Percutaneous Vertebral Augmentation: Vertebroplasty and Kyphoplasty

98

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Contents

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Indications

Vertebroplasty was initially described by Galibert et al. in 1987 as a percutaneous technique to treat vertebral angiomas [1]. Since that time, the treatment indication for vertebroplasty has expanded to include osteoporotic compression fractures, metastatic spinal lesions, and traumatic vertebral body fractures [2].

Affecting more than 24 million Americans, osteoporosis is a systemic metabolic bone disorder characterized by low bone density and the progressive microarchitectural deterioration of bone tissue leading to increased bone fragility and thus an increased risk of fracture [3]. Vertebral fractures are the most common type of osteoporotic fracture and are a significant cause of morbidity and mortality in the elderly population in the United States [4]. The incidence of osteoporotic vertebral fractures is difficult to accurately quantify given that only approximately 30 % come to medical attention [5]. The risk of developing VCF has been shown to increase with age. Slightly less than 25 % of women over the age of 50 years are afflicted by osteoporotic bone fractures [6]. This number increases only slightly into the seventies, after which there is an abrupt rise into the 40–50 % range for female octogenarians [5, 7]. However, this is not solely a women's disease, as a review by Olszynski et al. demonstrated that VCF occurs in approximately 40 % of men surviving into their eighth decade [8]. Osteoporosis has a significant

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socioeconomic impact, as the estimated cost of osteoporotic bone fractures within the United States in 1995 was approximately $746 million [3]. Considering the increasing life expectancy in the United States, as well as the growth in the senior citizen population as the "baby boomer generation" ages, the prevalence and economic impact of this disease will continue to magnify in the near future. Other factors that increase the risk of developing VCF include rheumatoid arthritis, cirrhosis, renal insufficiency, menopause, prolonged immobilization or immobility, chronic steroid therapy, diabetes mellitus, and malnutrition [9].

Metastatic spinal lesions that cause compression fractures have also been treated with vertebroplasty. Metastatic disease commonly affects the spine and is symptomatic in more than a third of patients afflicted with cancer [10, 11]. Spinal metastases are the presenting symptom in approximately 10 % of cases [12]. The majority of primary lesions are breast, lung, and prostate, which account for approximately 60 % of cases, while gastrointestinal and renal malignancies are each responsible for 5 % of cases [13]. Metastases are typically osteolytic processes, and result in subsequent weakness and fracture of the vertebral bodies. Symptomatically, these lesions result in debilitating pain, deformity, and neurological compromise [10, 11, 13]. These sequelae have a detrimental impact on the quality of life for patients who already have systematic neoplastic disease. Vertebroplasty has become a useful treatment for symptomatic relief for spinal metastatic disease [14–17] as well as multiple myeloma [18], has been used to treat malignant compression fractures with epidural involvement [19], and has been combined with radiotherapy [20].

Vertebroplasty has also been employed in the treatment of burst fractures [2], although this should be done with trepidation. Detailed analysis of radiographic images is essential to ensure that injection of cement does not cause further retropulsion of loose bone fragments into the canal. It has been shown that balloon vertebroplasty may be used safely in cases where damage to the longitudinal ligaments is expected [21]. In the setting of vertebral burst fracture, careful consideration must be made in the decision to perform cavity creation, and with what method (balloon or arc osteotome).

Natural History and Conservative Management

Osteoporosis-induced VCF can be a self-perpetuating cycle. Ross et al. examined how bone mass density and the presence of VCF were predictive of the development of future fractures [22]. After a mean follow-up of 4.7 years, they concluded that patients who had a bone mass less than two standard deviations from the mean have a fivefold increased risk of developing VCF. This increased risk was the same for patients with average bone density and a prior single VCF. However, in the presence of two or more VCFs, this risk is magnified to 12-fold. In the rare setting of a patient with a bone mass in the 33rd percentile and two or more fractures, the risk of future fractures is increased by 75-fold compared with women with bone density above the 67th percentile and no prior history of VCF. Although this population is at high risk for the development of multiple fractures, only approximately two thirds of patients with acute symptomatic fractures improve despite the management initiated [23].

Traditional conservative treatment includes oral analgesic therapy and bed rest. However, bed rest may accelerate bone loss and increases the risk of developing deep venous thromboses [24]. The pain caused by vertebral fractures may last for months and prove to be severely debilitating. Unfortunately, the use of analgesic medical therapy occasionally results in narcotic dependence. In a predominantly elderly population, this can alter mood and mental status, thus compounding the patient's condition [25]. Chronic pain, sleep deprivation, depression, decreased mobility, and loss of independence are all sequelae of VCF [26, 27]. In addition, both thoracic and lumbar compression fractures can lead to a decrease in lung capacity [28].

