoporotic VCFs not responsive to medical therapy.
- Symptomatic VCFs due to spinal neoplasia, not responsive to medical therapy.
- Failure of medical therapy is variably defined but may be considered when pain persists at a level that severely compromises mobility and function despite analgesic therapy or when undesirable side effects (e.g., sedation, confusion, or constipation) occur due to analgesic medications.

Absolute Contraindications

- Systemic sepsis or spinal infection
- Known allergy to polymethylmethacrylate (PMMA) bone cement
- Uncorrectable coagulopathy
- Myelopathy from fracture retropulsion or epidural tumor extension
- Inability to tolerate procedural sedation or anesthesia due to cardiopulmonary risk

Relative Contraindications (Best Performed by Experienced Operators)

- Vertebroplasty above T5 level
- More than 75% vertebral height loss or vertebra plana
- Disruption to the posterior vertebral body cortex
- Marked tumor destruction of vertebral body walls
- Epidural tumor extension into the central spinal canal or neural exit foramina

History and Examination

- The classic symptom of a VCF is deep midline pain. In osteoporotic or pathological bone, this may occur with minimal or no trauma.
- The pain is typically exacerbated on weight-bearing and motion (particularly flexion) and at least partially relieved by recumbency.
- Failure of conventional medical therapy should be documented, along with standardized pain and disability scores and current analgesic use. A reasonable trial of conservative management is 2–4 weeks, but it is reasonable to consider earlier treatment for those requiring narcotic analgesia, analgesic infusions, or hospitalization due to severe pain.
- Physical examination generally reveals midline tenderness at the fractured vertebra. Lower extremity neurologic examination should be performed to screen for myelopathy.

Imaging

Imaging of the spine is performed in all cases to identify the fracture level, assess acuity of fracture, and determine contraindications to treatment or potential technical difficulties. Plain frontal and lateral radiographs or computed tomography (CT) scans are often performed as the initial imaging modality but have limited capability for assessing fracture acuity. Magnetic resonance imaging (MRI) is the investigation of choice and is generally obtained if there are no contraindications. On short-tau inversion recovery (STIR) or fat-suppressed fast spin-echo T2 sequences, unhealed fractures show as T2 hyperintense signals consistent with bone marrow edema. MRI may identify other fracture levels that may not be evident on plain radiograph. It also allows for assessment of the posterior cortex, spinal canal, and neural exit foramina and determines the degree of fracture retropulsion and/or epidural tumor extension. CT is a useful adjunct for pre-procedural planning, particularly to evaluate the integrity of the posterior cortex.

In those with contraindications to MRI (such as a pacemaker), nuclear scintigraphic bone scan is the alternative investigation of choice. It allows the identification of unhealed fractures, which will take up injected tracer in higher concentrations than unhealed fractures. This can be particularly helpful when combined with CT-SPECT imaging to obtain three-dimensional imaging (Fig. 95.2).

Laboratory Investigation

Routine pre-procedural laboratory tests should screen for infection, coagulopathy, and major metabolic abnormality. The use of further tests, such as electrocardiography or chest radiography, is dictated by practitioner discretion and patient history.

The Vertebroplasty Procedure

Sedation

In the majority of patients, analgesia is achieved using a combination of moderate conscious sedation (intravenous fentanyl and midazolam) and local anesthesia (e.g., lidocaine). This approach is desirable as it allows feedback from the patient (e.g., worsening pain and changing neurological status) that can alert the operator to potential complications. However, general anesthesia may be required in some cases, particularly in those with high pre-procedure narcotic analgesic requirements. All patients receive continuous monitoring of pulse oximetry, blood pressure, and electrocardiography.

Patient Positioning

Patients are ideally positioned in the prone position for vertebroplasty procedures. In practical terms, an amount of freedom is allowed for patients to place themselves in a prone oblique position should this promote greater comfort during the procedure; this may introduce 10–15 degrees of

