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Kyphosis correction after vertebroplasty in osteoporotic vertebral compression fractures

SZYMON F. DRAGAN, WIKTOR URBAŃSKI*, BARTOSZ ŻYWIRSKI, ARTUR KRAWCZYK, MIROSŁAW KULEJ, SZYMON Ł. DRAGAN

Department of Orthopaedic and Traumatologic Surgery, Wrocław Medical University, Poland.

Percutaneous vertebroplasty is a minimally invasive method of treating vertebral compression fractures aimed mainly at reduction of pain. It has been observed that fractured vertebral bodies filled in with cement might also influence the increase of their height and thus lead to reduction of post-traumatic spine kyphosis. The aim of the research was to assess the possibility of reducing the kyphotic deformation of operated spine through kyphosis measurement of vertebras adjacent to fracture.

24 patients underwent percutaneous vertebroplasty on account of compression fracture of 40 vertebral bodies in thoracic and lumbar regions. On digital x-ray spine images taken in patients before and after surgery the angle of kyphosis or lordosis of bodies above and below the fractured vertebra was measured with the use of the Cobb method.

Vertebroplasty in the material examined caused reduction of kyphosis in 33 cases (80.48%) and correction by 5.78° on average. No regularity was found either between the occurrence of correction (and its level) and operated spine region or between the possibility of kyphosis correction and time that passed between fracture and surgery.

Key words: *vertebroplasty (PVP), vertebral compression fractures (VCF), kyphosis, osteoporosis*

1. Introduction

Among the procedures called vertebral body augmentation the most popular method of treatment is percutaneous vertebroplasty (PVP). It is a minimally invasive injection of bone cement to the pathologically changed vertebral body (figure 1). The aim of the treatment is in the first place to reduce pain as well as prevent development of deformation of the fractured or threatened by fracture vertebral body. In this method, the cement acts in the same way as external immobilisation (bracing) and in literature it is defined as "internal splint" [1], [2]. Leading to the immobilisation of body fragments in relation to each other it performs the stabilising role of an external corset much more efficiently and without the typical difficulties connected with it.

Vertebroplasty assumes injection of cement *in situ* without changing the configuration of the vertebra itself. On the contrary kyphoplasty is supposed to influence the repositioning and reduction of the fractured vertebra. Disputes between the supporters of vertebroplasty and kyphoplasty often take place in journals or during spine meetings and symposiums. Even though clinical results of both methods are similar certain differences in effectiveness depending on recommendation were found – kyphoplasty gives a bit better pain reducing results in compression fractures while vertebroplasty is more effective in treatment of cancerous metastases [3].

Despite widely accepted application of vertebroplasty in the treatment of selected spine pathologies its certain aspects still arouse controversy. Till today there is no agreement in matters regarding: clear indications and qualification of patient for the treatment,

* Corresponding author: Wiktor Urbański, Department and Clinic of Orthopaedic and Traumatologic Surgery, Wrocław Medical University, ul. Borowska 213, 50-556 Wrocław, Poland. Tel: +48-71-734-32-55, fax.: +48-71-734-32-09, e-mail: urbanski.wiktor@gmail.com

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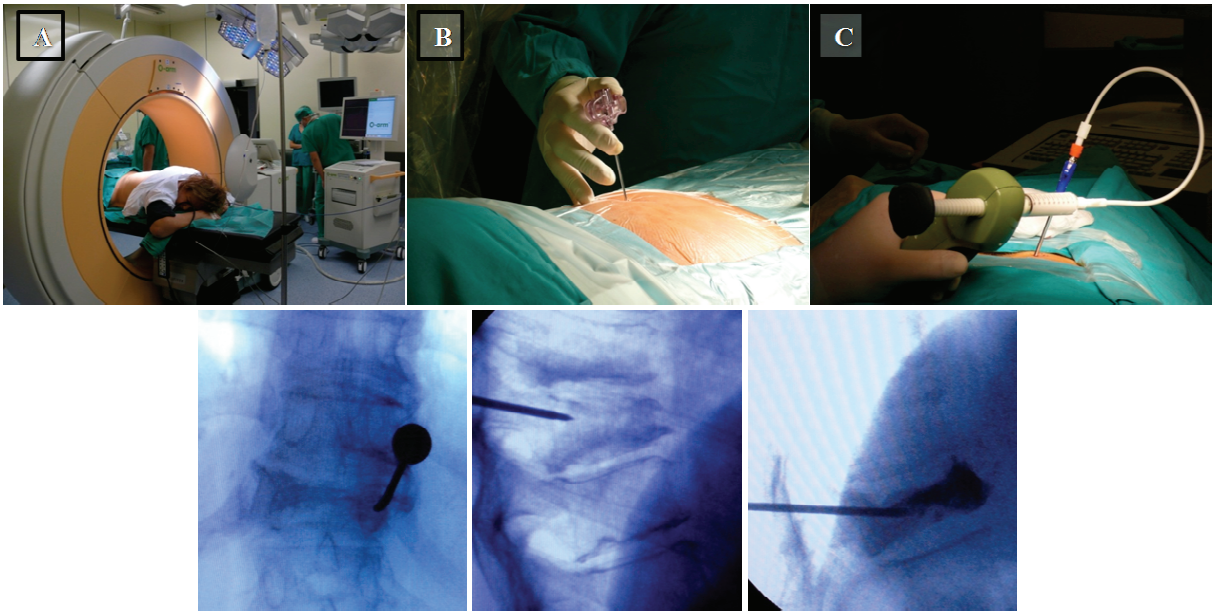