Alternatively, physical therapy and use of a hardshell brace that appropriately immobilizes

the affected segment may decrease the risks of complications due to bed rest. As noted above, the majority of patients improve regardless of the treatment prescribed, usually within 4–6 weeks. Several additional medical treatments have been studied with mixed results. Bisphosphonates, calcitonin, parathyroid hormone, or raloxifene have been shown to reduce subsequent fracture rates, whereas the results for calcitriol, etidronate, fluoride, and pamidronate have been mixed and inconclusive [29]. In comparing conservative treatment with vertebroplasty, Diamond et al. conducted a prospective, nonrandomized trial of osteoporotic patients with acute VCF [30]. It was shown that vertebroplasty provided a rapid and significant reduction in pain and an improvement in physical activity scores compared with medical treatment and it was concluded that vertebroplasty is a viable treatment option. A more recent study by Li et al. compared vertebroplasty or kyphoplasty versus conservative treatment in elderly polytrauma patients. This study showed a decreased length of hospital stay as well as decreased incidence of complications, especially bed rest complications, in the operative group compared to the conservative treatment group. There was no significant difference in mortality between the two groups [31]. It has also been shown that vertebroplasty and kyphoplasty are associated with longer patient survival than nonoperative treatment [32]. These data further support vertebroplasty or kyphoplasty as a viable treatment option for VCF.

Patient Evaluation and Selection

It is important to obtain a thorough medical history with specific attention to risk factors for VCF as well as surgical candidacy. Evaluation continues with a detailed neurological examination documenting any motor or sensory changes, and paying attention to any existing radiculopathies. Preoperative investigations should include routine laboratory work and coagulation studies. In addition, if malignancy is suspected, an appropriate work-up is indicated, including the determination of a tissue diagnosis, if possible. Radiological evaluation includes anteroposterior (AP) and lateral radiographs of the spine as well as a thin-cut, reconstructed computed tomography (CT) scan. The CT scan is scrutinized to evaluate the integrity of the posterior cortex, which may suggest an increased risk of cement extrusion into the spinal canal during the procedure, as well as the size of the pedicles, should a transpedicular route be considered. In patients with signs of myelopathy, it is essential to obtain a magnetic resonance imaging (MRI) or postmyelogram CT scan (if MRI is contraindicated) to evaluate for evidence of cord compression. The presence of bone marrow or endplate edema has been shown to be a positive prognostic sign for patients undergoing vertebroplasty [33]. Alvarez et al. also showed that signal changes in the vertebral body on MRI scan as well as 70 % or greater collapse of the vertebral body are both highly predictive of positive outcome [34].

The primary indication for vertebroplasty is failure of conservative management of a vertebral fracture in which patients continue to have pain that affects their mobility and activities of daily living. It is important in determining if vertebroplasty is indicated to ensure that the pain be localized and attributable to the fracture level. There is minimal evidence available in the medical literature to guide the duration of conservative therapy before it is deemed a failure. A consensus position statement published by several professional societies in 2014 stated that patients with persistent pain precluding ambulation or physical therapy or resulting in unacceptable side effects from analgesic therapy after 24 h of analgesic therapy should be considered to have failed conservative management [35]. Typically, patients are selected whose duration of pain from fracture is greater than 6 weeks but less than 1 year. Others have reported successfully treating painful fractures of 2-year duration [36]. While complete relief of pain is less likely in older fractures [37, 38], Irani et al. reported symptomatic improvement in fractures up to 5 years old [39]. Guidelines and reviews have been published to aid in the selection of patients, although the decision to undergo surgery is made by the treating surgeon [40, 41]. Painful osteoporotic

and osteolytic fractures without myelopathy constitute the vast majority of cases in most practices. Contraindications for vertebroplasty include severe wedge deformity with loss of greater than 90 % of vertebral height (vertebra plana), comminuted burst fracture, spinal canal compromise >20 %, epidural tumor extension, myelopathy, inability to lie prone, uncorrected coagulopathy, inability to localize source of pain, allergy to cement or radio-opaque dye, and infection (local or systemic). There has been considerable debate into the merits of prophylactic vertebroplasty in selected patients [40, 41]; however, it is the practice of the senior authors to only include symptomatic patients, because many patients never develop clinical symptoms. It is also prudent to have the facilities and capability to perform emergent decompressive surgery should extravasation of bone cement into the spinal canal occur, resulting in spinal cord compromise.

Kyphoplasty is a modification of the vertebroplasty technique that was developed in the late 1990s [42, 43]. This technique attempts to restore vertebral body height with the introduction of cement into a lower-pressure cavity. The use of a balloon creates a cavity for placement of the cement and may result in a lower incidence of cement extravasation [44]. Verlaan showed a reduced incidence of endplate fractures in balloon vertebroplasty [45]. In addition, recent developments have included the use of an arc osteotome, which creates a cavity for cement placement without attempting to restore vertebral body height. The indications for these procedures mirror those for vertebroplasty; however, with the goal of fracture reduction, the age of the fracture affects the success rate, although the exact timing has yet to be determined [41, 46]. In addition, technical considerations require a minimum of 8 mm of residual vertebral height to introduce the materials [41].

Vertebroplasty Technique

After obtaining appropriate medical clearance and written, informed consent, the patient is brought to either an interventional radiology suite or operating room (Fig. 1). Although in many centers both a radiologist and a surgeon are present, in other centers, the procedure is performed with only the surgeon present. The procedure may be performed under general anesthetic or under local anesthetic with mild sedation. Which type of anesthetic should be determined based on the patient's general medical condition, comorbidities, and in conjunction with the anesthesiologist. While the patient may be monitored for neurological dysfunction if the procedure is performed under local anesthetic, this method is typically uncomfortable for the patient. General anesthetic may be used safely, with frequent use of intraoperative fluoroscopy to prevent cement extravasation. The patient is placed in the prone position with their arms above their head and adequately padded for comfort and to prevent compressive peripheral neuropathies. A wide area of skin overlying the level of interest is then prepped and draped in strict sterile fashion to minimize the chance of a postoperative infection.