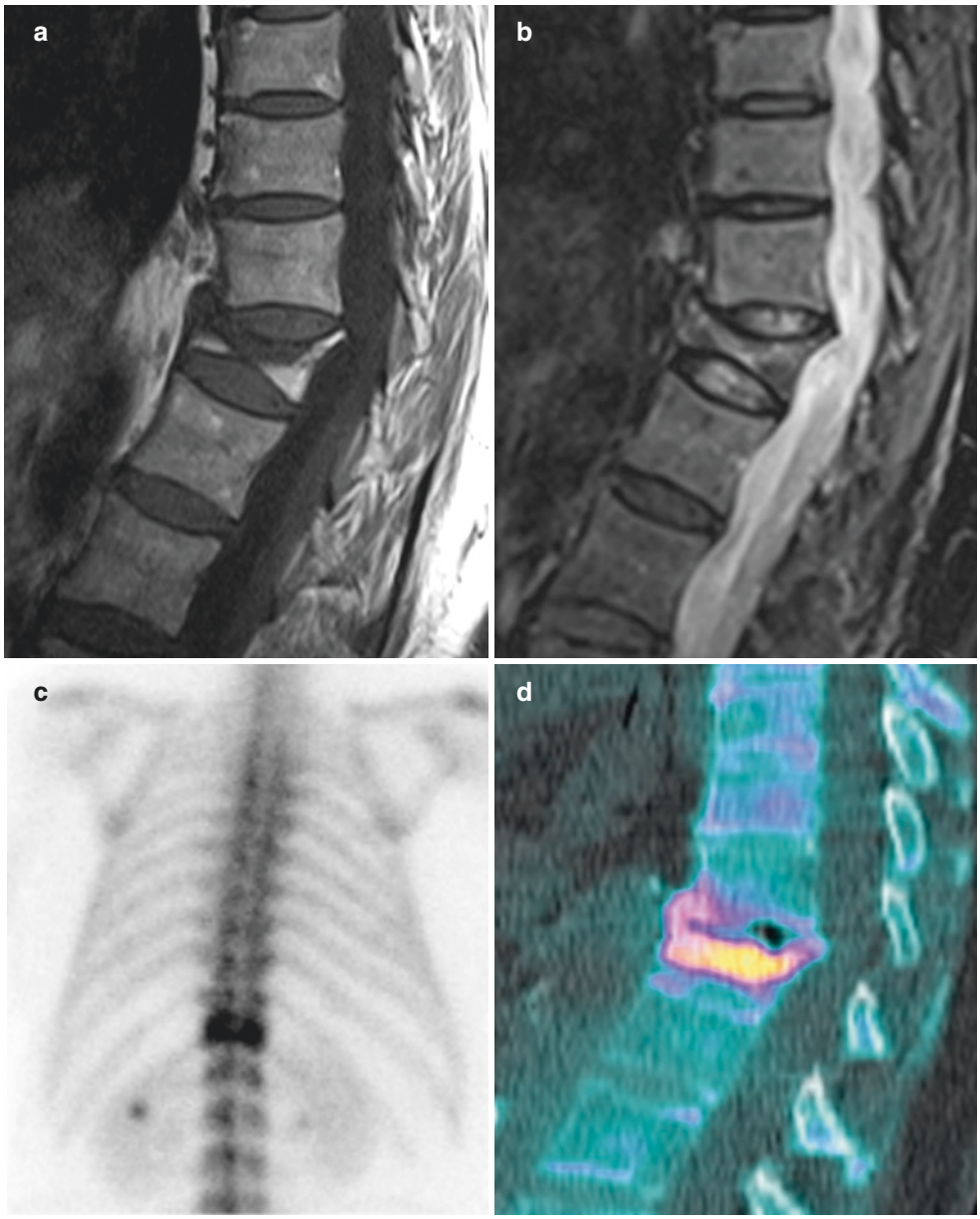

Fig. 95.2 Use of advanced imaging with MRI and bone scan with CT-SPECT to assess the fracture and select patients likely to respond to vertebroplasty. (**a**) Sagittal T1-weighted MRI image. Reduced T1 signal intensity at the T12 vertebral body from marrow edema. (**b**) Short-tau inversion recovery (STIR) MRI image. There is only mildly increased STIR signal intensity in the T12 vertebra. (**c**) Whole body delayed bone scan image. There is increased uptake in the T12 vertebral body. (**d**) Sagittal CT-SPECT image. There is significantly increased uptake that is clearly localized in the fractured vertebral body. The patient had significant pain reduction within 1 week of the vertebroplasty procedure

obliquity. Prone positioning, with proper cushion support under the upper chest and lower abdomen, maximizes extension of the fractured vertebral body, thus promoting reduction of kyphosis. The patient's arms should be placed toward the head, out of the path of the fluoroscope. Analgesia should be considered prior to positioning on the table, as transfer from the bed to the procedure table may be painful. Care should be taken in positioning the elderly and those with advanced osteoporosis, to avoid new fractures of the rib, extremities, or vertebra.

