Spinal Body Reconstruction in Osteoporosis

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Abstract

The treatment of osteoporotic vertebral body fractures often requires a well-thought-out therapeutic strategy. Most of the patients are at older age and multimorbid, so that therapy should be as gentle as possible. On the other hand, an early surgical stabilization to avoid immobilization of the patients often is necessary. Kyphoplasty and vertebroplasty are established minimal invasive procedures in the therapy of osteoporotic vertebral fractures. In literature the outcome after cement augmentation is quite good and the complication rate, especially in kyphoplasty, is low. In cases of a total collapse of the vertebral body, in older fractures with kyphotic deformity or in cases of instability, a posterior instrumentation with an anterior column support is needful. Due to the fact that there is no comparative long-term evidence-based data in literature concerning the different implants, general recommendations cannot be given. To avoid implant failure we propose an additional instrumentation of the adjacent vertebral bodies within the posterior stabilization and – if procurable – we always do an anterior column support with an expandable titanium cage. Furthermore, a pedicle screw system which allows cement augmentation of the screws after placement of the screws could be helpful to elevate the stability of the instrumentation. Further clinical examinations have to be carried out.

Key Words

Osteoporosis · Vertebral body fractures · Cement augmentation · Posterior instrumentation · Anterior column support

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Introduction

Contrary to traumatic fractures of the spine, a surgeon has to be aware of special circumstances concerning the therapy of osteoporotic vertebral body fractures.

On one side, patients with osteoporotic fractures often are *multimorbid* and have a poor bone quality; on the other side, an early operative stabilization to avoid immobilization of the patients with resulting pneumonia or *decubitus* ulcera could be needed [1]. Another problem is the risk of implant failure after stabilization because of the tender bone and the higher morbidity and the elevated risk for the patient in cases of revision surgery.

In synopsis with the literature and our own experiences, this article wants to give decision supports for the treatment of osteoporotic vertebral body fractures.

Epidemiology

Osteoporosis is a common disease. The prevalence in Germany is about 6 million patients [2]. Twenty-five percent of the postmenopausal women suffer from osteoporosis [3] and the life-time risk for women over 50 for getting an osteoporosis is nearly 40% [4].

The mortality in women over 65 years with more than one vertebral body fracture is elevated about 23% [4] and we find comparable 5-year survival rates to hip fractures [5].

There are several factors described which increase the risk of getting an osteoporosis. Concerning this, a higher risk is associated with the age and female sex [6], family history with osteoporosis, a body mass index (BMI) below 20, loosening of body height more than 4 cm and inadequate physical activity [3].

Osteoporotic compression fractures are an important public health concern, leading to significant morbidity, mortality and economic burden. According to

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estimates of experts 80–90% of all femoral neck and vertebral fractures and 70% of all distal radius fractures of Caucasian, postmenopausal women are caused by osteoporosis [3].

In addition, there is a five times elevated risk of getting further fractures in patients with one pre-existing osteoporotic fracture and a seven to nine times elevated risk when there are two or more [3, 7].

The rate of diagnosed vertebral body fractures in women over 50 is about 530 per 100,000 person-years (py), but the true incidence may be 1,800 per 100,000 py [8]. So only one-third of osteoporotic vertebral body fractures are diagnosed clinically.

Diagnostic Investigations

When patients complain about persisting back pain over 3 months, in spite of conservative therapy a radiological examination should be done [9]. In cases of additional risk factors and contingent progressive kyphotic deformity, an earlier diagnostic proceeding can be recommended.

The first diagnostic tool is an X-ray in two levels [10]. When there is a correlation between the pathology in the X-ray and the clinical examination, further diagnostic procedures should be applied. The MRI can give information about the age of the fracture and may identify osteoporotic vertebral fractures with no sign of vertebral body collapse on initial radiographs [9, 11].

The CT scan assesses an involvement of the posterior wall and shows the morphology of the pedicles. Therefore, it is helpful for the preoperative planning, especially to decide whether an open access is needed or not [12].

Therapy

The decision for conservative or surgical treatment often is difficult. One part of a sufficient conservative treatment includes the corresponding medical therapy with bisphosphonates and substitution of Vitamin D and calcium [13, 14]. The other part is the early mobilization of the patients with the help of orthoses and an attendant pain therapy.

