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Operative treatment of thoracic and lumbar vertebral fractures in osteoporotic patients according to the OF score – Current concepts in Germany

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Abstract

The paper deals with major improvements in the field of defining indications for osteoporotic vertebral fractures. Since indications and techniques for stabilization of non-pathologic vertebral fractures cannot simply be applied in cases with insufficient trabecular and cortical bone stock the OF score has shown good a capacity to reduce implant failure rates and other severe complications. The OF score is described in detail, as well as the implications of osteoporosis for additional operative features such as kyphoplasty, screw augmentation, and planned material removal. Evidence and practical caveats of conservative features such as orthoses and braces are also briefly mentioned.

Introduction

Osteoporotic vertebral body fractures (OVBF) have a prevalence of around 20% in Europe. It is estimated that about 50,000 such fractures occur per year. Osteoporotic fractures make up the vast majority of these fractures, 25% of all women above the age of 50 years have at least one OVBF, 49% of which are located between Th11 and L3. Quality of life in these patients, as compared to age-matched fracture-free cohorts, is significantly decreased and

mortality increased by 25%, at least partly due to their reduced mobility.[1,2]

Most of these injuries can be treated conservatively, depending upon the resources provided by the individual setting of the patient and the treating facilities. This article tries to present accepted guidelines for operative treatment in Germany, according to the new so-called OF classification, based upon scientific evidence of diagnosis and treatment of osteoporotic fractures of the thoracic and lumbar vertebrae.

Diagnostics

Once the presence of OVBF can be assumed, the examiner will often not find the patient's history very helpful. Many elderly patients tend, e.g., not to remember a fall or accident, and may even play down such incidents to cover up their decreasing ability to live autonomously. They often locate their back pain below the actual fracture due to its tendency to radiate downwards. The clinical exam, thus, mostly relies on provoking a local pain by percussion to prevent taking radiographs missing out the fracture. Neurological deficits should be routinely noted during the first exam.

In cases where the patient is able to stand, upright radiographs of the lumbar and/or thoracic spine should be taken and compared to older radiographs, if available. CT scans and MRI scans should follow, if a new fracture and/or spinal stenosis must be suspected.

Since the "classical" scores for assessing the fracture's severity (e.g. TLICS,[4] AO,[5] Genant[6]) are mainly focusing upon non-pathologic, i.e. true traumatic fractures, their application would often lead to recommendations for surgery without respecting the individual needs and limitations of elderly patients with often severe comorbidities. Thus, in Germany Schnake et al.[7] have developed a very useful score to classify OVBF. Their OF score consists of seven clinical and radiological items which are incrementally rated by points. The type of fracture herein is not in accordance with the AO classification of non-pathologic fractures but mainly contributes to the score values.

OF 1 fractures often can only be discerned by additional MRI, showing bone bruise signs around the endplates without deformation, primarily giving a clear indication for conservative treatment.

OF 2 is defined as deformation with involvement of posterior vertebral wall ≤ 1/5 in CT or without any such participation of posterior elements, indicating towards conservative therapy.

CRITERIA	POINTS
Morphology (OF 1-5)	
OF Grade 1	2
OF Grade 2	4
OF Grade 3	6
OF Grade 4	8
OF Grade 5	10
Bone Density	
T-Score < -3	1
Dynamic of fracture settling over 1 week	
Yes	1
No	-1
Pain under analgesics	
Numeric Rating Scale >= 4/10	1
Numeric Rating Scale < 4/10	-1
Neurologic deficit due to fracture	
Yes	2
Mobilization possible under analgesics?	
No	1
Yes	-1
General health/comorbidity	(Maximum -2, zero if not to be determined)
ASA < 3	-1
Dementia	-1
BMI < 20	-1
Helplessness	-1
Anticoagulation	-1
Total score and recommendation	**0-5: Conservative, =6: Relative indication for surgery, >6: Absolute indication for surgery**

Figure 1: Score for OF Classification, according to Schnake et al. [4]

OF 1: No deformation (CT, bone bruise only MRI-detectable)

OF 2 Deformation without or involvement of posterior vertebral wall ≤ 1/5 (CT)