Antibiotic Prophylaxis and Skin Preparation

Infection risk is minimized by following standard guidelines for sterile skin preparation, draping, and operator scrubbing. No randomized controlled data currently support or oppose antibiotic administration, but there are reports of post-procedure spinal infections, and the use of PMMA can make these infections difficult to treat. Antibiotic prophylaxis is thus routinely used. Typical regimens include intravenous cefazolin (2 g) or clindamycin (600–900 mg, if penicillin allergy).

Needle Placement

In vertebroplasty, a needle is inserted through a small skin incision in the back, through the subcutaneous tissues and into the fractured vertebra. The key aspect of needle placement is to maintain the needle trajectory lateral to the medial cortex of the pedicle and superior to the inferior cortex. This prevents entry of the needle into the spinal canal or

neural foramen. Ideally, the final needle position should be as close to the midline as possible. The trajectory taken may be transpedicular or parapedicular (Fig. 95.3). The transpedicular approach takes the needle from the posterior surface of the pedicle, through the entire length of the pedicle and into the vertebral body. However, the pedicle configuration may limit the ability to place the needle tip near the midline. A parapedicular approach takes the needle along the lateral surface of the pedicle, penetrating the pedicle along its path or penetrating the vertebral body at its junction with the pedicle. This may permit a more medial placement of the needle tip, which is particularly useful when treating anatomically smaller pedicles, such as in the thoracic spine.

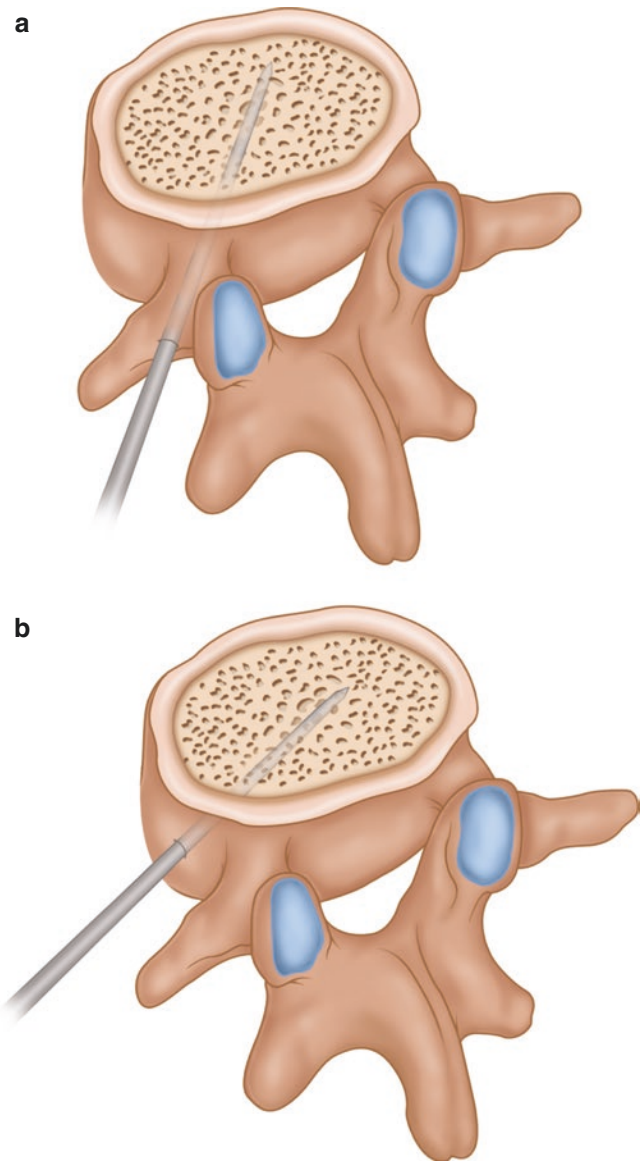

Fig. 95.3 Transpedicular compared to parapedicular approaches. (**a**) The transpedicular approach takes the needle from the posterior surface of the pedicle, through the entire length of the pedicle and into the vertebral body. (**b**) The parapedicular approach takes the needle along the lateral surface of the pedicle, penetrating the pedicle along its path or penetrating the vertebral body at its junction with the pedicle. This may permit a more medial placement of the needle tip, particularly when treating anatomically smaller pedicles