Once the patient is satisfactorily positioned, the fracture site is identified using biplanar fluoroscopy. Although some authors have advocated CT scanning to facilitate needle placement [36, 47], it is our experience that CT guidance is necessary only in a few rare instances when anatomical constraints prohibit easy identification of an appropriate trajectory and placement of the needle. A mark is placed on the skin overlying the pedicle of interest. The skin is infiltrated with a buffered anesthetic solution containing 0.5 % or 0.25 % Marcaine, 1:200,000 epinephrine (Abbot Labs, Chicago, IL), and Na bicarbonate (American Pharmaceutical Partners, Los Angeles, CA) down to the level of the periosteum over the pedicle.

Currently, there is a wide selection of needles and cement from several vendors that can be used for percutaneous vertebroplasty. Alternatively, the procedure can be completed using routinely available surgical equipment such as that shown in Fig. 1b. In addition, there is no standardized technique for needle placement. The senior authors use either a transpedicular or a parapedicular approach (Fig. 2). Biplanar fluoroscopy is used to confirm the appropriate trajectory regardless of

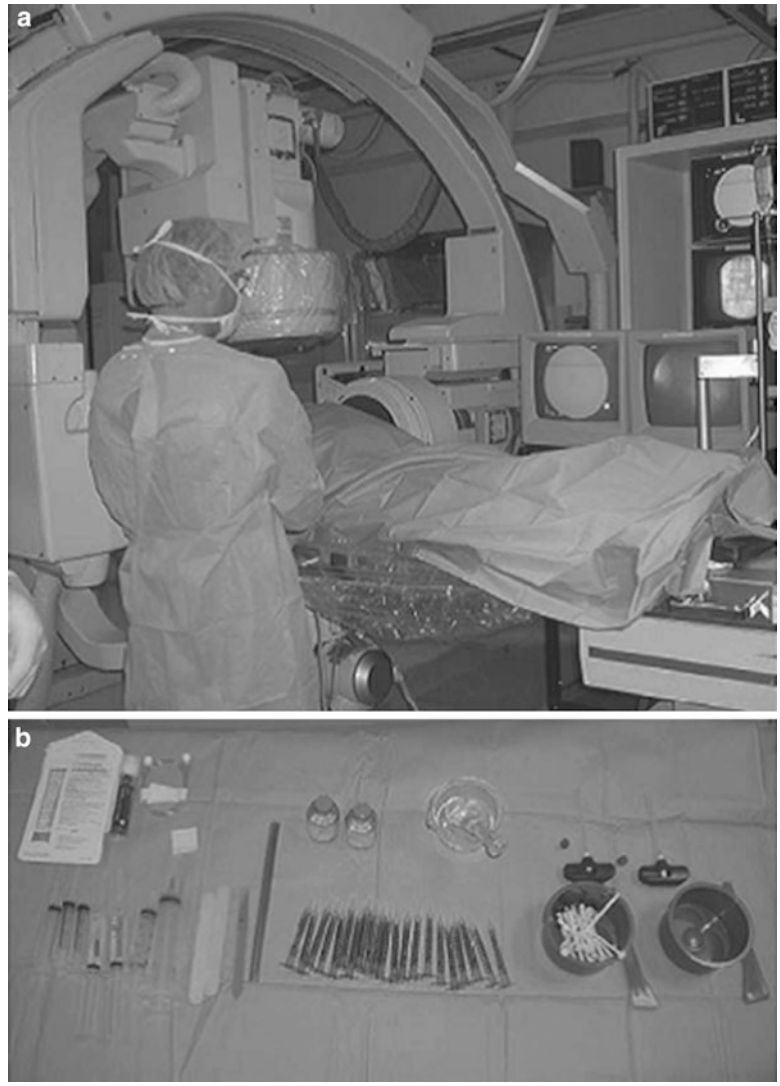

Fig. 1 Patient positioning and angiography suite setup (**a**) with biplanar fluoroscopy is shown. Basic surgical supplies needed to perform percutaneous vertebroplasty are pictured (**b**)

which approach is used (Fig. 3). A 2-mm stab incision is created with a #11 scalpel blade lateral to the midline at the point previously marked to identify the pedicle. A #11 Jamshidi needle with the trocar in place is introduced. In the transpedicular approach (Fig. 4), the needle is advanced until it docks onto the pedicle. The preferred entry point is at the upper and outer quadrant of the pedicle, because perforation at this location has few consequences compared with the inferomedial quadrant, which places the exiting nerve root at risk. In this "bull's eye" approach, the needle forms the center, while the cortex of the pedicle is the outer ring. The location and trajectory are again confirmed with fluoroscopy, and the needle is advanced into the vertebral body. An identical procedure is then repeated for the contralateral pedicle.