OF3 Deformation with involvement of posterior wall > 1/5 (CT)

OF 4 Loss of frame structure, collapse, pincer type fracture (CT)

OF 5 Distraction or rotation injury with loss of anterior and/or posterior tethering (CT)

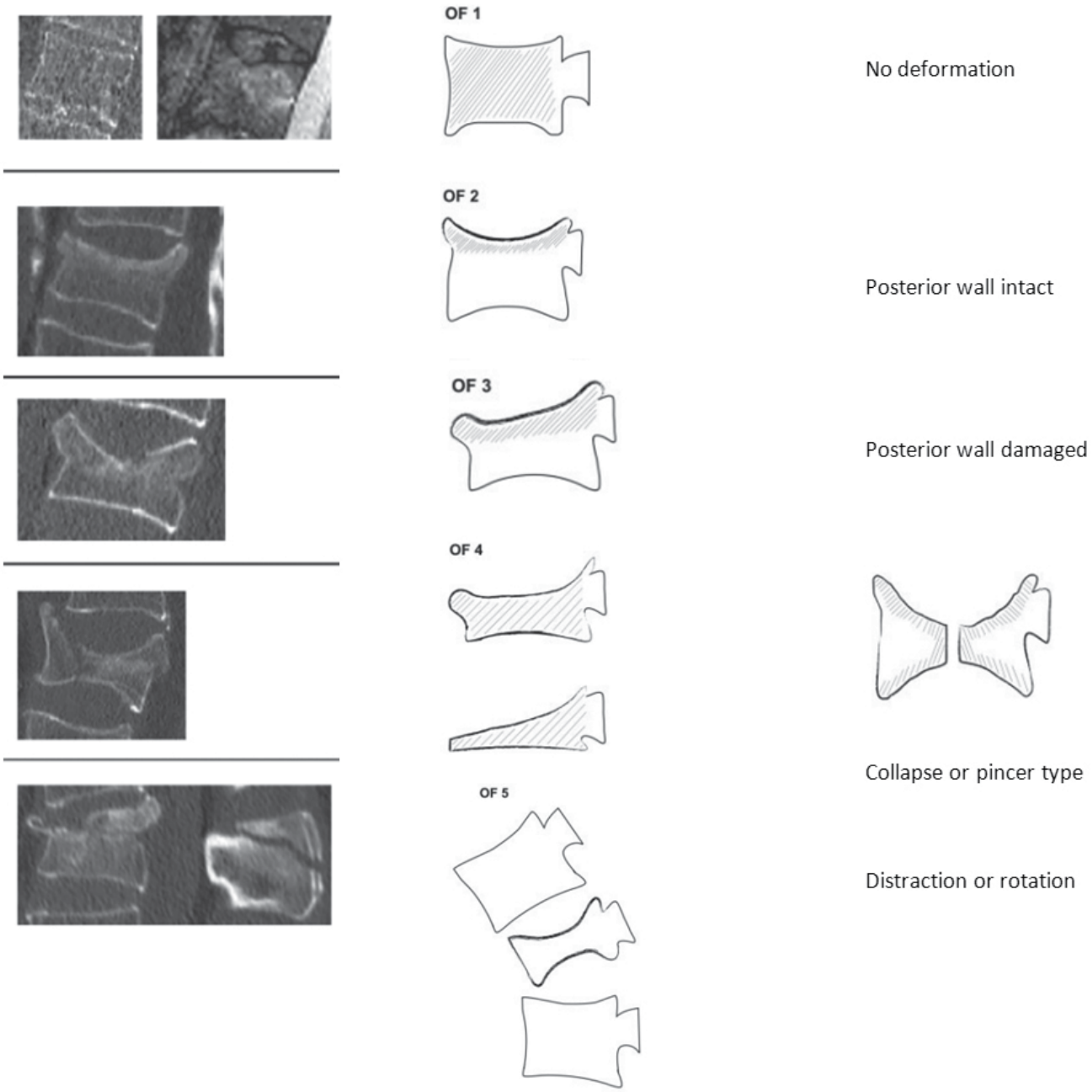

Figure 2: CT representation of OVBF, for OF 1 with MRI (right) (Modified according to [4])

OF 3 means deformation with distinct involvement of the posterior wall (>1/5). Posterior instrumentation is advocated.