Fig. 1. Percutaneous vertebroplasty procedure: (A) patient placed prone, O-arm for intra operative imaging, (B) introduction of trocar into vertebral body, (C) injection of cement into vertebral body. Photos in the bottom row present intra operative X-ray images

patient and social benefits after PVP, superiority of PVP in relation to conservative fracture treatment, treatment and occurrence of complications (leakage of cement, subsequent fractures) and possibility of vertebral body height correction.

Compressively fractured vertebras cause post-traumatic kyphosis which substantially influence patients general health condition and is also a cosmetic problem. In the thoracic region it limits chest mobility which leads to decrease of lung expansion with all its consequences. The deformation disturbs the sagittal balance of the spine, leading to body center gravity shift forward, increases load of the front spine column, increases the frequency of subsequent vertebral fractures and disk overload leading to their faster degeneration.

Hence correction of post-traumatic kyphosis is crucial in the treatment of vertebral compression fractures. Vertebral body height correction after vertebroplasty does not concern mainly recent or not healed fractures. However it has been proven that 20% of all osteoporotic vertebral compression fractures (VCF) is a kind of subacute or chronic fracture and healing takes even up to 6 years – they are type II fractures. VCF type I accounting for 80% of fractures heals within 1–2 months [4], [5]. In patients with fracture type II the mobility of vertebral body fragments occurs even after many months from the injury and such patients might undergo reduction (vertebral body height) and deformity correction (kyphosis reduction) after vertebroplasty. The possibility of correction may also be enhanced by avascular necrosis called Kümmell's disease [6], until recently considered a rare phenomenon [7] however occurring much more often than it was previously assumed. It results from different terminology of the same pathology functioning in literature: posttraumatic vertebral osteonecrosis, avascular necrosis – AVN, pseudoarthrosis, intervertebral vacuum, gas cleft, delayed vertebral collapse, VCF non union [8].

The aim of the study was to assess the possibility of correcting kyphotic deformation of the operated spine fragment through measurement of kyphosis of two adjacent vertebrae.

2. Materials and methods

24 patients were examined (2 men and 22 women) aged from 55 to 86 years (average 73) who underwent percutaneous vertebroplasty due to compression fractures of 40 vertebral bodies in thoracic (21) and lumbar regions (19) (figure 2). All fractures according to AO classification were classified as group A1. Except for three cases of recent fractures treated with vertebroplasty, all patients were previously treated conservatively (immobilisation in a corset, painkillers, physiotherapy). Despite the treatment all patients qualified to PVP demonstrated palpable pain in the area of the fracture and other causes of pain were excluded.

Patients underwent surgery from 3 days to more than 24 months after fracture, however, in majority of cases the moment of fracture was not clear, not recorded by the patient or in medical documentation. All fractures occurred in the course of osteoporosis as a result of low-energy trauma or without a noticeable trauma. In one case the patient suffered from myeloma, received high doses of steroids for a long time and since MRI did not confirm neoplastic character of fractures it was classified as osteoporotic compression fracture.

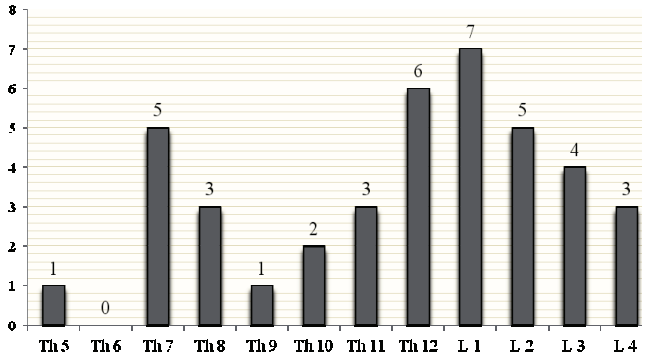

Fig. 2. Number of treated fractures on each level

Vertebroplasty was performed in local anaesthesia (lignocaine 1%, 7–8 ml/level) percutaneously, trocars were introduced through transpedicular approach, uni- or bilaterally under X-ray guidance. For the surgery, patients were placed in hyperextension of treated spine region.