When utilizing the parapedicular approach (Fig. 5), only a unilateral cannulation is necessary because the more lateral approach allows for a more centrally directed needle. The Jamshidi needle is docked on the transverse process and advanced immediately caudal to the transverse process. The appropriate entry point is at the lateral vertebral body on the AP projection and at, or immediately ventral to, the posterior cortex on the lateral fluoroscopic image. The biplanar

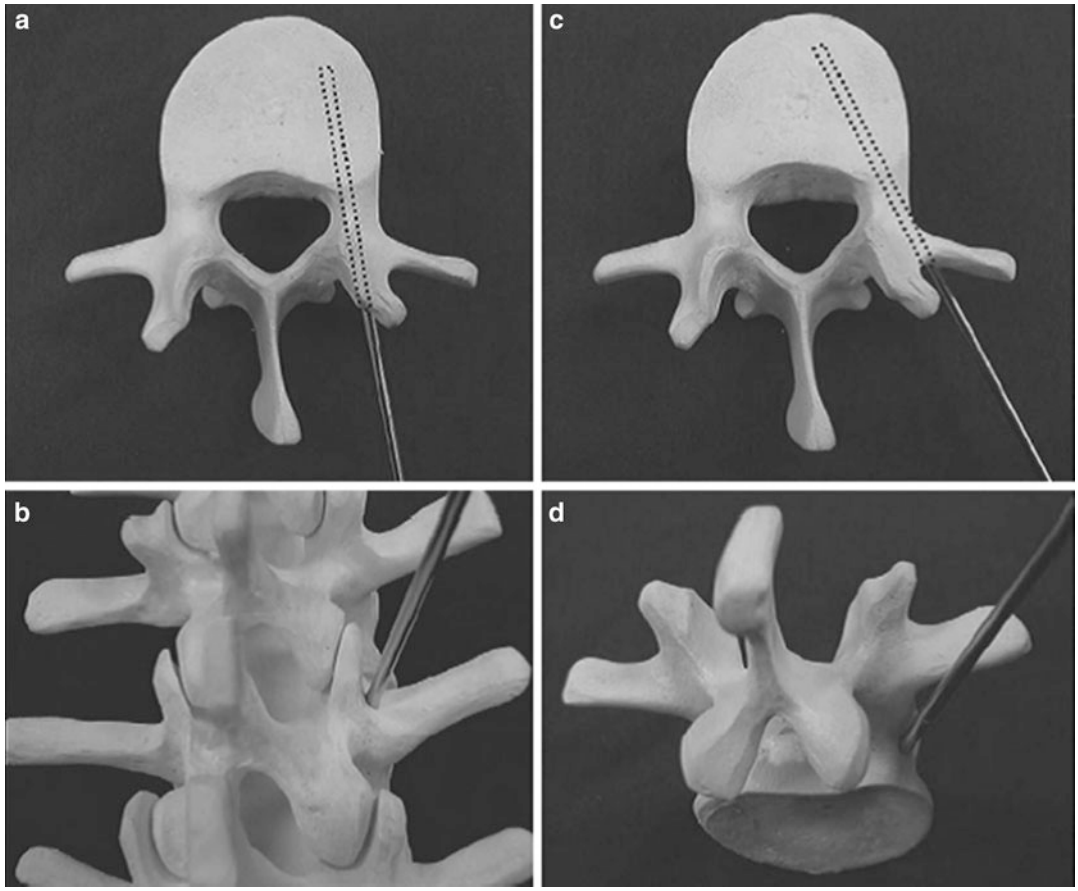

Fig. 2 Model illustrations depicting the entry points and needle trajectories for both the transpedicular (**a** and **b**) and parapedicular (**c** and **d**) approaches

fluoroscopic images are used to help guide the needle trajectory, keeping the needle tip equidistant from the vertebral body on both AP and lateral views. Once the vertebral body is encountered, the needle is advanced toward the center of the body. While there is a theoretical increased risk of pneumothorax and bleeding with this approach [48], it has been our experience that the complication rates are similar between the two approaches.

Regardless of which approach is used, the target of the needle tip should be in the anterior half of the vertebral body on the lateral views and the medial third in the AP views. The bevel of the needle can be directed in the most optimal direction for cement placement for each given patient. Given the frequency of fluoroscopic image acquisition, a clamp may be used to stabilize the needle during imaging to minimize the exposure of the operator's hand. Intraosseous venography had been advocated in some centers, particularly within the United States, prior to injection of cement [49–51]. However, as more centers have increased their experience with this technique, it has become apparent that there is no increase in safety afforded by venography [52–54]. In most centers, venography is typically no longer used prior to cement injection. To avoid the introduction of air during the injections, the needle is filled with sterile saline after adequate placement has been confirmed.

There are a number of cement products and suppliers available and the choice is left to the surgeon performing the procedure based on their