OF 4 means loss of vertebral frame structure, vertebral body collapse, or pincer type fracture. Here In cases with loss of vertebral frame structure posterior instrumentation or long-segment posterior instrumentation is recommended.

OF 5 fractures coincide with AO type B- and C-fractures, mostly giving clear indications for operative treatment due to their significant instability and bad spontaneous healing tendency.

A detailed summary of this classification is given in Figure 1 and a visual representation of CT scans in Figure 2.

Treatment

The OF score can help to identify patients who do not necessarily have to be operated on and/or would not benefit enough from operative treatment. These are patients with "stable" fractures, "semi-stable" fractures, and those with "non-stable" fractures, being inoperable for various reasons.

From a score of 6 points upward, surgical therapy can be advocated as a standard strategy. In type OF 3 and OF 4 fractures surgical treatment should always be considered as the primary option.

Options for conservative treatment:

First of all, it should be made clear that all fractures without surgery should be re-evaluated by a follow-up radiograph at least one week after mobilization of the patient since fractures may deteriorate in due course and even unexpectedly. An example of such progress is given in Figure 3.

Still, there is a tendency of treating non-operative patients with stabilizing orthoses, yet "stiff" orthoses like Jewett or 4-point corsets are often nowadays abandoned for "active" orthoses. Yet, it should be borne in mind that there is only little, if any, evidence for benefits of orthotic treatment at all. From a subjective point of view, some orthoses, braces, and corsets may alleviate pain, since they are able to distribute the intraabdominal pressure more evenly, thus reducing the intraspinal venous pressure peaks during changes of posture, coughing, defecation, etc. In a lying position the are useless in any case, and could even be harmful due to causing pressure sores. Often, elderly patients are unable to put them on and off themselves which does not increase their acceptance. Also, their considerable cost must be noted. Some of these orthoses can be "downsized" in terms of stiffness, which allegedly reduces the risk of posttraumatic muscular disuse atrophy. Kweh et al have recently conducted for the first time a comprehensive systematic review of 2019 articles which support the use of orthoses in such fractures.[3]

Early physiotherapeutic mobilization under appropriate pain medication, anti-osteoporotic therapy according to its underlying cause and secondary anti-osteoporotic prophylaxis has highly beneficial results in non-operated and operated patients. In many European countries, national guidelines for such treatment are available, the German version is quoted here *pars pro toto.*[8]

Surgical options:

In cases with vertebral body collapse a polysegmental posterior instrumentation is recommended, in cases with reducible vertebral body collapse posterior or posterior instrumentation with additional anterior reconstruction is recommended. In cases with pincer type fracture, posterior instrumentation with an option for anterior reconstruction should be considered. Several possibilities are outlined as follows:

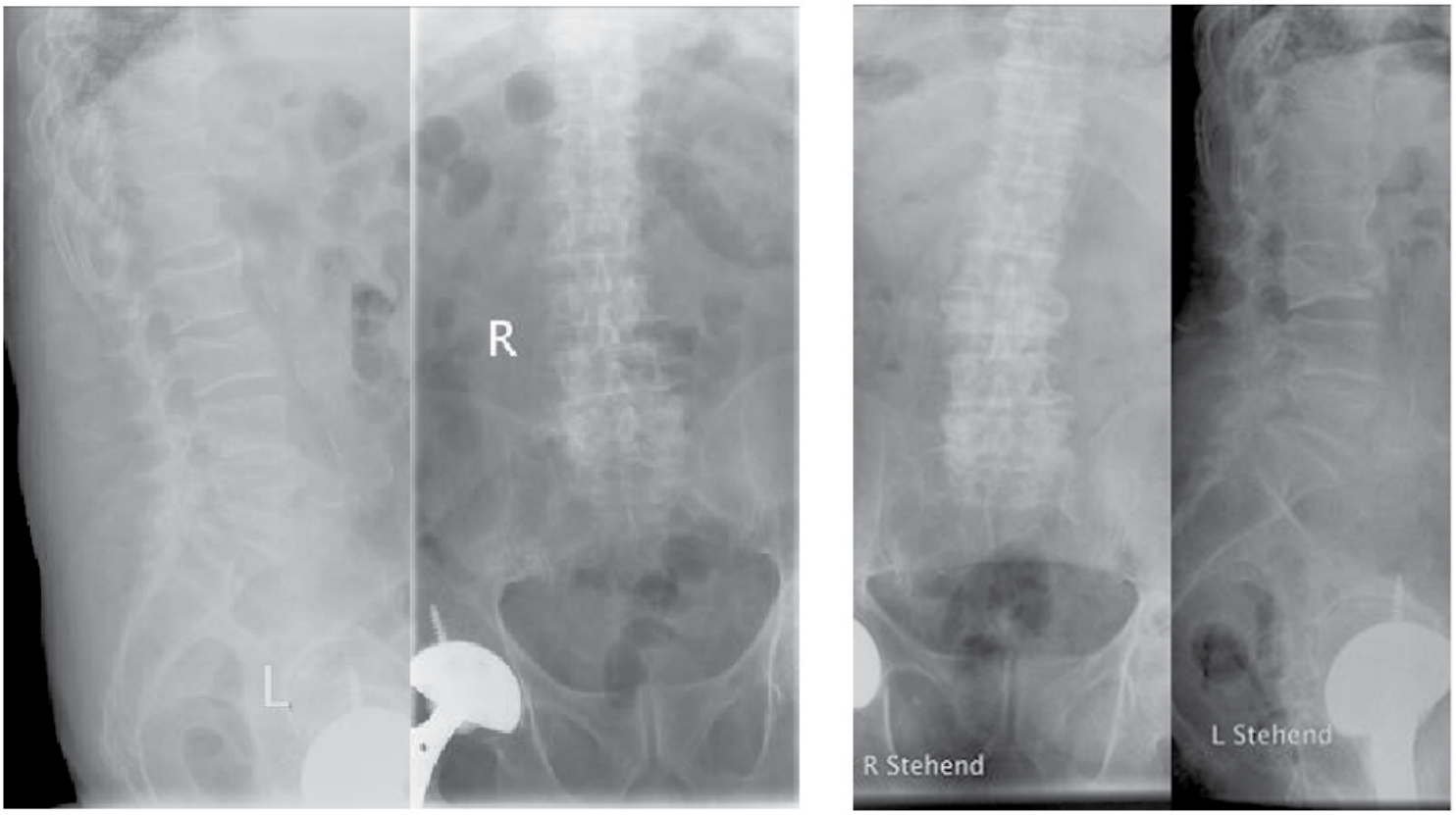

Figure 3: Deterioration of an OF 2 into an OF 4 fracture after mobilization

- Standalone (up to OF2) or additional Kyphoplasty (Figure 4).
- Polysegmental posterior stabilization with pedicle screw-rod-based systems with or without screw augmentation with PMMA cement (Figure 5) with or without posterior decompression of the spinal canal.
- Rarely, and if necessary, mostly in combination with posterior instrumentation: Anterior vertebral body replacement (Figure 6).

Nowadays, often percutaneous minimally invasive (MIS) techniques with cannulated screws are preferred, yet open techniques are not obsolete (Feng et al.), especially if permanent fusion is desired.[9] MIS procedures do not have lower complication rates and relevant implant placement inaccuracies have been reported. An implant removal in OVBF cases in old patients, to the author's personal experience, can only be advocated in case of symptomatic complications. Spontaneous fusion and even remodeling of severe spinal encroachment often occurs.[10]