Measurements were taken on digital X-rays of spine taken in patients lying down supine, the day before and right after the surgery. With the use of the Cobb method [9] and K-PACS software (version V 1.6.0) on lateral X rays kyphosis or lordosis angle was determined. The measurements were performed on the upper vertebra end plate above the fracture and lower end plate of vertebra below the fracture (figure 5).

3. Results

When analysing the angles in sagittal profile of treated spine region before and after vertebroplasty in the entire material examined, reduction of kyphosis was found (increase of lordosis respectively) on average by 4.575°. Solely in 8 cases no correction, that is no reduction of kyphotic deformation, was observed. In other 33 (80.48%) cases correction occurred, on average by 5.78°.

The correction levels analysed were divided into three groups: no or minimum correction, reduction of kyphosis from 3–5° and above 5° (figure 3). This division was introduced due to the margin of measurement error in the Cobb method which is set at +/–3° [9].

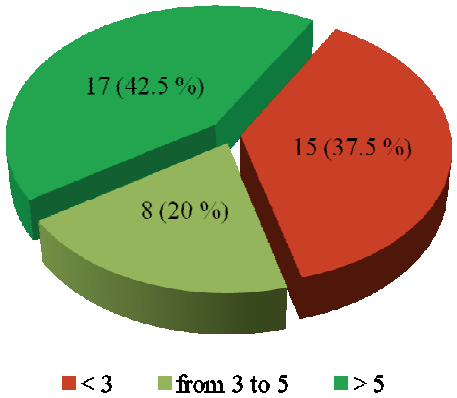

Fig. 3. Percentage and numbers of treated vertebral levels in groups of correction

No regularity of kyphosis correction (and its level) depending on treated spine region was found (figure 4).

The majority of patients had inveterate fractures. 13 fractures took place 12 months or more before the treatment; in 21 cases, the lack of previous X-ray documentation, no clear beginning of complaints and

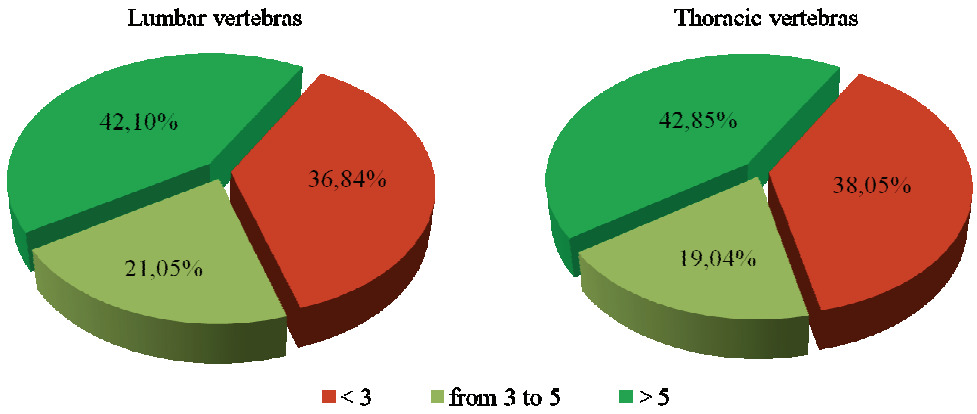

Fig. 4. Percentage and numbers of treated vertebral levels in groups of correction depending on treated spine region