Relative indications for surgical treatment are compromising serious pain symptoms, pre-existing *osteoporotic* fractures and the progressive loosening of vertebral body height with or without kyphotic deformity [15–17].

A surgical treatment becomes mandatory in cases of instable situations or neurological deficits.

The surgical strategy comprises the classic open techniques on one side and the vertebral body augmentation with bone cement on the other side.

The classic open surgery includes the posterior instrumentation with a pedicle screw system and the anterior column support. The anterior support can be achieved with titanium plates, autologous bone graft from the iliaca crest and expandable titanium cages.

Furthermore, there are several biomechanical tests concerning the implants for the anterior support, but a comparative study with long-term results does not exist in literature. In our department, we always prefer the posterior instrumentation plus the anterior column support with expandable titanium cages, if procurable. If an anterior approach to the spine is not possible because of the morbidity of the patient, another *option* could be the combination of a posterior instrumentation and a cement augmentation of the vertebral body.

The vertebral body augmentation is practicable with the kyphoplasty or the vertebroplasty in a percutaneous or open technique [18]. According to our experiences kyphoplasty is preferred mostly because of the lower leakage rate and the reduced loss of height and degree of kyphotic deformity *due to the possibility of deformity correction* [19–22].

The complications of cement augmentation over all are below 10% [23]. *They are mainly attributable* to cement leakages and can cause neurological deficits or pulmonary embolism. A further complication is the fracture of an adjacent vertebra after kyphoplasty or vertebroplasty [24].

The outcome after cement augmentation of the vertebral body is quite good. Pain reduction between 70 and 100% is described in the first 48 h [25–29].

Indications for a classic open technique are a collapse of the vertebral body, older fractures with kyphotic deformity and instability [16]. Aside from this, *kyphoplasty* should be done if possible, either in a percutaneous technique or in case of a damage of the posterior wall of the vertebral body in the open technique [18].

While planning his strategy, the surgeon has to be aware of the typical problems that are associated with osteoporotic fractures. *Mostly one deal with* old patients with high *comorbidity* and poor bone quality. Therefore, the targets for the surgical technique are short operation time, less morbidity related to the approach and to avoid revision surgery caused by implant failure. To achieve this, there are three technical considerations.

Optimized Screw Design

Multiple pedicle screw systems have been evolved over the last three decades. All have certain attractions and all have drawbacks. What does a spine surgeon expect from an ideal screw?

According to the tendency of minimal invasive access surgery a pedicle screw needs to be cannulated for percutaneous application over a k-wire and needs to have a self-tapping thread which is friendly for the user. Further, the screw should be perforated at the tip for an optional cement augmentation through the implanted screw and should have a thickened thread in the intrapedicular region for a bigger surface area to reach a pressfit fixation inside the pedicle.

Screw Augmentation with Cement

Cement vertebral augmentation has been used for many years. It reduces the risk of screw loosening and increases the pullout strength of the screw [30]. The well-known conventional technique comprises first of all the preparation of the pedicle, then inserting cement into the pedicle and at least the surgeon has quickly to turn in the screw before hardening of the cement.

The drawbacks of this conventional technique are clear. There is an elevated risk for cement leakages, the operation situs could be contaminated with bone cement and – especially in cases of multi-segmental pathologies – several times cement mixing is necessary, which increases costs and time for surgery.

To avoid these drawbacks, cement augmentation through the screw after screw placement is needful. Therefore, the screws are cannulated and perforated in the anterior third of the thread. Due to a special augmentation adapter, which is temporarily fixed to the screw, there is no risk of cement leakage blocking the polyaxial mechanism after augmentation.

Figure 1 shows the cement augmentation with the tangoRS™ system (Ulrich, Ulm, Germany).

Another advantage is that the spine surgeon can decide whether a cement augmentation of the screws is necessary or not after he placed the screw. This may reduce costs and time for surgery.

Additional Instrumentation Above and Below the Fracture

Stabilizing techniques in the surgical therapy of osteoporotic vertebral body fractures often implicate the risk of implant failure caused by poor bone quality.

To avoid implant failure is one of the main targets and there are several options concerning the surgical treatment. As we propose the posterior instrumentation should be the first measure.