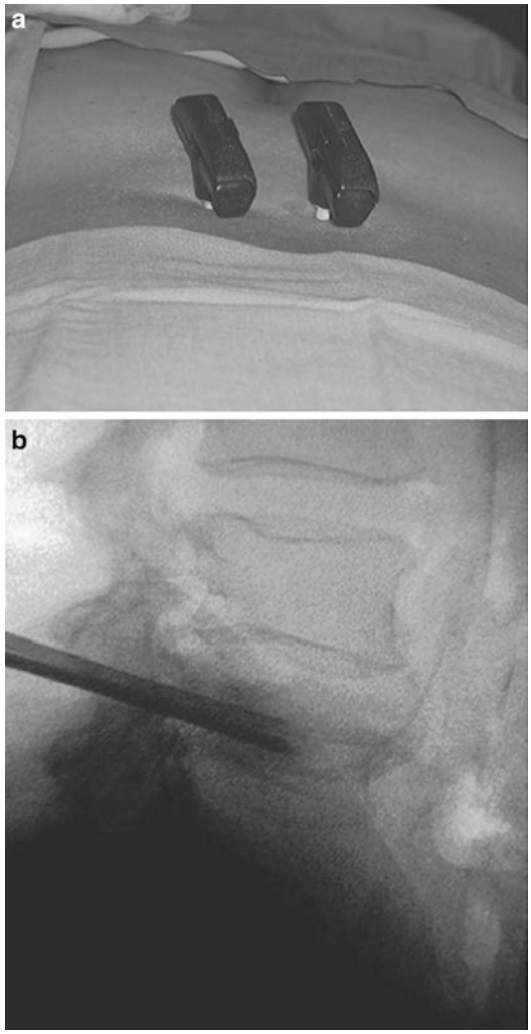

Fig. 3 Percutaneous access to both pedicles with 11-gauge biopsy needles is depicted (**a**); radiographic confirmation of adequate placement of the needles is obtained on lateral fluoroscopy (**b**)

experience and training. The increased application of percutaneous vertebroplasty has led to advances in the mixing and administration devices so that one can achieve a uniform, consistent product and minimize exposure to vapors. PMMA is provided in two separate components, a methylmethacrylate polymer in powder form and a liquid methylmethacrylate monomer. When combined, an exothermic polymerization reaction occurs and the resulting compound progresses from a liquid to solid state. The ideal time for injection is when the consistency of the polymer approximates that of toothpaste. The timing will vary depending upon the specific product used. Most commercially available products come with an aliquot of a radio-opaque marker, which is combined with the PMMA to facilitate visualization during the injection process. If not available, sterile barium sulfate powder can be added to the methylmethacrylate polymer and mixed thoroughly with the compound. The thickened PMMA solution is poured into a 10-cm^3 syringe or one of the many commercial delivery devices available. Some vertebroplasty application devices require placement of a guidewire through the Jamshidi needle, removal of the Jamshidi needle, and placement of a larger working cannula. The delivery device is then attached to the hub of the Jamshidi needle or working cannula and, under intermittent fluoroscopic monitoring, the PMMA is injected slowly under a consistent pressure (Fig. 5). In general, it is typically possible to inject 5–10 cm^3 of PMMA into each treated vertebral body; the thoracic spine accepts less volume than the lumbar spine due to their relative sizes. Extravasation of cement beyond the confines of the vertebral body is an indication to stop the injection. It is not clear what volume of cement is necessary to reliably produce pain relief, nor is it known by what mechanism the pain relief is achieved. Possible proposed mechanisms include mechanical stabilization of the fracture site [48] and neural thermal necrosis secondary to the heat generated during the curing process [55].

Once the operator is satisfied with the injection, the inner cannula is replaced and the needle is removed with a twisting motion. Closure of the wound is usually unnecessary. Occasional bleeding is controlled with direct pressure. Patients are kept recumbent for 2 h and are then allowed to sit and ambulate with assistance. A postoperative CT scan of the region treated to assess the degree of vertebral body filling and to rule out any occult spinal cord compression and X-rays are obtained as a baseline for later comparison. Patients are then discharged home on nonsteroidal anti-inflammatory drugs (NSAIDS) and muscle relaxants later the same day. Ambulation is encouraged and participation in routine activities of daily living is emphasized.

