Kyphoplasty - the Current Treatment for Osteoporotic Vertebral Fractures

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Contents

Abstract

Vertebral osteoporotic fractures are the most frequent fractures in older patients with low mineral bone density. Kyphoplasty is a technique that tries to recover the height of the fractured vertebral body and support this fracture with the injection of cement into the vertebral body. This procedure is usually performed percutaneously and requires appropriate training so as to avoid potential complications. This chapter reviews the indications, pre-operative preparation and planning, operative technique guidelines, post-operative care and rehabilitation and the complications that might appear during and after this procedure.

Keywords

Complications • Indications for surgery • Kyphoplasty • Minimally-invasive surgery • Osteoporotic vertebral fractures • Operative technique-inflatable bone tamps • Rehabilitaion • Vertebral augmentation

General Introduction

Osteoporosis is the most common metabolic bone disorder. It affects two hundred million individuals worldwide [1]. Vertebral compression fractures are a frequently encountered clinical problem in these patients and are becoming increasingly more important as the median age of the population continues to rise. Patients with

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painful vertebral compression fractures may have severe pain for prolonged periods of time. When such a fracture does cause pain, it can usually be successfully managed with a combination of medications, activity modification, and occasionally bracing [2]. In a patient who does not respond to this initial treatment, an internal splinting of the vertebral body with percutaneously injected methylmethacrylate may provide adequate pain relief that allows the patient to return to his or her previous level of functioning. In this way, the key principles of the percutaneous cement augmentation techniques are the immediate stabilization of vertebral body fractures to decrease pain or prevent further collapse of the vertebral body.

Percutaneous kyphoplasty is the placement of balloons in the vertebral body with a one-off inflation/deflation sequence that creates a cavity before the cement (generally polymethylmethacrylate) is injected. This procedure is most often performed percutaneously on an outpatient (or short-stay) basis. Kyphoplasty was developed in an attempt to reduce the deformity of the vertebral body and subsequent kyphosis while providing pain relief similar to that provided by vertebroplasty [2–12]. This should decrease the associated risks related to the deformity, increase filling control, stabilize the vertebra and, thereby safely decrease pain and improve mobility [12].

The exact mechanism of the analgesic effect of vertebral augmentation remains unclear. Some investigators attribute the reduction of pain to the toxic and/or thermal effect of the polymethylmethacrylate (PMMA) cement by the destruction of nerve fibres [13, 14]. A more mechanical viewpoint attributes the effect to the fixation of fragments and reduction of micro-motion and the associated irritation of periosteal nerve fibres [15].

Indications for Kyphoplasty

Percutaneous vertebral augmentation (vertebroplasty or kyphoplasty) is indicated for painful osteoporotic vertebral compression fractures [16–21] or lytic tumours, such as plasmocytoma or multiple myeloma [22], metastasis [23] and painful hemangiomata [24]. Evidence favours the use of this procedure for the pain associated with these disorders. The indications and contraindications of this procedure are summarized in Table 1. Indications for kyphoplasty in osteoporotic fractures extend to vertebral fractures of less than 8 weeks with an increasing deformity of the vertebra. This is so even in cases of significant posterior wall disruption as well as in fractures with non-union with an intravertebral vacuum phenomenon [25, 26]. In the classification by Magerl, the fractures thereby suitable for augmentation are the A1.1 (end-plate impression), the A1.2 (wedge fracture), the A1.3 (vertebral collapse) and the A3.1 (incomplete burst fracture) types. A new indication for kyphoplasty in combination with posterior

Table 1 Summary of guidelines for percutaneous vertebroplasty and percutaneous kyphoplasty according to the Society of Interventional Radiology and Cardiovascular and Interventional Radiological Society of Europe

Indications
Painful osteoporotic VCF refractory to 3 weeks of analgesic therapy
Painful vertebrae due to benign or malignant primary or secondary bone tumours
Painful VCF with osteonecrosis (Kummell's disease)
Re-inforcement of vertebral body before surgical procedure
Chronic traumatic VCF with non-union
Absolute contra-indications
Asymptomatic VCF
Patient improving on medical therapy
Active infection
Prophylaxis in osteoporotic patient
Uncorrectable coagulopathy
Myelopathy secondary to retropulsion of bone/canal compromise
Allergy to PMMA or opacification agent
Relative contra-indications
Radicular pain
VCF > 70 % height loss
Severe spinal stenosis, asymptomatic retropulsion
Tumour extension into canal/epidural space
Lack of surgical backup

short-segment instrumentation has recently been described for the treatment of patients with traumatic burst fractures (non-osteoporotic). This combination has proven to provide good results [27–32].

The exclusion criteria for balloon kyphoplasty include vertebral fractures that are not painful or that are not the primary source of pain, the presence of local or systemic infection, arterio-venous malformations, bone fragments retropulsed into the vertebral canal or an epidural extension of a tumour [26]. Balloon inflation for the kyphoplasty procedure might force material into the spinal canal and thus cause cord compression. There are also relative contra-indications to kyphoplasty.

First, there must be sufficient residual height for the instruments used with kyphoplasty to be inserted in the compressed vertebral body.

Second, small pedicles may also be a limiting technical factor. When the pedicles appear to be too small to accommodate the instruments, a parapedicular approach can be utilized. Kyphoplasty can be performed safely from L5 to T7 in most patients [33].

Third, this technique is not recommended in high-energy injuries with concomitant ligamentous or posterior element injury. In this case, posterior instrumentation should be added.