There are innumerable pedicle screw systems available to the spine surgeon. Starting in the 1970s with simple systems that allowed a solid fixation between adjacent vertebrae [31], many modifications were made over the years [32]. In the 1990s polyaxial systems were developed [33, 34], nowadays systems that allow a minimal invasive access surgery are the goal [35]. Those systems are useful especially for the therapy of osteoporotic vertebral body fractures, because in succession of minimal invasive approaches to the spine, less morbidity by the surgical intervention and earlier mobilization of the patients is possible.

The fixation should take the forces that are involved and the stability should maintain over time [34]. These demands on the pedicle screw systems are getting the more important, the poorer the bone quality is. Due to our own experiences we prefer an instrumentation of at least two vertebral bodies above and below the fracture, whether an anterior column support has been carried out or not (Figure 2). Hereof, we expect a better stabilization and lower rate of implant failure. Further examinations have to be carried out.

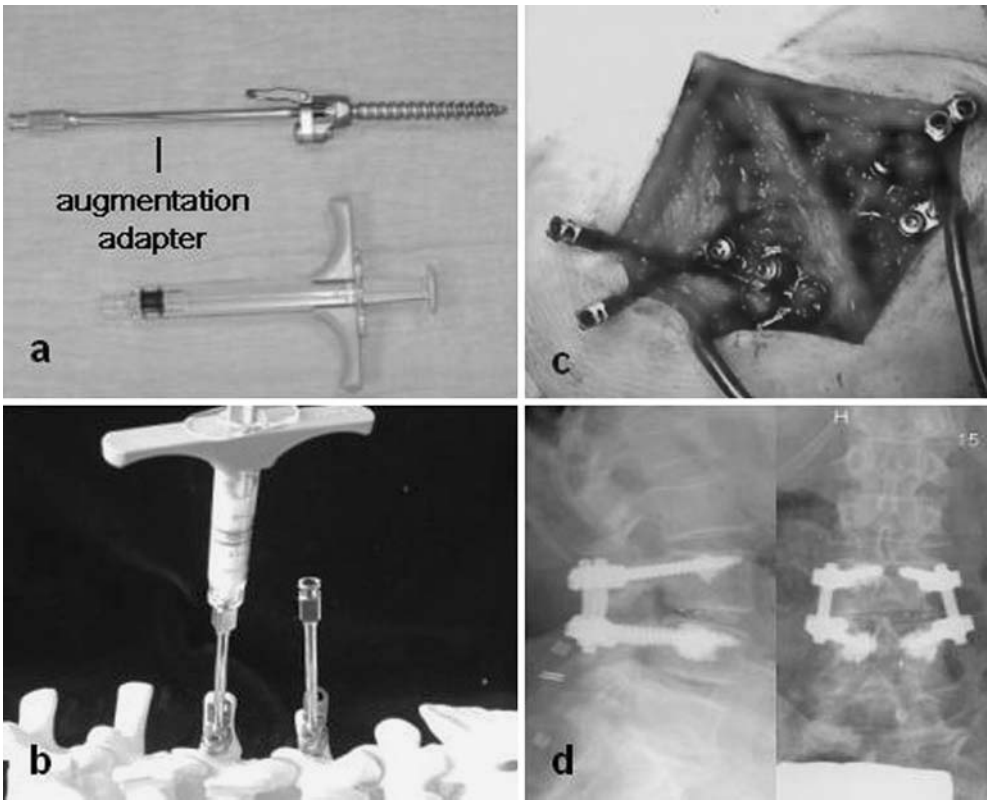
Discussion

The treatment of osteoporotic vertebral body fractures often requires a well-thought-out strategy. So what can be recommended for the diagnostic and therapeutic measurement?

Due to the fact that only 30% of the vertebral body fractures are diagnosed clinically [8], an earlier diagnostic examination is necessary, especially in appearance of risk factors [3–6, 9].

Before a final therapeutic decision will be made, a conventional X-ray in two levels and an MRI are needed [9, 11]. If a surgical therapy is planned, an additional CT scan should be done.