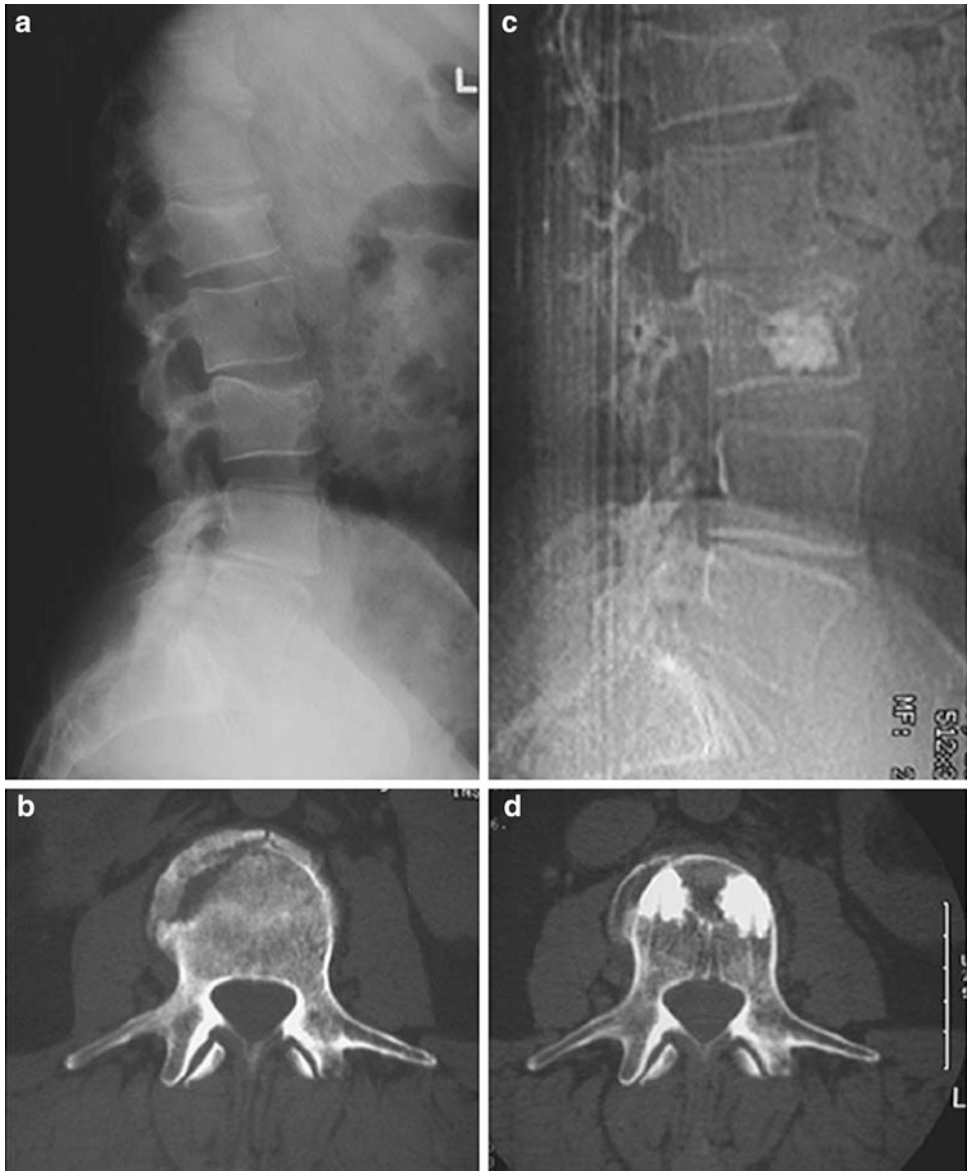

Fig. 4 Illustration of the transpedicular approach. A 46-year-old man suffered a traumatic compression fractures at L1 and L3. He complained of chronic back pain for several months after the injury, which was localizable to the L3 level. Lateral lumbosacral X-ray (**a**) and axial CT scan (**b**) demonstrate the L3 fracture. He underwent vertebroplasty with bipedicular injection of PMMA. Lateral X-ray (**c**) and axial CT scan (**d**) show good placement of cement in the anterior third of the vertebral body

Kyphoplasty Technique

Kyphoplasty is a procedure whereby a cavity is created in the vertebral body for cement injection with an inflatable bone tamp or balloon. The procedure attempts to restore the vertebral body back to its original height. In doing so, it is thought that a low-pressure cavity is created within the bone that may then be filled with cement [43, 56]. However, restoration of vertebral body height does not correlate with pain

relief or improvement in quality of life [57, 58]. Expansion of the vertebral body is followed radiographically by placing contrast medium in the balloon. Alternatively, an arc osteotome may be used to create a cavity. However, this form of cavity creation does not result in restoration of vertebral body height.

The kyphoplasty procedure was first described by Garfin et al. [43]. The bone tamp is placed using either the transpedicular or parapedicular approach. This is accomplished with the aid of a guide pin and biplanar fluoroscopy. Once cannulation of the vertebral body has occurred, an obturator is passed over the guidewire and inserted into the vertebral body. A working cannula is then passed over the obturator until the cannula tip is in the posterior portion of the vertebral body. The inflatable tamp is passed through a corridor created by drilling along the cannula path. Once in place, the device is inflated under fluoroscopic guidance to a pressure of no more than 220 psi. An inline pressure gauge allows for constant pressure monitoring within the balloon. Once a sufficiently sized cavity has been created and an appropriate reduction has been obtained, the PMMA cement is prepared. At this point, smaller cannulas filled with cement are inserted into the working cannula. The cement-filled cannula is inserted into the working cannula, with subsequent passage into the vertebral body. A plunger-like effect is obtained by using a stainless steel stylet to extrude the cement into its target location. Filling the cavity with cement continues under lateral fluoroscopic guidance and ceases when the mantle of cement reaches approximately two thirds of the way to the posterior cortex of the vertebral body.

When utilizing an arc osteotome system such as the Arcuate XP system (Medtronic Sofamor Danek, Memphis, TN), vertebral body access is obtained as described above through either the parapedicular or transpedicular approach. A guidewire is then placed through the Jamshidi needle, and the Jamshidi needle is removed. A working channel with a port in the lateral aspect of the anterior aspect of the channel is then placed into the vertebral body. A flexible metal arc osteotome is then placed and deployed through the port. The surgeon will feel variable resistance depending on the degree of osteoporosis present. The port is turned to allow deployment of the osteotome superiorly, medially, and inferiorly, allowing creation of a cavity. Once the cavity is created, the osteotome is removed, an inner cannula is placed that occludes the side port, and PMMA is injected through the tip of the working channel. Closure proceeds as described above.