Controversy exists concerning the specific indications for kyphoplasty as opposed to vertebroplasty [34]. As a review of the literature shows, the pain relief and biomechanical stability resulting from both procedures are comparable [35] although other factors need to be taken into account in choosing one of these techniques over the other. Fracture reduction and restoration of vertebral body height may be achieved through kyphoplasty. However, severe loss of height and an older fracture age may limit the aforementioned effects to a minimum [35]. The most valuable effect achievable through kyphoplasty is the markedly reduced rate of cement leakage [36] through the injection of high-viscosity bone cement into the cavity that is created.

Pre-Operative Preparation and Planning

Patients with a symptomatic vertebral fracture typically present with severe back pain following a minor injury [37]. The pain is made worse by standing erect and occasionally even by lying flat. The spine shows exaggerated thoracic kyphosis and the pain is typically reproduced by deep pressure over the spinous process at the involved level. Neurological deficits are rarely associated with these fractures, but they must always be ruled out [37, 38].

Pre-operative planning includes obtaining a detailed history and performing a thorough physical examination [39]. The proper identification of the painful vertebrae can sometimes be difficult and the patient's symptoms need to be linked to the vertebral compression fracture. Diagnostic studies usually include anteroposterior and lateral plain X-rays of the spine and magnetic resonance imaging (MRI) [39].

Radiographs show the osteopenia characteristic of these patients [40]. The vertebral body shows a fracture with loss of height and wedging and occasionally retropulsion of osseous fragments into the spinal canal. Fractures commonly occur in the thoracolumbar region, but they may be present anywhere in the spine [40]. If non-union of a fracture is suspected, flexion and extension lateral X-rays can be helpful in assessing the degree of fracture healing and mobility. Magnetic resonance imaging of the spine is probably the single most useful test for determining fracture age, the ruling out of a malignant tumour and selection of the appropriate treatment [41]. MRI has the advantage of revealing additional spinal conditions that may contribute to the pain syndrome; in particular degenerative spinal disease, infections, injury of the disk or ligaments. In the acute period following a vertebral fracture, magnetic resonance imaging shows a geographic pattern of low-intensity-signal changes on T1-weighted images and high-intensity-signal changes on T2-weighted images [41]. In addition to that,

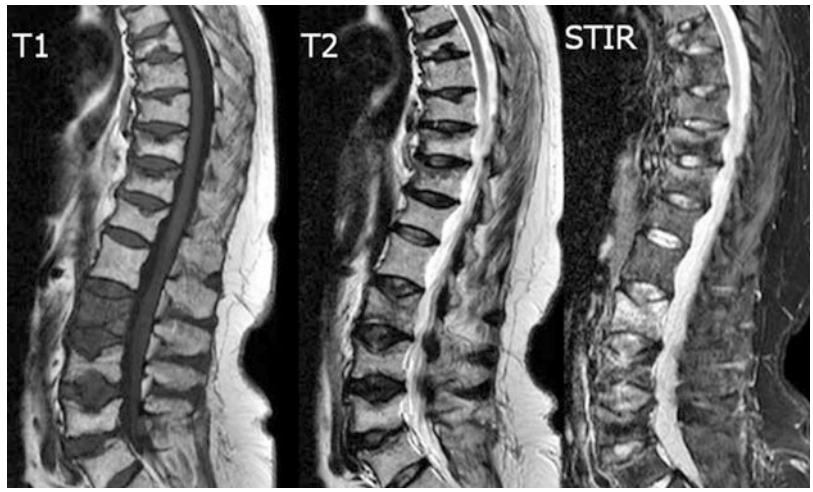

Fig. 1 T1-weighted, T2-weighted and Short Tau Inversion Recovery (*STIR*) magnetic resonance image showing increased signal through the L2 vertebrae, suggesting a recent fracture

fat-signal suppressing STIR (short tau inversion recovery) of the MRI is particularly helpful in differentiating between fresh and healed fractures [41] (Fig. 1).

Scintigraphy in combination with CT can also be used as an alternative to locate the affected vertebrae in patients with a contra-indication to MRI, such as brain aneurysm clips or cardiac pacemakers [42]. Scintigraphy provides useful information about bone turnover and thereby identifies any vertebral fracture that has an on-going healing process. Bone scans are sensitive enough for the detection of fractures, but they have low specificity for the diagnosis of another underlying disease. An additional limitation of bone-scanning is that increased bone turnover can be detected as long as 2 years following a vertebral fracture [42]. The long term bone turnover period shown on scintigraphy limits the ability of a bone scan to demonstrate the acuity of an osteoporotic vertebral fracture and is not helpful in determining the source of the pain or the predictability of the response to treatment.

Computed tomography (CT) scan provides excellent detail of the bony structures and is the best imaging procedure for assessing the vertebral body deformity and the posterior wall and end-plate involvement. Furthermore, it is necessary to precisely classify the fracture type. It is also important to distinguish between a compression fracture with a collapse of the anterior vertebral cortex and a burst fracture in that the posterior wall is fractured as well [43].