Vertebroplasty

- The trocar trajectory is planned. For a transpedicular approach, its entry position should be at the 3 o'clock position of the right pedicle or the 9 o'clock position of the left pedicle. For a parapedicular approach, an entry position just lateral to the 3 or 9 o'clock position of the pedicular cortex is optimal. 15 degrees of obliquity during planning may help facilitate unilateral trocar trajectories to achieve midline position (Fig. 95.4).
- The skin and periosteum are anesthetized with lidocaine or bupivacaine.
- A small vertical incision is made to the skin, and an 11- or 13-gauge diamond-tip stylet, sheathed in a cannula, is placed.
- In the bone, the needle is advanced by carefully tapping the handle of the needle with an orthopedic hammer.
- The needle must remain lateral to the medial cortex of the pedicle until it has traversed the entire pedicle. After this point, the diamond-tip needle may be replaced with a bevel-tip for improved maneuverability. The needle is then advanced further, to the anterior one-third of the vertebral body.
- The needle stylet is removed and the injecting system connected.
- The PMMA cement is prepared. Working time varies from 10 to 20 minutes, depending on temperature and the specific formulation. PMMA is slowly injected under continuous biplane fluoroscopic guidance. The optimal volume of cement remains a matter of debate. Ideally, cement will extend across midline from one pedicle to the opposite pedicle by the end of injection (Fig. 95.5).

Adjunct Procedures

For neoplasm-related fractures, vertebroplasty may be combined with the adjunct procedures of radiofrequency ablation (RFA) or cryoablation. In RFA, a high-frequency current is applied through an insulated needle prior to the injection of cement. The thermal energy produced at the tip of the needle may ablate pain-sensitive fibers and thus reduce transmission of pain signals from the periosteum. In addition, this may also provide local tumor control. Cryoablation is a similar procedure that applies extreme cold rather than current. Liquid nitrogen or high-pressure argon gas is administered through an applicator known as a cryoprobe, producing intense cold that may disrupt pain-sensitive fibers and ablate neoplastic tissue. Some of these ablative techniques are off-label and performed at operator discretion.

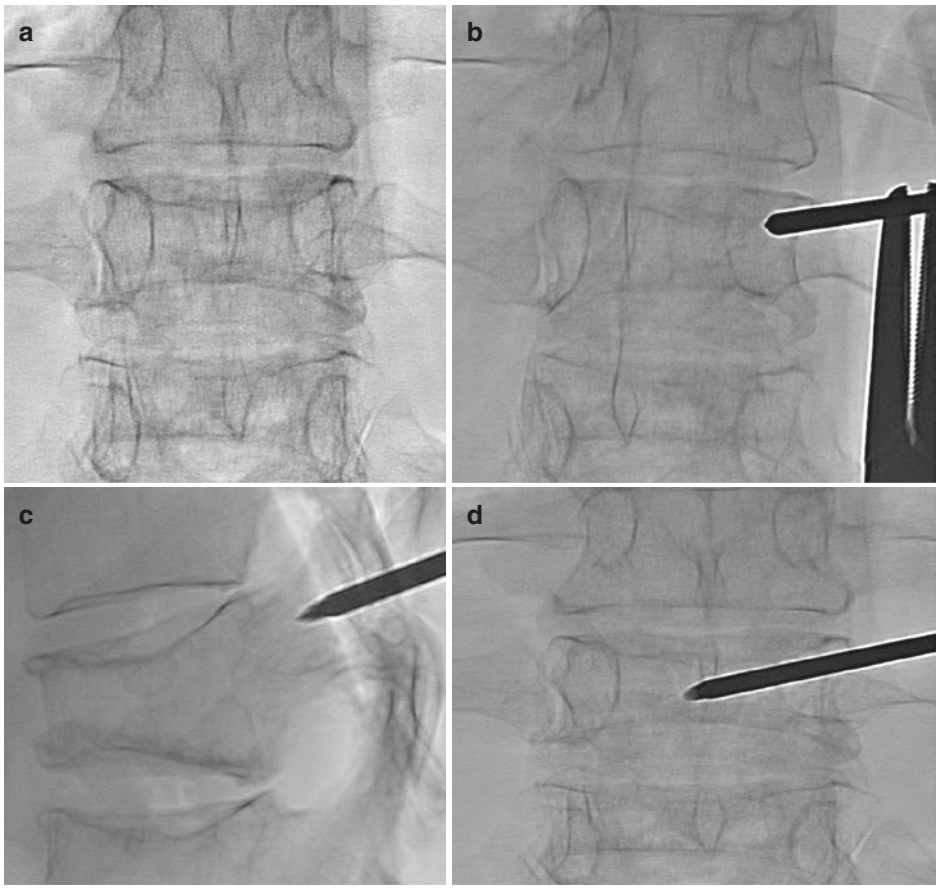

Fig. 95.4 Needle trajectory for unilateral approach. (**a**) Anteroposterior (AP) fluoroscopic image. The image intensifier is rotated to the AP position by aligning the spinous process midway between the pedicles (vertical dotted line), and adjustments are made in the craniocaudal angulation until the pedicles and anterior vertebral body endplates are within the midportion of the vertebral body (horizontal dotted lines). (**b**). AP fluoroscopic image. The image intensifier has been rotated 15 degrees oblique, and the needle tip has been placed approximately at the 3 o'clock position for pedicle entry. (**c**) Lateral fluoroscopic image. The entire needle trajectory is extrapolated during the initial planning and needle entry to optimize final needle position (solid line). (**d**) Midline needle position achieved via unilateral transpedicular approach