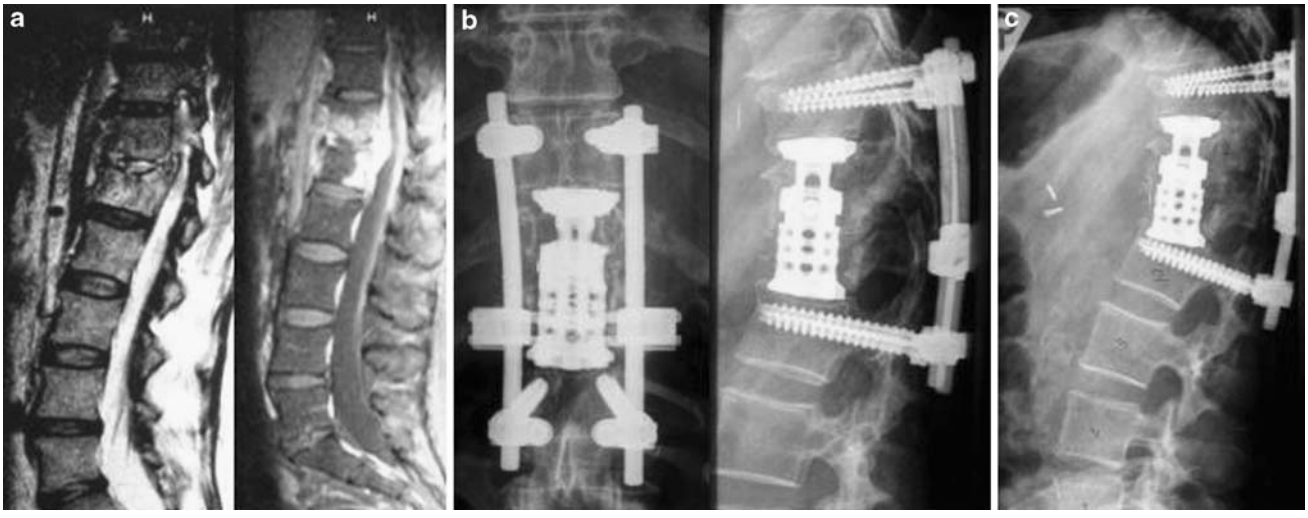
After decision for surgical treatment, the spine surgeon has to asses the way of the surgical intervention. Due to the height and the stability of the vertebral body, cement augmentation by kyphoplasty or vertebroplasty is the first option in the surgical treatment, either in a percutaneous or – in cases of a damage of the posterior wall with neurological deficits – in an open technique [16]. Concerning this, the collapsed vertebral body has to be high enough to place the balloon of the kyphoplas-



Figures 1a to 1d. Cement augmentation through the implanted pedicle screws; a) system components, b) saw bone model and c) intraoperative after fixation of the augmentation adapter, d) postoperative X-ray control with cement in the anterior third of the screws (L4 right, L5 both sides).

minimal invasive procedures in the therapy of osteoporotic vertebral fractures. The outcome after cement augmentation is quite good [36] and the complication rate especially in kyphoplasty is low [23, 25–29], so that from our point of view and according to literature *kyphoplasty* should be preferred.

In cases of a total collapse of the vertebral body, in older fractures with kyphotic deformity or in cases of instability, a posterior instrumentation with an anterior column support is needful [16, 37]. The problem of each instrumentation is the difference between the hardness of the osteoporotic bone and the rigid implant. Pedicle screws may cut the bone with their sharp thread like a saw which can cause a loosening of the screws. Concerning the titanium cages, the endplates as the hardest part of the ty system and there should be no major damage of the endplates, which can cause a cement leakage into the disc. Kyphoplasty and vertebroplasty are established



Figures 2a to 2c. a) Clinical case: 72 years, female, osteoporotic fracture T12/L1. b) Posterior instrumentation T11 to L2 plus anterior column support with expandable titanium cage. c) After 6 weeks progressive kyphotic deformity and sintering of the cage. Additional instrumentation T10 and L3 would have been useful.

vertebral body mark the bearing for the cage. Therefore, the cage may sinter into the vertebral body which can cause a progressive kyphotic deformity and increase the forces to the screws with the risk of implant failure.

Although there is no evidence-based data, the combination between the posterior instrumentation and the anterior support is recommended [38], which is concordant to our strategy.

To increase the stability of the implant system and to avoid revision surgery caused by implant failure, there is the possibility of screw augmentation with cement. The benefit of this procedure is often published [30] and is similar to our experiences. Like already proposed, we prefer a screw system which allows cement application after screw insertion.

Concerning our knowledge, there is no study which shows the advantage of an additional instrumentation of the adjacent vertebrae within the posterior stabilization, whether an anterior column support has been carried out or not. In our department this technique has been used for nearly 1 year and we are looking forward to the first clinical examinations in our follow-up studies concerning the – hopefully minimal – rate of implant failure.

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