Complications

The overall complication rates for vertebroplasty and kyphoplasty are in the range of 1–2 % for osteoporotic fractures and 5–10 % for metastatic lesions [40, 48]. The most common complication after vertebroplasty is a transient increase in pain at the injected level. This is readily treated with NSAIDs and typically resolves within 48–72 h [48]. Acute radiculopathy has been reported to occur in up to 5 % of cases. The symptoms are often transient and a short course of steroids may be of benefit; however, in some cases surgical decompression is necessary. The relatively higher complication rate in malignancy is now well recognized and documented [40]. Chiras et al. reported on a series of vertebroplasty cases and documented a complication rate of 1.3 % in osteoporotic compression fractures, while higher complication rates were noted with more destructive bone lesions such as hemangiomas (2.5 %) and vertebral malignancies (10 %) [59]. Cement leakage is a common problem, particularly in lytic lesions [48], and has been reported in up to 30–70 % of cases; fortunately, most of these occurrences are asymptomatic [60]. Some have reported cement leakage necessitating surgical intervention, with surgical findings consistent with thermal injury due to the exothermic reaction of the PMMA [61]. Other reported complications include fractures of the rib or pedicle, pneumothorax, spinal cord compression, and infection. There have been reports of embolic complications such as pulmonary embolism [13, 62–67], embolization of cement into the vena cava and pulmonary arteries [68] and into the renal vasculature [69, 70], and death [50, 71] occurring during or

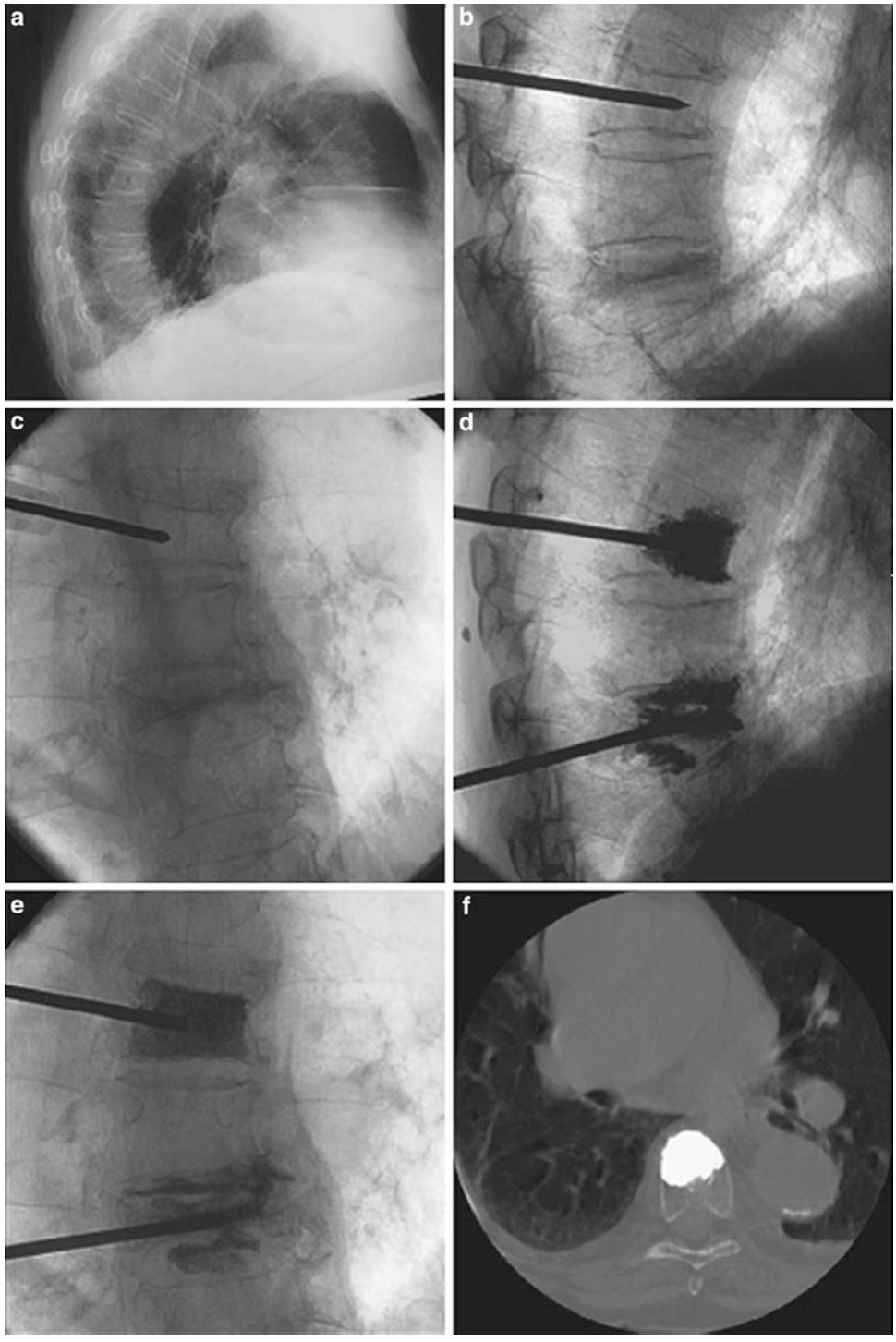

Fig. 5 (continued)

shortly after vertebroplasty. The cause of these events has not been delineated; however, it has been postulated that cement with low viscosity and a large number of levels treated concurrently may play a role [48]. Other rare but reported complications include acute pericarditis [72], osteomyelitis treated successfully with antibiotics [73] and necessitating subsequent corpectomy [74, 75], cardiac perforation [76], and fat and bone marrow embolization [77].