The character of the fracture and bone quality must be assessed during the pre-operative evaluation [21]. In the osteoporotic vertebrae with a rarefied trabecular structure, fractures tend to result in varying degrees of vertebral body collapse with possible retropulsion of the posterior wall into the spinal canal. In contrast to fractures in non-osteoporotic vertebrae, splitting or severe fragmentation occur less frequently. A secondary indicator of posterior wall compromise is the presence of an epidural haematoma. This suggests that the fracture communicates directly with the epidural space and thus may be a conduit for cement leakage. Percutaneous kyphoplasty should only be pursued with great caution. The likelihood of restoring vertebral body height depends largely on the density of the bone and the acuteness of the fracture [18]. Fractures treated within 1–3 weeks of the event are much less likely to have experienced substantial healing and provide the best opportunity for height restoration.

Vertebral compression fractures can be caused by pathological conditions. Unless the diagnosis of osteoporosis is well-established, a biopsy is recommended. In patients who have a dual-energy x-ray absorptiometry (DEXA) study consistent with osteoporosis, no history

of malignancy, and a previously known osteoporotic vertebral compression fracture, a biopsy is not necessary.

Operative Technique

The patient should be placed in a prone position on a radiolucent surgical table. Gentle lordotic positioning allows some postural reduction in certain fractures. The procedure can be performed with local anaesthetic in many patients, but the patient should be able to lie prone for at least 1 h without significant pain or respiratory difficulties [44]. The anaesthetic injection under the periosteum at the entry point decreases pain during trocar insertion and is recommended even in patients under general anaesthesia for peri-operative and post-operative pain control. A gentle intravenous sedation can be added to decrease pain during the procedure. If general anaesthesia is utilized, the patient must be handled gently. Rib fractures may occur as a result of undue pressure in the course of patient positioning and during impacting manoeuvres to insert the trocar into the thoracic vertebral body [45]. During multi-level injections, the cement load is greater. Toxic monomeric constituents have the potential to cause cardio-respiratory collapse. The anaesthetist must be alert at the time of each injection procedure. Vasoactive substances to treat sudden hypotension must be readily available [14, 44–46].

The use of bi-planar fluoroscopy greatly aids cannula insertion and cement injection [44, 47, 48]. Bi-planar fluoroscopy is readily obtained by using two separate C-arms (Fig. 2). The lateral image is bought over the top and the arc, leaning away toward the patient's head. The anteroposterior image is brought in diagonally with the image intensifier directly over the target site. It is most convenient to obtain a true anteroposterior image first because the diagonal entry makes this process challenging. Meticulous attention should be paid to obtaining true anteroposterior and lateral images of the target vertebrae. On the AP plane, the pedicles should be symmetrical in shape. The lateral edge of the vertebral body should be equidistant from both pedicles and the spinous process should be centred between the pedicles (Fig. 3). Caution should be exercised when using the spinous process to obtain a true AP image because there is a significant anatomical variation in the shape of the spinous process [49]. Intra-operative fluoroscopic imaging of the mid-thoracic spine can be challenging in the severe osteoporotic patient. The image can be improved by halting respiration and bringing the x-ray tube closer to the patient. This magnifies the image and decreases beam scatter.

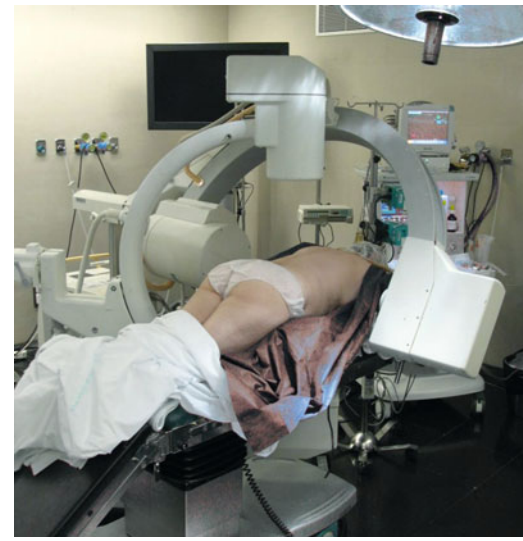

Fig. 2 Operative set-up for the percutaneous Kyphoplasty under bi-planar fluoroscopic guidance, with positioning of the patient and typical arrangement of the both C-arms

The entry point to the pedicle is marked using high-quality bi-planar images. It is necessary to obtain a true AP view of the pedicle with an oval shape in order to avoid lesions of the surrounding neural structures (Fig. 4). A trocar needle is inserted into the vertebral body either with a transpedicular or extrapedicular approach (Fig. 5). The transpedicular approach is best suited for large pedicles such as those in the lumbar and lower thoracic spine. Localization of the pedicles is performed in a manner similar to that used for vertebroplasty. A posterior approach with a slight ipsilateral obliquity of 10–25° is preferred [49–51]. The medial wall