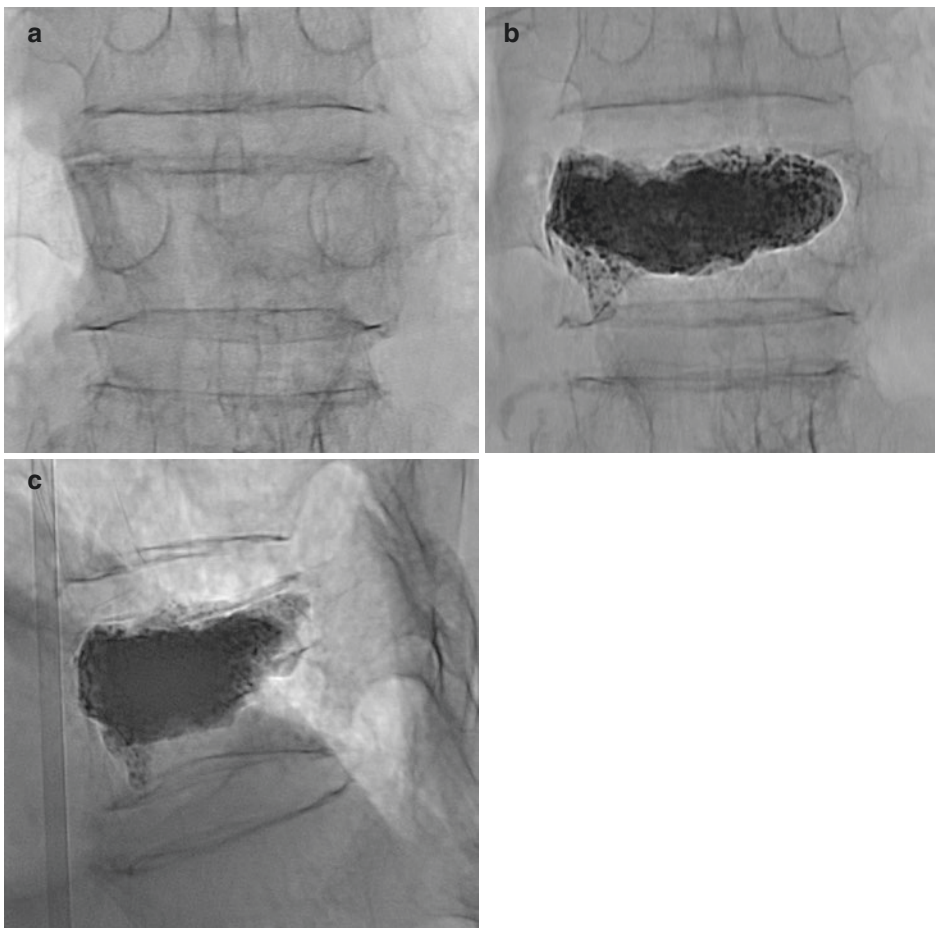

Fig. 95.5 Cement fill within the vertebral fracture. (**a**) Anteroposterior (AP) fluoroscopic image of the fractured vertebral body prior to vertebroplasty. (**b**). AP fluoroscopic image after unipedicular vertebroplasty. Note the cement has been deposited in the vertebral body across the midline. (**c**) Lateral fluoroscopic image. There is no cement extending into the spinal canal or pedicles

Post-procedure Care

Immediately following the procedure, manual compression is applied over needle access sides to prevent hematoma formation. The patient should remain supine and flat in bed for 2 hours post-procedure, followed by a further hour with the head of the best inclined at 30 degrees. Most patients may be discharged later in the same day, though more fragile patients may require an overnight stay for observation. Procedure-related pain is typically treated with nonsteroidal anti-inflammatory medications, or occasionally muscle relaxants or short-term narcotics, and generally resolves over a period of 24–72 hours.