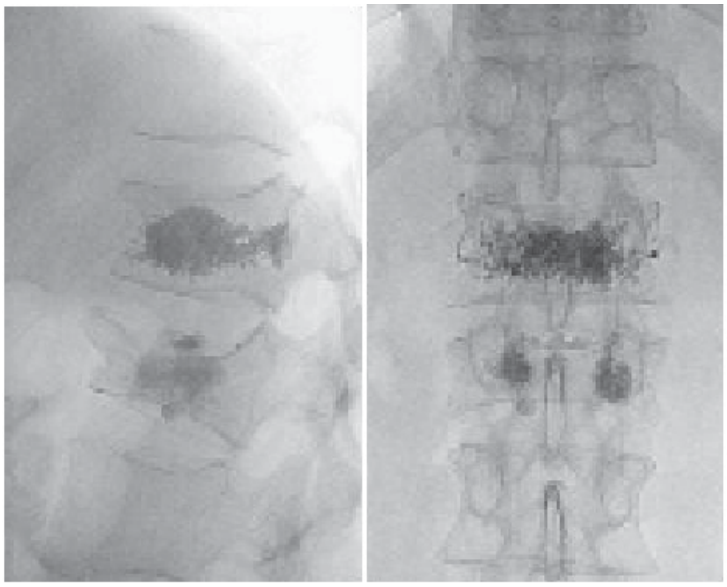

Figure 4b: Note that application of cement alone without the wall-condensing balloon kyphoplasty ("vertebroplasty") shows insufficient results since the vertebral body walls are fragile and may even give way into the disc space (and eventually the spinal canal) without warranting sufficient restoration of disc height. The upper level was treated with bilateral kyphoplasty, the lower with bilateral vertebroplasty.