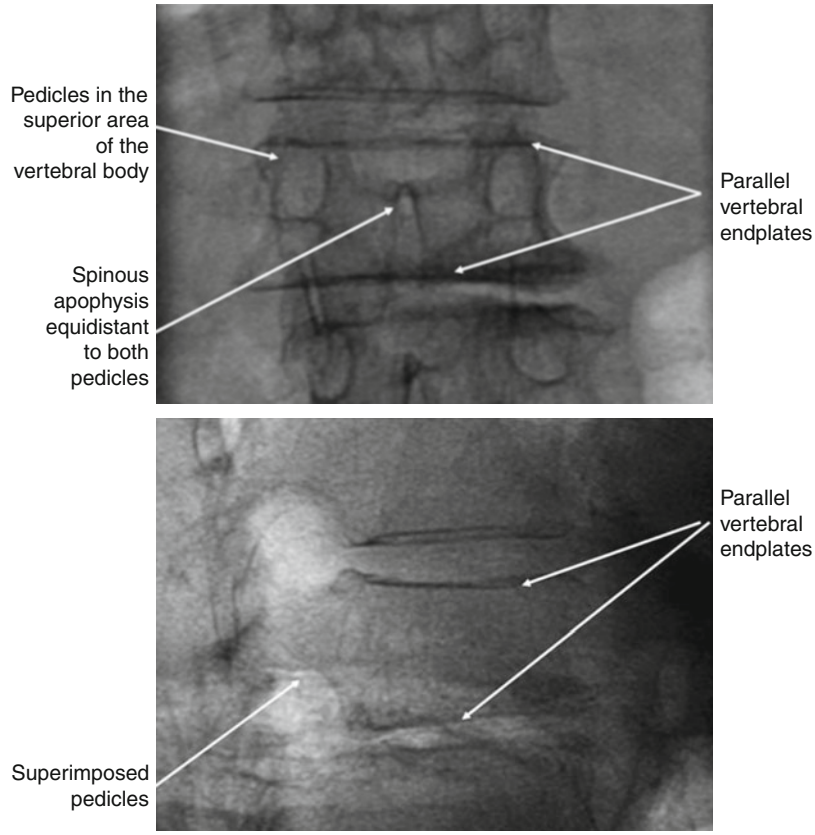

Fig. 3 Intra-operative fluoroscopy. The AP view is adjusted with the spinous process of the targeted vertebral body in the exact mid-line, end-plates parallel and pedicles placed symmetrically in the upper lateral quadrant of the projection of the vertebral body. The lateral view is adjusted with pedicles superimposed, end-plates parallel and the posterior wall aligned with a single contour

of the pedicle must be well visualized. The extrapedicular approach is best suited for the mid-thoracic spine. The entry point for the extrapedicular approach lies between the lateral edge of the pedicle and the costovertebral joint [44, 45, 48]. The rib head helps direct the needle into the vertebral body. The extrapedicular approach allows a trajectory more latero-medial, thereby accessing the central portion of the vertebral body. The approach is usually bilateral. However, adequate cement distribution into the vertebral body can be accomplished through a unilateral injection site with this technique.

The kyphoplasty procedure requires an 11- or 13-gauge bone entry needle, a scalpel, a kyphoplasty kit, inflatable balloon tamps, sterile barium sulphate or another opacifier, and bone cement. The surgical steps involved in transpedicular placement of a kyphoplasty balloon are shown in Fig. 6.

First, is necessary to place the needle (usually an 11-G Jamshidi needle) at the pedicle entry site at the angle between the upper articular process and the transverse process [44]. The needle targets a starting point just superior and lateral to the pedicle. One must be cautious to avoid injuring the exiting nerve roots and the beginning point must not be so far lateral as to puncture the bowel or kidney [45]. Oblique views should also be used to confirm proper positioning. The needle should pass through the pedicle centre without perforating the medial pediclar cortex, and go on to enter the vertebral body. Only now does the tip of the needle cross the projection of the medial pediclar cortex, as viewed from the rear. The optimal final placement of the needle should be in the anterior third of the vertebral body [47].

After needle insertion, the trocar is removed. A Kirschner wire is then directed through the needle and into the bone to act as a guide-wire. The cannula is inserted over the guide-wire and

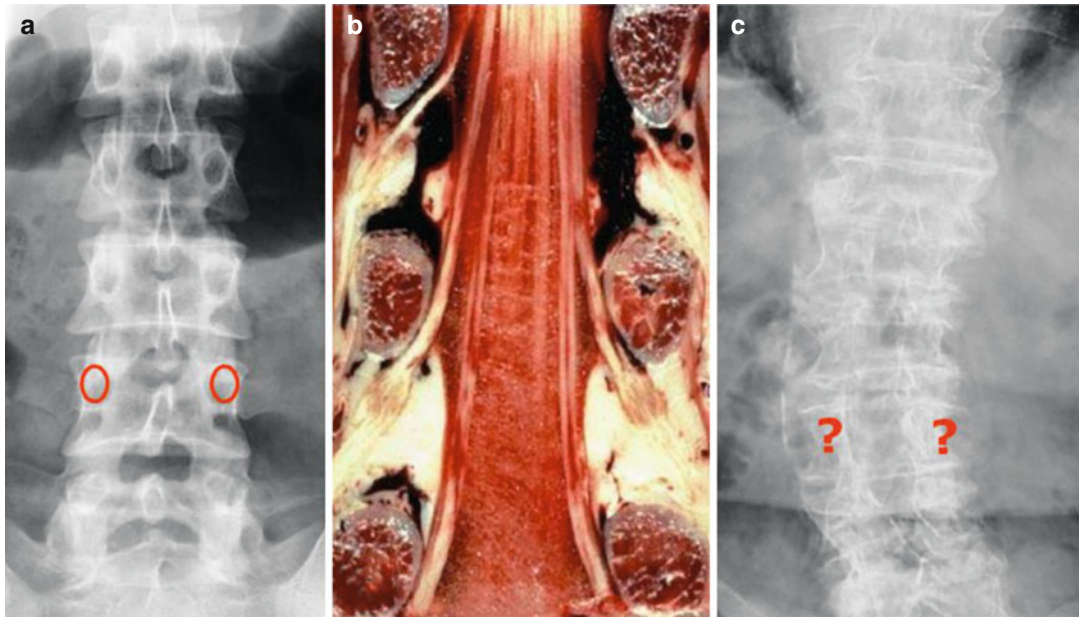

Fig. 4 (**a**) X-ray of a patient with a good visualization of the cross-section of the pedicles in the AP view. (**b**) Anatomical coronal cut across the pedicles, showing the neural structures around the pedicles that we must avoid during the procedure. (**c**) X-Ray of a patient with a bad visualization of the cross section of the pedicles in the AP view. In this case, is not possible to perform a safe technique and we recommend that the procedure be aborted because there is a high risk of neurological injury