Post-procedure review of the patient's progress should occur a few weeks after the procedure, to assess pain and mobility levels. The patient should be counseled to report any acute increase in back pain, or new back pain, as this may indicate a new fracture. Imaging should be performed, although it is important to note that normal MRI findings following vertebroplasty include persistent bone marrow edema at the treated level which may persist for many months post-procedure.

Evidence for Efficacy

The predominant mechanism for vertebroplasty reducing pain is thought to relate to reduced motion at the fracture site by PMMA interdigitating through the fracture and trabecular bone. There also is a direct thermal effect on the intraosseous nerves. To date, evidence for the efficacy of vertebroplasty in VCFs remains mixed. Initial enthusiasm was driven by positive results from meta-analyses and observational data. However, this was dampened by the 2009 publication of two highly publicized randomized controlled trials (RCTs) in the *New England Journal of Medicine (NEJM)* that found no improved pain outcomes from vertebroplasty. Since that time, several large prospective trials have focused on more stringent patient selection and provided further high-quality evidence. Discussion of the NEJM and subsequent randomized controlled trials are summarized below and in Table 95.1.

NEJM Trials

In 2009, two large double-blinded RCTs comparing vertebroplasty to a sham procedure in osteoporotic VCFs were published in the *New England Journal of Medicine (NEJM)*. The INVEST trial (Investigational Vertebroplasty Safety and Efficacy Trial) included patients aged ≥50 years, with moderate-to-severe back pain (≥3/10 on numerical rating scale (NRS)) and fracture age < 1-year duration. Fracture acuity was confirmed by plain radiography, with MRI performed if fracture age was uncertain. A total of 131 patients were randomized to receive vertebroplasty (N = 68) or a sham procedure (N = 63). At 1-month follow-up, there was

Table 95.1 Major prospective randomized trials evaluating the efficacy of vertebroplasty for osteoporotic fractures

	INVEST	Buchbinder et al.	VERTOS II	VAPOUR
Publication year	2009	2009	2010	2016
Total enrolment (*n*)	131	78	202	120
Comparator	Sham procedure: periosteal lidocaine	Sham procedure: periosteal lidocaine	Medical management	Sham procedure: subcutaneous lidocaine
Age (years) threshold	≥50	None	≥50	≥60
Mean (SD) age (years)	73.8 (9.4)	76.6 (12.1)	75.2 (9.8)	80.5 (7)
Pain score threshold	NRS ≥3/10	None	VAS ≥5/10	NRS ≥7/10
Mean (SD) baseline pain score (0–10 scale)	7.0 (1.9)	7.3 (2.2)	7.8 (1.5)	8.6
Number (percent) with severe pain (0–10 scale)	61 (47%) NRS ≥8	38 (49%) NRS ≥8	NR	120 (100%) NRS ≥7
Fracture age (weeks) threshold	<52	<52	<6	<6
Mean (SD) fracture age (weeks)	22.5 (16.3)	11.7 (11.1)	5.6	2.6
Number (percent) with fractures < 6 weeks	26 (20%)	31 (40%)	202 (100%)	120 (100%)
Advanced imaging (MRI, SPECT) required?	No	Yes	Yes	Yes
Mean (SD) PMMA volume (mL)	NR	2.8 (1.2)	4.1 (1.5)	7.5 (2.8)
Primary endpoint	Mean NRS pain and RDQ at 1 month	Mean NRS pain at 3 months	Mean VAS pain at 1 month	Percent NRS pain <4/10 at 2 weeks
Primary outcome	No difference	No difference	Vertebroplasty superior	Vertebroplasty superior
Notable secondary endpoints	Quality of life (EQ-5D) at 1 month	Disability (RDQ), quality of life, QUALEFFO, EQ-5D)	Disability (RDQ), quality of life (QUALEFFO)	Disability (RDQ), quality of life (QUALEFFO), analgesic use
Secondary outcomes	No difference	No difference	Vertebroplasty superior	Vertebroplasty superior

no difference between groups in back pain NRS ($p = 0.19$) or disability ($p = 0.49$) measured by Roland-Morris Disability Questionnaire (RDQ). Limitations included the inclusion of fractures up to 12 months old (one-third had fractures of >6-month duration), the lack of MRI as an inclusion requirement, and the use of a controlled intervention (periosteal local anesthetic infiltration) rather than a true sham procedure.