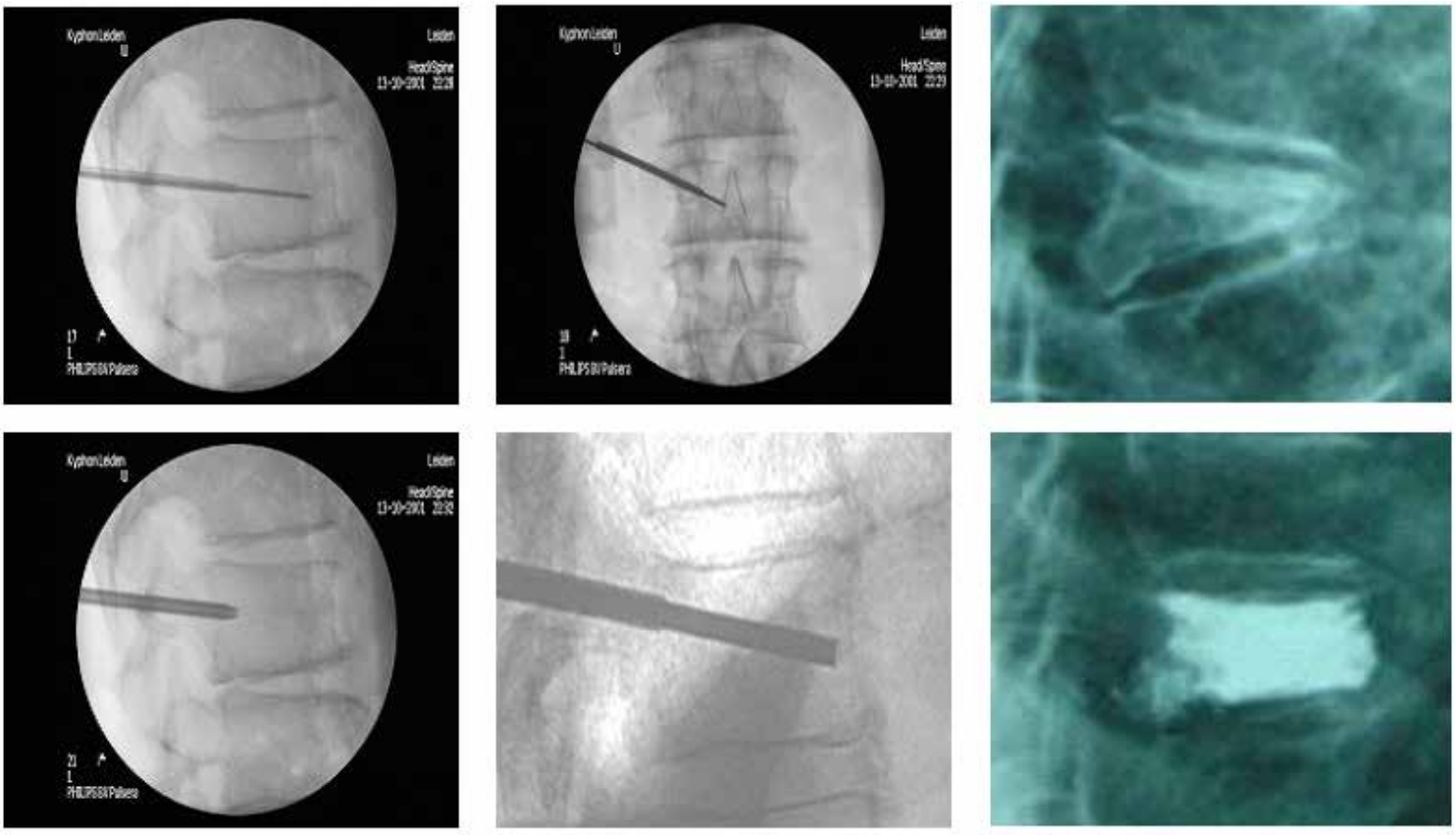

Figure 4a: During kyphoplasty, inflatable balloons are introduced via the pedicles, and the thus condensed cavity is filled by high viscosity, at low temperature polymerizing PMMA cement. Significant restoration of vertebral body height can be achieved if the technique is properly applied. The left images show insertion of the tools for one pedicle only, yet kyphoplasty should be performed on both sides.

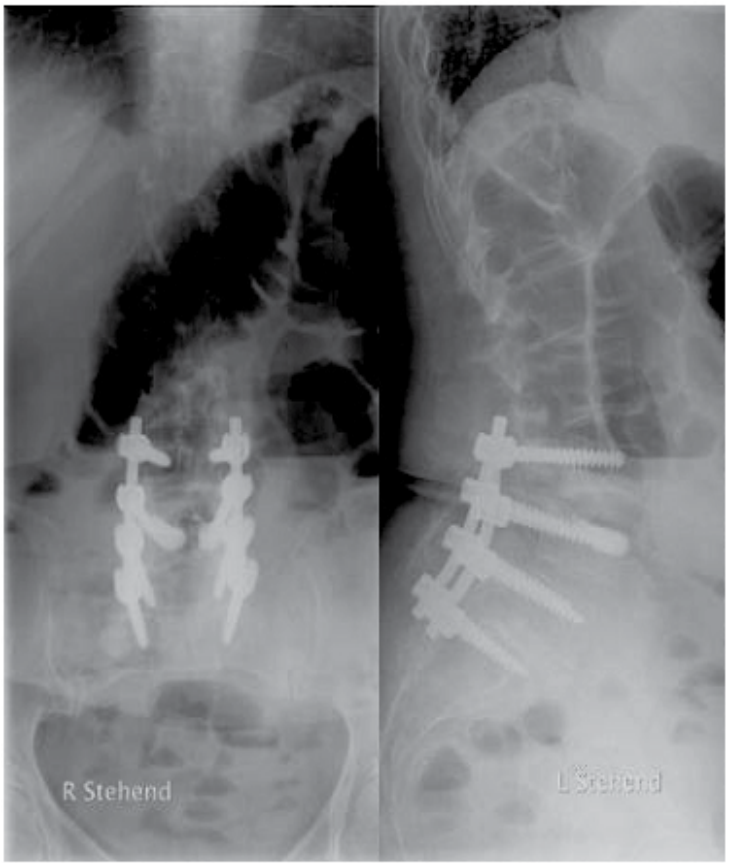

Figure 5: 3-level instrumentation from L3 to S1 with fenestrated polyaxial pedicle screws, being augmented in the fractured vertebral body L4 with PMMA cement, inserted through cannulated screws. It would have been possible also to reinforce the purchase of the adjacent screws that way. Equally, it would have been possible not to instrument the broken vertebra itself, as opposed to here with so-called index screws, but to add a further pair of screws in the L2 vertebra to increase construct stability. However, this would have sacrificed mobility in one additional segment.