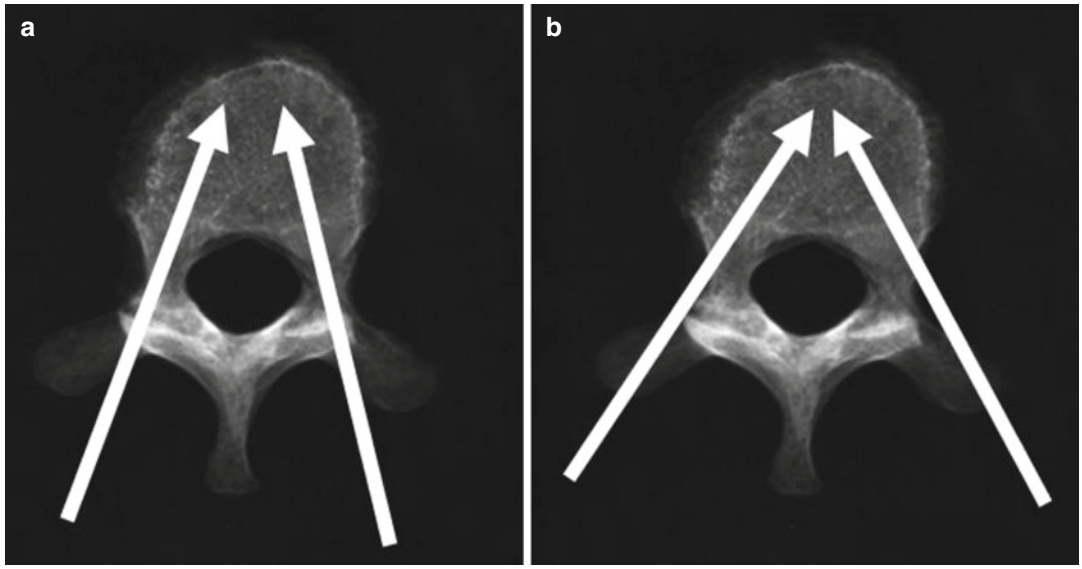

Fig. 5 Axial view demonstrating the trajectory of the needle in a transpedicular approach (**a**) and in a parapedicular approach (**b**). In the parapedicular approach, the needle follows the junction of the rib and transverse process of the vertebra and enters the vertebral body along the lateral margin of the pedicle