An Australian multicenter blinded RCT of vertebroplasty for osteoporotic fracture was also published in the *NEJM* in 2009, by Buchbinder and colleagues. Inclusion criteria were back pain of <1-year duration and fracture confirmed on MRI. A total of 78 patients were given vertebroplasty ($N = 38$) or sham procedure ($N = 40$). No significant differences in pain scores were observed at 1 week, 3 months, or 6 months. There was also no difference between groups in disability and quality of life measures. Key limitations included the lack of a minimum pain score for inclusion in the study, the lack of physical examination component, and, as with the INVEST trial, the inclusion of fractures up to 12 months old (only 32% of patients had fractures <6 weeks old).

The 2010 VERTOS II trial was a prospective open-label RCT comparing vertebroplasty with medical management for osteoporotic fractures. Patients were included if there was severe back pain (score < 5 on visual analogue scale (VAS)) of <6-week duration, focal tenderness on clinical examination, and bone edema on MRI (thus addressing some limitations from the 2009 trials). A total of 202 patients received vertebroplasty ($N = 101$) or medical therapy ($N = 101$). At 1 month, vertebroplasty resulted in significantly improved pain relief. The mean reduction of VAS was 2.6 greater in the vertebroplasty group than conservative management, and this difference between groups was sustained at 1 year. The vertebroplasty group also demonstrated greater improvements in quality of life (as determined by several standardized questionnaires), earlier significant (VAS reduction >3 points) pain relief (30 days vs 116 days, $P < 0.0001$), and gain of 120 pain-free days. The major limitation of this trial was the lack of blinding, which may have led to overestimation of treatment effect.

Multiple further small prospective RCTs comparing vertebroplasty with medical management for osteoporotic fractures have been subsequently published demonstrating benefit in acute (<6 weeks), subacute (6–12 weeks), and chronic (>12 weeks) old fractures. The hallmarks of these positive RCTs were inclusion of patients with moderate or severe pain with advanced imaging selection, mainly MRI edema. A large multicenter case series of 3320 patients treated with vertebroplasty for osteoporotic fractures also demonstrated significant reduction in pain 48 hours after vertebroplasty. However, over the course of these studies, there remained ongoing concern regarding the potential impact of the placebo effect from these open-label RCTs.

In 2016, the VAPOUR trial (Vertebroplasty for Acute Painful Osteoporotic fractURes) was published in *The Lancet*, comparing vertebroplasty with a placebo procedure. Patients were older than previously studied (inclusion criteria of >60 years), all had severe pain (≥7/10), and all fractures were < 6 weeks in duration (mean fracture age 2.6 weeks). Fractures were confirmed with MRI or SPECT. In total, 120 patients were randomized to vertebroplasty ($N = 61$) or placebo ($N = 59$). At 2 weeks, a significantly higher proportion of patients in the vertebroplasty arm had pain scores of 4 or less, compared to the placebo arm, meeting the primary outcome. This benefit was sustained at 1 and 6 months. Notable secondary outcomes observed in the vertebroplasty group included reduced disability, improved quality of life questionnaire scores, reduced analgesic use, and median reduction of 5.5 hospital inpatient days.

There is less high-quality data available for vertebroplasty for neoplastic vertebral fractures. A systematic review that included 987 patients with spinal metastasis and myeloma across 30 studies revealed pain reduction of 20–79% 1 month after vertebroplasty. At 6 months, pain reduction ranged from 47% to 87%. There was no association between cement volume and pain reduction. A subsequent large pooled analysis of vertebral augmentation in 923 myeloma patients (60% received vertebroplasty) also demonstrated significant and sustained pain reduction up to 1 year posttreatment; both vertebroplasty and kyphoplasty were equally effective at reducing pain.

The combination of vertebroplasty with local adjunctive therapies such as radiofrequency ablation and cryotherapy does not seem to achieve superior pain reduction to vertebroplasty alone. However, the use of these adjunctive therapies may be promising for local tumor control. In a recent small study of 49 patients with painful vertebral metastases who underwent combined vertebroplasty and RFA, apart from reduction in pain and disability scores by 2–4 weeks, short-term post-ablation MRI demonstrated reduced tumor bulk, and posttreatment FDG-PET showed either reduced or absent metabolic activity.

Evidence for Safety

Overall, the rates of major complications from vertebroplasty are low. Major complication rates are <1% for patients with osteoporotic fracture and < 5% of those treated for neoplastic fractures. Potential serious complications that have been reported in literature include permanent neurologic deficits resulting from nerve or spinal cord injury; fractures of the rib, sternum, or pedicle; symptomatic cement leakage; allergic or idiosyncratic reactions; infection; pulmonary

embolus; hemothorax or pneumothorax; local vascular injury; or death from cardiac or pulmonary cement embolism or anaphylaxis.