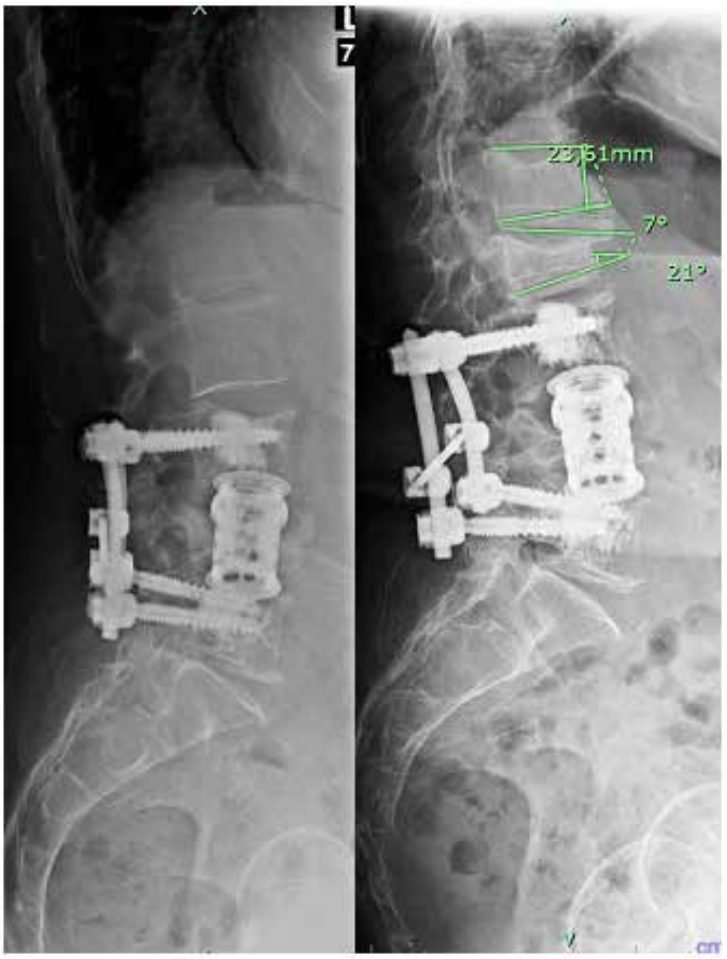

Figure 6: Here additional anterior vertebral body replacement was utilized via a retroperitoneal approach. However, a few years later adjacent OVBF occurred, creating a very complicated situation. Note that the rods were stabilized with a crosslink to increase rotational and bending stiffness of the construct. This is often necessary to prevent early implant dislocation and/or screw loosening.

Special caveats in case of cement use, particularly in kyphoplasty are the presence of a primarily underestimated posterior wall breach with possible leakage of cement into the spinal canal.[11] Overly high pressure during the maneuver is usually prevented by use of manometers on the tip of the inflating cement syringe. Nevertheless, the dynamics of the cement extrusion cannot be reversed. Thus, it is mandatory to have continuous fluoroscopic control since the extrusion progress can be quite fast.

Another caveat is the use of kyphoplasty in standalone technique without noting the presence of OF 1 type fracture in adjacent segments. We advocate always taking additional MRIs together with the CT scans. This is also important for screw-rod based implants, since the "stiffening" of the operated segments increases the load upon adjacent segments. This is detrimental when obscure fractures are already present at these levels. However, the in any case necessary adjuvant postoperative anti-osteoporotic medication takes months to show its effect and the risk of adjacent fractures is high during that period, especially if further accidents are not prevented. Figure 6 shows an example of such a problem.

Also, it seems advisable to calculate the axial and sagittal minimum diameter of the pedicles which need to be instrumented up front *via* CT scans to choose the right diameter of pedicle screws, which are mostly available from 4 mm upwards. One should always take enough time for that and other preparations of the planned procedure, since it is rare that neurological complications are present at first contact with the patient which would enforce an immediate intervention.