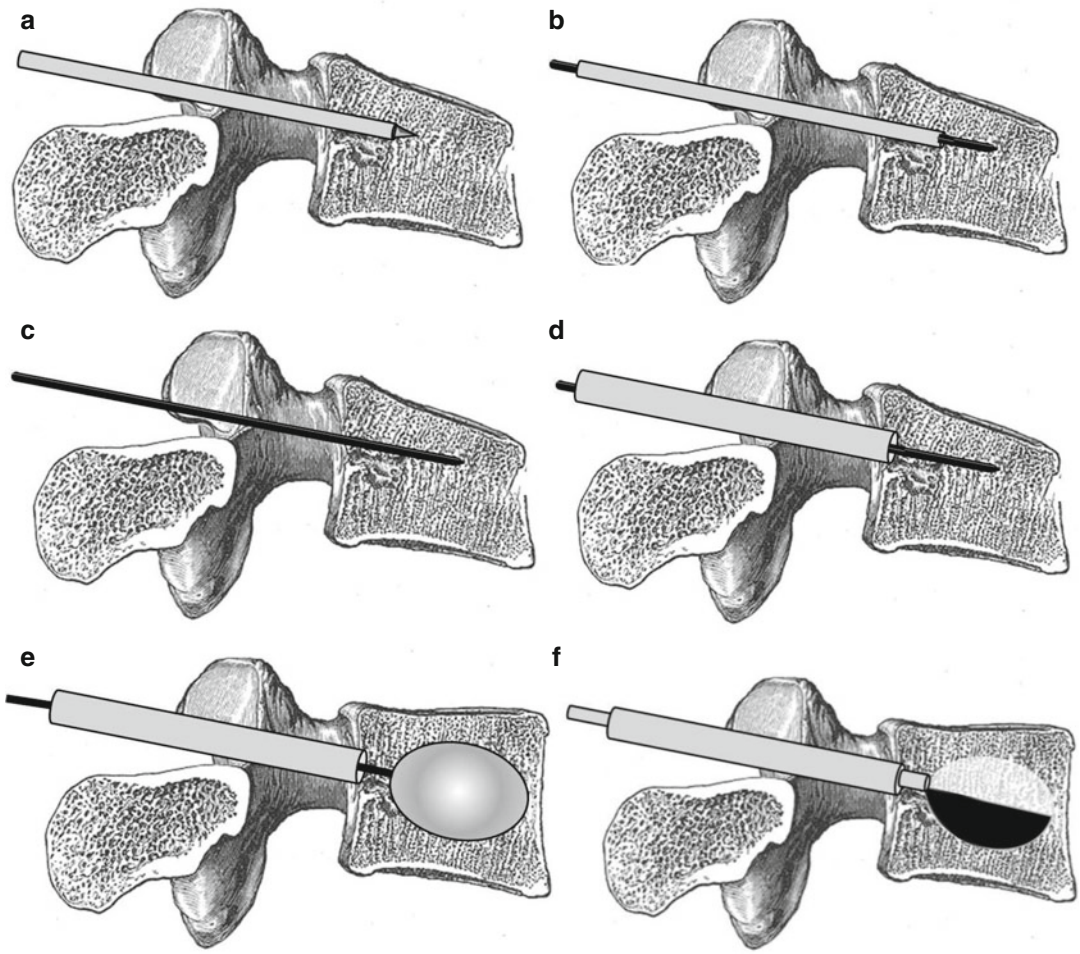

Fig. 6 Schematic diagram of a transpedicular kyphoplasty of a lumbar vertebral body. The surgical steps involved are: (**a**) placing the biopsy needle at the pedicle entry site at the angle between the upper articular process and the transverse process. (**b**) Kirschner wire fed through the biopsy needle and acting as a guide. (**c**) The biopsy needle is removed. (**d**) Introduction of the cannulated trocar via guide-wire. (**e**) Positioning the kyphoplasty balloon in the drilled channel in the fracture zone. Pressure-controlled inflation of the kyphoplasty balloon and the simultaneous gain in height of the vertebral body. (**f**) The cavity that remains after the kyphoplasty balloon has been removed is filled with high-viscosity augmentation material through the cannula

into the vertebral body. The operating surgeon should always have control of the proximal end of the Kirschner wire because the sharp tip could easily and inadvertently penetrate soft bone and breach the anterior vertebral cortex [44]. A skin incision is then made to accommodate the working cannula, which is advanced through the soft tissues and through the pedicle to rest at the posterior aspect of the vertebral body. A plastic handle can be placed on the hub of the cannula to advance it manually into the vertebral body, or a mallet can be used to tap the plastic handle, driving the cannula into the vertebral body [47]. The cannula is inserted approximately 2–3 mm. past the posterior vertebral body wall. If there is considerable resistance to placing the working cannula, the cannula handle can be rotated in an alternating clockwise-counter clockwise motion to help breach the cortex and facilitate advancement [46, 49]. The guide-wire is removed and a drill is used to create a path for the inflatable balloon tamp. If a biopsy is needed, a biopsy

trocar is used to sample the vertebral bone prior to drilling the vertebral body. A 3 mm. drill is advanced through the cannula and multi-planar fluoroscopy is used to re-check the orientation of the working cannula. The drill is then ideally directed along a slightly posterolateral to anteromedial trajectory into the vertebra until the tip of the drill is 3 mm. posterior to the anterior margin of the vertebral body [47]. Extreme caution should be used to avoid breaching the anterior cortex of the vertebral body with the drill. For bilateral transpedicular or extrapedicular approaches, the sequence of events is repeated on the contralateral side [47].

After this, the kyphoplasty balloon is positioned in the drilled channel in the fracture zone. If the clinician feels resistance in the passageway of the drilled hole, perhaps secondary to small shards of bone, the drill or bone filler device can be inserted and withdrawn once or twice along the path to clear it of debris. Thereupon, the balloon tamp can be inserted without difficulty. The inflatable balloon tamp is available in different sizes. Each balloon has markers to delineate its distal and proximal extents. Once both balloons are in the vertebral body, they are pressure-controlled inflated with a radio contrast medium (for visualization) simultaneously under bi-planar fluoroscopy so as to gain height of the vertebral body. The inflatable bone tamp compacts the cancellous bone and re-expands the body. Before inflation, air is purged from the balloons, and the reservoir of an angioplasty injection device (incorporating a pressure monitor) is filled with 10 ml. of diluted iodine contrast material. Inflation via the injection device is begun under continuous fluoroscopy, increasing balloon pressure to approximately 50 psi. to secure the balloon in position. Balloon inflation should be performed slowly and progressively by half-millilitre increments. There should be frequent pauses to check for pressure decay, which occurs as the adjacent cancellous bone yields and compacts [49, 50]. If the bone is osteoporotic, pressure decay may be immediate. If the bone is quite dense, there may be little or no pressure decay, even at pressures up to 180 psi. The balloon system is raised to 180 psi., with a practical maximum of 220 psi. The possible end-points of inflation are shown in Table 2. The operating surgeon must maintain both visual and manual control throughout the entire inflation process and should record the amount of fluid used to inflate the balloon when the end-point has been achieved [47]. This volume indicates the size of the cavity that has been created and it will serve as an estimate of the amount of cement to be delivered. In some cases, reduction of the vertebral body can be accomplished. If substantial height restoration has not been achieved, careful repositioning of the bone tamps and re-inflation can be helpful [45]. The reduction manoeuvre is best accomplished when the balloon pushes up against the end-late and shows a flattened appearance on fluoroscopic image. When positioned properly, this technique elevates the end-plates without expanding the fractured vertebral body laterally or posteriorly. Two balloons are generally used to provide a greater reduction. Rupture of the balloon (who rarely occurs) is not a hazard, other than that of exposure to small volumes of radio contrast medium. If a balloon ruptures, it is simply withdrawn through the working cannula and replaced. The inflation of the balloon should be stopped before causing a cortical fracture, which is revealed by the appearance of a small outward bleb in the balloon [44].