Analysis of major RCTs reveals low rates of serious complication from vertebroplasty for osteoporotic fractures, with no procedure-related mortality reported. In the VERTOS II trial, the only symptomatic complication referable to vertebroplasty was one urinary tract infection. The INVEST study reported a single thecal sac injury, while the INVEST study reported one case of osteomyelitis in a patient who did not receive antibiotics. In the VAPOUR trial, one patient had a respiratory arrest after administration of sedation before starting the procedure. This patient was treated uneventfully 48 hours later. Another patient sustained a humeral fracture during transfer onto the procedure table. In contrast, two patients in the control group had interval vertebral collapse with spinal cord compression; one remained paraplegic.

For neoplastic fractures, the risk of serious complications is higher. A previous systematic review of vertebroplasty in 987 patients for neoplastic fracture revealed a serious complication rate of 2%. In a larger multicenter series of 4547 patients with a total of 13,437 treated vertebrae (73% osteoporotic fractures), no major neurological complications occurred. Rates of pulmonary embolism, hematoma, or infection were < 1%.

Asymptomatic cement leakage outside the vertebra is common when assessed with CT scanning (72% in the VERTOS II trial; 34% in VAPOUR). Leakage is more likely in cases with cortical disruption, fracture clefts, low-viscosity cement, and high-volume injections. Symptomatic cement leak is rare, with secondary cement embolization exceedingly rare. Although rates of cement leak are reduced by use of kyphoplasty compared to vertebroplasty, there is no difference in rates of pain or disability reduction.

Pearls and Pitfalls

- The optimal threshold of cement infusion volume remains controversial, with some operators advocating injecting cement to fill the vertebral body and others recommending injecting lower volumes of cement to maximize safety. However, there has been no clear data to suggest improved pain outcomes with higher cement volumes. Moreover, there is increased risk of cement extravasation from higher injected cement volume. The current evidence favors a more cautious approach to the injected cement volume to maximize safety.
- Consistency and viscosity vary between cement preparations with variable working times. Higher viscosity generally requires injection of cement at higher pressure and typically has shorter working time than low-viscosity cement, and thus less total volume of cement may be injected. However, use of higher-viscosity cement reduces the rates of cement leak, with data suggesting comparable pain outcomes. A drip test can be used to test cement viscosity—The cement should ball up at the end of the needle and not drip downward, resulting in a consistency slightly more viscous than toothpaste.
- Vertebroplasty can be performed with placement of a single unilateral approach or bilateral approach. Key benefits of a unipedicular approach include reduced procedure time and less risk of pedicular breach or adjacent tissue injury. The key advantage of a bipedicular approach is the likelihood to inject a greater cement volume. Importantly, there is no difference between the two approaches with regard to pain relief, anatomic outcomes, or quality of life measures. Use of a unilateral approach is sufficient in most cases and may be converted to bilateral if midline position is difficult to achieve due to vertebral or fracture morphology.
- Treating >3 fractures in a single session remains controversial, with concerns regarding prolonged prone positioning, excessive sedation, post-procedure discomfort resulting from multiple needles, and PMMA toxicity. While some studies have demonstrated the safety of vertebroplasty independent of the number of levels treated per session, previously published data have highlighted concerns regarding PMMA reactions including hypotension and death when multiple levels are treated in one setting. This may relate to the increased risk of systemic emboli with treatment of multiple levels. Thus, a more cautious approach would be to treat up to three levels in a single session.
- Optimize spatial resolution and magnification during fluoroscopy while performing vertebroplasty. Patients may have marked osteopenia or focal bony lysis from neoplasm making bony landmarks challenging to identify. This can be partially overcome by optimizing radiation dose and using appropriate magnification. Use of biplane fluoroscopy is particularly helpful to facilitate continuous monitoring during cement injection.
- When performing vertebroplasty in the setting of posterior wall osteolysis or epidural tumor extension, there should be awareness of the neurologic risks from epidural extension of cement or posterior displacement of the tumor by the cement. Certain safeguards should be considered, including biplane fluoroscopy, more modest cement injection, using thicker cement, limiting cement to anterior two-thirds of the vertebral body, and use of conscious sedation (to facilitate assessment of lower limb neurological status or development of new pain during the procedure).
- Needles used during vertebroplasty are typically straight. However, curved needle systems are available that may enable better maneuverability and the ability to target the

flow of PMMA within a quadrant of the vertebral body. This may allow one to reach a more desired radiographic endpoint, such as targeting of focal neoplasm or achieving final needle position beyond midline from a unilateral approach.

Recommended Reading

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