Fracture of adjacent vertebral levels after vertebroplasty has been known to occur. The cause is most likely multifactorial and may include the diffuse nature of the osteoporotic disease, relief of pain with a subsequent return to higher levels of physical activity, and increased strength in vertebrae that are subject to increased loads from kyphotic deformity. In 2005, Syed performed a retrospective analysis of 253 female patients who were treated with vertebroplasty. Of these patients, 21.7 % experienced a new symptomatic VCF within 1 year [78]. Tanigawa showed that one third of patients who underwent vertebroplasty had a new compression fracture, half of which occurred at the adjacent level within 3 months of the procedure [79]. Kim et al. reported an increased incidence of new compression fractures after percutaneous vertebroplasty when treatment was performed at the thoracolumbar junction, and when a greater degree of height was restored [80]. Lin et al. reviewed their series of patients treated with vertebroplasty for compression fractures, concluding that cement leakage into adjacent disk spaces was related to an increased rate of adjacent level fracture [81]. Gradual increase in activity and continued use of orthotic devices (for 6 weeks after vertebroplasty) may help prevent adjacent level fracture in those at high risk.

There have been no reported complications related to balloon tamps during kyphoplasty procedures [43, 56]. Several complications related in some way to needle insertion have been documented. During Phase 1 testing of an inflatable bone tamp, Lieberman et al. found that kyphoplasty was a safe procedure, with no significant complications related to their device. Cement extravasation was the most common problem occurring in 8.6 % of their patients [56]. There were no clinical sequelae resulting from cement extravasation. Furthermore, the authors were encouraged that rates of cement extravasation during their kyphoplasty procedure were lower than those of published vertebroplasty series, which may indicate that cavity creation may prevent cement extravasation.

The exposure to ionizing radiation must be considered for both the patient and the treating team. Mehdizade et al. evaluated the radiation dose received by operators in a series of 11 cases [82]. They noted significant radiation dosage measurements, particularly on the operator's hands. Kruger and Faciszewski made a similar observation, however they were able to demonstrate that proper shielding and limiting the radiation used significantly reduced the measured exposure [83].

Outcomes

Several recent clinical trials and meta-analyses have compared outcomes of vertebroplasty, kyphoplasty, and conservative treatment. These studies have shown similar pain relief effects of vertebroplasty and kyphoplasty, with diminished length of hospital stay and decreased complication rates compared to conservative management [84–86]. A large, multicenter randomized clinical trial is required, however, to confirm these findings.

Vertebroplasty has been shown to reduce pain in 90–95 % of patients suffering osteoporotic

Fig. 5 Illustration of the parapedicular approach. A 64-year-old woman presented with a complaint of back pain. There was no history of trauma or malignancy. Compression fractures of T8 and T10 were identified and both were thought to be symptomatic. Lateral thoracic X-ray (**a**) demonstrates the fractures. Lateral (**b**) and AP (**c**) images confirm the cannulation of T8. Lateral (**d**) and AP (**e**) images after injection of T8 and during injection of T10. Postoperative CT scan demonstrates good filling of the anterior portion of the T8 vertebral body (**f**)

vertebral fractures [48, 60, 87]. Additionally, improvements in mobility and in activities of daily living occur. Also of note, patients who have undergone percutaneous vertebroplasty have a tendency to decrease their use of narcotic pain medications. Furthermore, the reduction in pain is rapid, usually within 48–72 h [46]. The analgesic effect has been shown to persist in a cohort of patients followed prospectively for a minimum of 5 years [88]. The success rate is slightly less in patients with metastatic disease, with approximately 65–80 % reporting significant improvement in pain scores [48, 89].

In 2001, Lieberman et al. reported the results of a Phase 1 clinical trial examining the efficacy of kyphoplasty in osteoporotic fractures [56]. They reported that, in 70 % of levels operated, a mean restoration of 47 % of the lost vertebral body height was achieved. In addition, the patients demonstrated a significant improvement in measures of pain, activity, and energy. Similar results have been reported in patients with multiple myeloma [90].

Conclusions

Percutaneous vertebroplasty and kyphoplasty provide minimally invasive options for the management of osteoporotic and osteolytic vertebral body compression fractures. These techniques provide substantial pain relief and support without having to sacrifice mobility, and have been shown to have an acceptable complication rate. These procedures allow stabilization of VCF through a short procedure, and also allow rapid mobilization of the patient. However, large-scale clinical trials need to be done comparing these various approaches for the different indications to which they are applied. In this way, surgeons will have better information upon which to base the decision to choose vertebroplasty or kyphoplasty. In addition, cost-effectiveness of any new treatment should be evaluated and scrutinized. Currently, the cost of kyphoplasty is significantly greater than vertebroplasty. To justify the additional cost, kyphoplasty must be shown to be safer and/or to provide added clinical benefit such as greater stability, better pain relief, or reduced operating time. Most published studies demonstrate equivalent results in stability and pain relief, as well as complication rates, though some have suggested lower rates of cement extravasation. In addition, both procedures utilize a similar technique and are roughly equivalent in technical difficulty to perform. Therefore, at this time, it seems reasonable to question the cost/benefit ratio of the kyphoplasty procedure when compared with vertebroplasty.

Regardless, vertebral augmentation techniques such as vertebroplasty and kyphoplasty provide pain relief and improvement in quality of life in the highly selected patient [91–93]. Complications can be avoided with careful surgical technique, and good outcomes can be achieved with proper patient selection.

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