Table 2 End-points of balloon inflation during kyphoplasty

1. Restoration of the vertebral body height to normal position
2. Flattening of the balloon against an end-plate without accompanying height restoration
3. Appearance of a small outward bleb in the balloon
4. Contact with a lateral cortical margin
5. Inflation without further pressure decay
6. Reaching the maximum volume of the balloon
7. Reaching the maximum pressure of the balloon

The cavity that remains after the kyphoplasty balloon has been removed is filled with high-viscosity augmentation material through the cannula and the cement can be deposited under low pressure. Once adequate inflation has been

achieved, the cement is mixed in a manner similar to that for vertebroplasty. The cement mixture is transferred to a bone filler device [14]. Once the bone cement has undergone transition from a liquid to a cohesive, doughy consistency (about 5 min after mixing, depending on the cement), the bone filler devices are passed through the working cannula and into the anterior aspect of the vertebral cavities. Small volumes of cement (about 0.5 cm [3]) are injected in a step-wise fashion with fluoroscopic visualization. The volume of cement for injection is approximately 1 ml. more than the volume of the cavity created by each inflatable balloon tamp [52]. In addition to filling the void created by the ballon tamp, additional cement is needed to allow integration of the cement into the surrounding trabecular bone. This serves to "lock in" the cement. If a quantity of cement is equal to or less than the volume of the cavity, the vertebra will not be re-inforced and may lead to further re-collapse of the surrounding bone due to excessive motion at the bone-cement interface. The cement should be injected into the anterior two-thirds of the vertebral body and the cavity should be filled from the anterior to the posterior aspect of the vertebra. By avoiding the posterior one third, the risk of cement leakage into the spinal canal is minimized [46]. Continuous fluoroscopic monitoring is maintained to identify leakage of cement into the spinal canal, paraspinous veins, inferior vena cava, or disc space [49]. When cement leakage is observed, injection should be halted immediately. The cannula is re-positioned to another location and another attempt at injection may be pursued after adequate time has passed to allow the first injection to polymerize. In most cases, cement leakage is clinically inconsequential. If a significant leak is suspected, a "wake-up" test is performed prior to departing the operation room. If there are clinical signs and symptoms of neurologic compromise, emergency decompression should be considered.

Treatment of multiple levels can be performed using a single batch of cement. The cement is stored in a sterile ice-water bath to slow the polymerization process. The guide-wires are inserted into all the target vertebral bodies. The first site in then drilled, the balloon tamp deployed, and the cement injected. The next level is then drilled, treated with the balloon tamp, and subsequently injected. A third site can be treated thereafter in the same sequence. This step-wise sequence allows use a single pair of balloon tamps for the treatment multiple levels. The limitation of the number of levels is dictated by the cement load. The risk of cement toxicity increases with the number of levels treated. As a general rule, no more than three levels should be treated during a single procedure [44].

Maintenance of reduction can be difficult in certain fractures, particularly in fractures with an intravertebral vacuum phenomenon. Once a balloon is deflated, the fracture may collapse again. The reduction can be maintained by the "eggshell technique" [44]. A small amount of cement (0.5–1 cm^3) is injected into the cavity. The balloon tamp is re-inserted and gently re-elevated. The small cement bolus is then spread around the balloon to create a thin eggshell of cement. When the balloon is removed, the eggshell mantle holds the reduction until the remainder of the cement is injected. This technique can also be utilized to control cement leakage [44].

When cement filling of the cavity has been confirmed fluoroscopically from both the lateral and anteroposterior views, the bone filler devices are partially withdrawn to allow complete filling of the cavity. They are then used to tamp the bone cement in place before being completely withdrawn. The patient remains prone on the table and is not moved until the remaining cement in the mixing bowl has hardened completely [15].

Post-Operative Care and Rehabilitation

The patients can be mobilized immediately after surgery without restrictions and without external support. When calcium phosphate has been used, we prescribe 12-h bed-rest as the process of hardening takes longer [44].

Pain relief occurs within 1 or 2 days in most cases and it has been correlated with fracture reduction. The patient is dismissed with routine pain medications and a graduated resumption of activity.

Discharge instructions for the patient should include: a call to the physician for the onset of new back pain, chest pain, lower extremity weakness or fever. The first follow-up after the procedure is at 1 week [47] and after this the patient should come back to the office at 1 month and at 3 months after the procedure. Six months after the procedure the patient can be definitively discharged.

As vertebral augmentation techniques cannot be shown to reduce the rate of further vertebral fractures, additional medical treatment for osteoporosis and physiotherapy are required [49].

Complications

The overall risks of the procedure are low, but serious complications (including spinal cord compression) can occur. With good patient selection and careful technique, these complications are avoidable and make the risk-to-benefit ratio highly favourable [53, 54].

Early complications of kyphoplasty are divided in three groups:

(a) systemic complications
(b) local complications related to the technique or to the placement of hardware in an incorrect location
(c) local complications due to extrusion of cement outside of the vertebra.

Delayed complications include a re-fracture or an insufficiency fracture of the cemented vertebrae, fractures of the adjacent level and delayed dislocation of the cement [14, 55–57].