Special threads and hydroxyapatite coatings for screw use in osteoporotic patients are offered by certain manufacturers. Pros and cons of these features shall not be discussed here. More important is that the screws should fill the pedicles snugly for best purchase but must not exceed their volume. Note that not all cannulated screws have a lateral fenestration for cement augmentation. If cement is applied through hollow screws without lateral fenestration the cement will take mostly an anterior path out of the screw cavity. If the anterior vertebral body wall is not patent, cement may then protrude into the vicinity of the big vessels in front of the vertebrae and polymerize there, building needle-sharp formations.

Cement augmentation is not a magic bullet to prevent screw failure. Using cement may also bear some risk for vertebral body necrosis in the aftermath of instrumentation.[12]

From our personal experience, in OVBF it seems useful to do decompression of posterior structures prior to instrumentation, if necessary at all. Canal encroachment by posterior fragments in OVBF is less prone to be reduced *via* distraction ("ligamentotaxis")[13] than in traumatic fractures. The reason is that screw purchase in osteoporotic vertebrae is diminished and if distraction is applied the screws rather tend to toggle out instead of producing a straightening of the posterior vertebral body wall. We also rarely try to reduce posterior fragments by pushing them back into the vertebral body directly. Remodeling of the spinal canal by resorption of intraspinal extradural bony and soft tissue sequelae is surprisingly common and neurogenic claudication is rare. This, admittedly, also might be due to the (often already) limited walking distance of these patients.

Discussion

The OF score has given us valuable assistance in choosing appropriate treatment for OVBF. However, certain aspects should be discussed:

The threshold between 6 and more points relies mainly upon assessment of the posterior wall structures, i.e. additional (and repetitive, see below) CT scans seem necessary. It is sometimes difficult to tell whether the posterior vertebral body wall is affected more or less than 2/5 since the original publication is not very specific about that point.

The obligatory reassessment of OVBF after one week *via* standing radiographs is sometimes difficult to supervise since in the German health care system many conservatively treated patients are quickly transferred into geriatric facilities after primary emergency evaluation.

In the OF score, the definition of "mobilization under analgesics" as given in Figure 1 is ambiguous and a T-value will not always be at hand immediately for decision making. It should be borne in mind that the T-value in vertebral bodies with severe spondylosis, scoliosis, and even in condensed older fractures is not reliable and often yields "too good" values.

Indications for conservative treatments such as helplessness, BMI <20, and dementia may also be not only a contraindication for operative, but also for orthotic treatment.

The OF score so far has the (lowest) evidence status of an expert-opinion. Of course, for methodological reasons, validation of the score for improving mid- and long-term results seems very difficult. Its use should in future be compared with cohorts being treated without using the OF score. However, the use of the OF score in our department has proven, useful at least in avoiding short-term complications and to allow early mobilization of our patients. It has rendered decision making more justifiable to physicians and therapists, as well as for patients and relatives. On the basis of the OF assessment in patients with high comorbidity, surgical treatment should be considered to be undertaken in specialized centers, with availability of neuromonitoring, microscopic assistance for decompression, and sufficient ICU support. The score gives good arguments for reasonably requesting such a transfer in selected cases.

Any treatment of OVBF without addressing the underlying cause of osteoporosis is not only useless, but dangerous. This also includes assessment of the situation of the patient at the patient's residence. If there remain permanent tripping hazards, reappearance of the patient in the hospital will be just a matter of time. The optimal physiotherapy and the use of orthoses still remains controversial.

Conclusion

The paper recommends the use of the OF Score for application in cases of OVBF but also points out the fact that the score needs further evaluation and may have to be adapted in some ways to most sufficiently tailor to the needs of its very demanding clientele. A holistic approach, not only taking into account radiological

aspects, but the entire background of the pathology and the further fate of the patient is advocated. However, to the opinion of the authors, it is necessary to define centers for specific and efficient treatment of OVBFs since these special demands can only be met on the basis of skillful techniques, availability of modern technology, and sufficient means of postoperative or conservative treatment and secondary prophylaxis. To spread awareness for this is the main purpose of the aforementioned considerations.

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