Early systemic complications include cardiovascular changes, fat embolism and fever that are usually resolved in 2–4 days. It may occur as a result of inflammation or infection at the site of injection or as a result of exothermic effects of the cement [58, 59]. Unreacted monomer from the cement can have systemic cardiopulmonary effects resulting in hypoxia and embolism.

Infectious complications, although rare, have been reported. There are several reports of osteomyelitis requiring corpectomy [53]. Meticulous attention to sterile technique is warranted, including pre-operative intravenous antibiotic administration.

Complications related to the technique include, post-operative epidural bleeding, injury to the neural elements, temporary radicular pain, vascular injuries, dural tears and rib, pedicle or sternum fractures. Rib fractures are also known to happen as a result of pressure on the back and chest occurring during needle placement while the patient is prone [58]. New osteoporotic rib fractures are thought to occur when the patient is placed in prone position on the table for and during the procedure. However, they might significantly bias the clinical outcome relative to pain relief and should be treated with analgesic medications for an appropriate period. Pedicle fractures may be a primary finding of the vertebral compression or might be induced by the passage of the cannula during the procedure. Complications resulting from improper needle placement or inattention to fluoroscopic patterns of cement distribution during injection are dependent on operator training and experience.

Complications secondary to extrusion of cement include pulmonary embolism and nerve or spinal cord compression by cement. The most frequent problem is a transient radicular pain due to cement leakage into the radicular veins in proximity to the vertebral foramina. Cement leakage into peridural veins can, in the worst case, lead to para- or tetraplegia by compression of the thecal sac and its contents. In a group of thirty patients who underwent kyphoplasty, Lieberman et al. reported cement leakage into the epidural space in one patient, into a disc space on two occasions, and into the paraspinal tissues in three patients [33]. Cement leakage can occur less often in kyphopasty than vertebroplasty. The incidence of cement extrusion outside of bone occurring during kyphoplasty has been reported to be 8.6–33 %. In contrast to this, cement extrusion with vertebroplasty has been reported to occur in 3–70 % of cases [59].

Cement leakage into the paravertebral soft tissues or veins is generally asymptomatic. Cement leakage into the disc space is controversial because some studies have shown an increased risk for subsequent fractures of adjacent vertebral bodies [60–62], whereas others

have claimed that cement leakage into the disc space is of no clinical significance [54, 57]. The incidence of cement leakage following either procedure can be higher than that seen on radiographs. Yeom et al. found that computerized tomography revealed cement leakage 1.5 times more frequently than did radiographs [63]. Garfin et al. reported on two patients with spinal cord injury following kyphoplasty [17]. Phillips et al. evaluated whether the creation of a bone void during kyphoplasty reduced the risk of cement leakage [36]. Under fluoroscopic control, they injected radiopaque contrast material into the vertebral body prior to and following the creation of a void within the vertebra. There was less extra-vertebral leakage of the contrast material into the epidural vessels, inferior vena cava and transcortically following the creation of the cavity, suggesting that cement leakage may be less likely following kyphoplasty [64]. Because cement extrusion outside of the vertebral body is usually asymptomatic with either vertebroplasty or kyphoplasty, it makes more sense to monitor and compare symptomatic complications rather than the incidence of cement extrusion.

Cement propagation via paravertebral veins into the inferior vena cava and pulmonary embolism has been described in several case reports as a possible cause for hypotension, arrhythmia, and hypocapnia [65, 66]. In a retrospective analysis, pulmonary cement embolism has been described in 4.6–8.1 % of the cases of vertebropasty, with 1.1 % of patients being symptomatic [67]. Experimental data have demonstrated that high-viscosity cements might probably reduce the leakage rate to avoid those complications completely in future. A decrease in the potential for cement extrusion with kyphoplasty has been suggested because of the cavity formed and a more viscous cement that results in the need for less injection pressure [67]. Highly vascular lesions and a liquid consistency of cement may also cause leakage of methylmethacrylate into perivertebral veins. In such cases, injection should immediately be discontinued so as to avoid pulmonary embolism from the cement.

In addition to the short-term peri-procedural risk of kyphoplasty, there can be an additional risk of new fracture development subsequent to the treatment. New vertebral fractures are reported in numerous patients subsequent to kyphoplasty. They usually occurred within the first year after treatment [68]. The hypothesis is that the restored stiffness of the augmented vertebra itself might propagate secondary fractures in adjacent non-augmented vertebrae. Because new vertebral fractures can occur in osteoporotic patients simply secondary to disease progression rather than as a result of vertebroplasty or kyphoplasty [69, 70], it is difficult to determine the added risk of fracture resulting from these procedures.

In general, kyphoplasty is a relatively safe procedure when performed by skilled operators. The overall symptomatic complication rate reported for kyphoplasty as a treatment for osteoporotic compression fractures is less than 1–6 %. They mostly consist of minor complications such as rib fractures and temporary radicular pain [19, 45, 47]. Major complications, such as permanent neurological injury or serious pulmonary embolism are rare. They occur in less than 1 % of cases [45].

A prospective, randomized trial directly comparing outcomes of kyphoplasty and vertebroplasty would be necessary to accurately compare the relative safety of both procedures.

Summary

In conclusion, kyphoplasty is a good technique for the treatment of osteoporotic vertebral fractures in order to relieve pain and restore vertebral body height. On the other hand, this procedure has serious potential complications that can lead to irreversible consequences for the patient, even to death. Following the guidelines set out above along with proper training allows for the carrying out of this technique with a low complication rate and with good results.

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