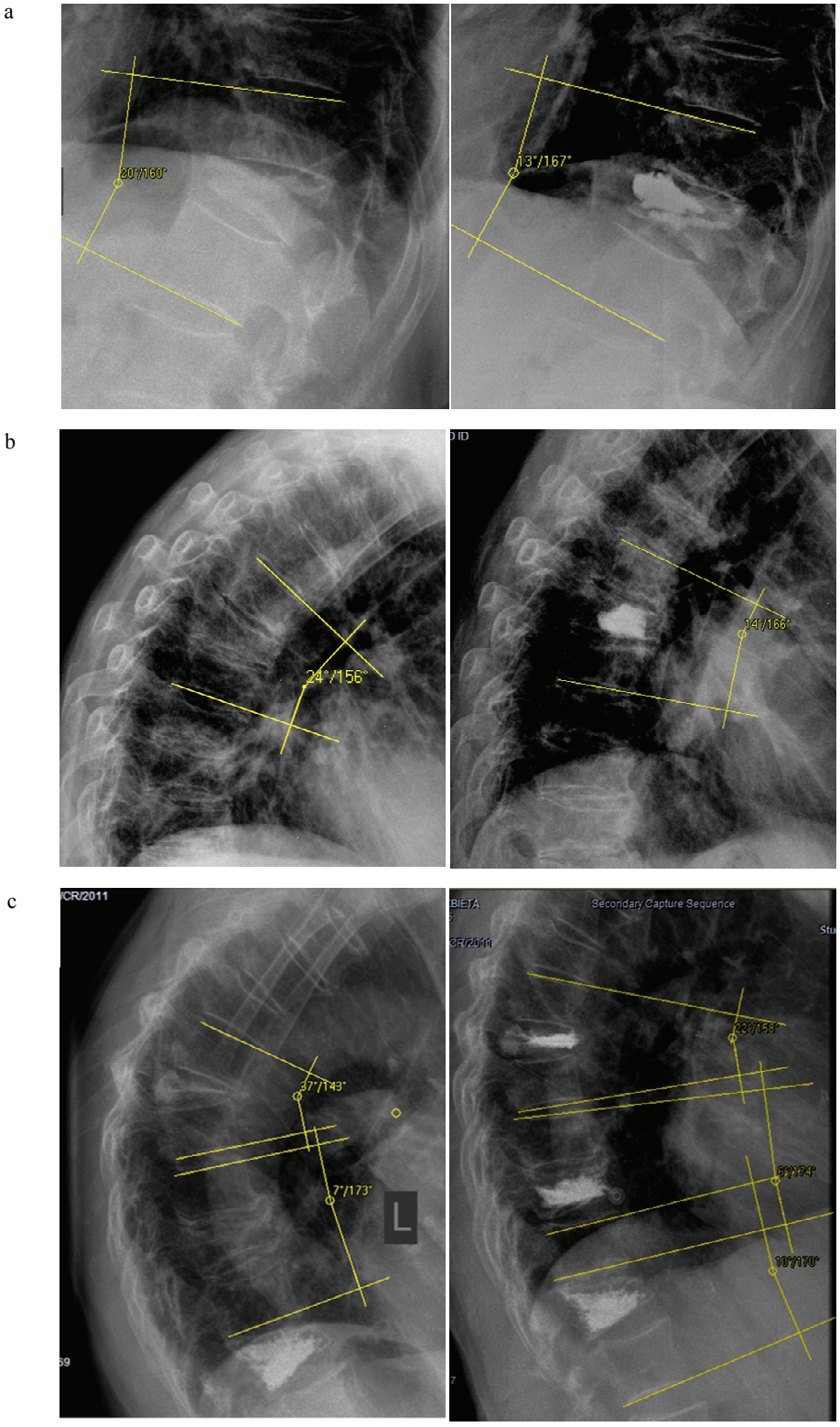

Fig. 5. Clinical examples of kyphosis reduction after vertebroplasty:
(a) vertebral compression fracture, primary osteoporosis, no data when the fracture happened,
(b) patient after steroid therapy, fracture noticed more than 24 months before PVP,
(c) osteoporotic fractures 1.5 year before PVP

trauma did not let us estimate the moment of the fracture occurrence. Solely 3 patients were operated within one month and further 3 within six months after the fracture. However, no connection was observed in kyphosis correction and the time from fracture to surgery.

4. Discussion

The main indication to perform percutaneous vertebroplasty (PVP) is pain in the area of fractured vertebra and the purpose of the treatment is to decrease or eliminate it. Vertebroplasty does not assume the possibility of increasing height of compression-fractured vertebrae nor corrections of deformation created this way [1], [2], [10], [11].

In the present research the authors examined the change of kyphosis in segments adjacent to treated vertebra after PVP and observed its significant reduction in more than 80% of patients with average kyphosis decrease by almost 6°. The possibility to recreate the height of the compression fractured vertebra with the use of PVP was described also in literature. HIWATASHI et al. [12] performing vertebroplasty in a typical way noticed in 72 vertebras (out of 85 being treated) an average increase of vertebral body height by 2.2 mm. Whereas Hiwatashi et al. did not place the patients in hyperextension, other authors took X-rays when patients were lying prone with (and without) spine in hyperextension and proved that the angle of vertebral body "wedging" decreases in hyperextension. These authors performed vertebroplasty in hyperextension in order to reduce the wedging of the operated vertebral body [13]. In their research they observed, satisfactory height increase, however the kyphosis angle decreased insignificantly. This can result from the fact that the curve of the spine in sagittal plane is the resultant of the parameters of adjacent vertebrae as well as the condition of the discs and intervertebral body space. Other authors noticed that vertebroplasty caused an increase of wedging angle by 3.5° on average, reduction of kyphosis by 5° and only in 15% of patients no vertebral body height increase was observed [14].

Based on their own observations but also on literature the authors of the present study give two main reasons for the kyphosis correction phenomenon after PVP: firstly, position of the patient (mobility of VCFs [15]), secondly, cement administered under pressure recreates the height of vertebra, fills it in and even increases existing spaces in fractured vertebra [13].

Many authors emphasise the significant impact of the time from fracture to PVP on the effect of body height increase [12]–[15]. In the literature, there are opinions that PVP in the treatment of old fractures is connected with low effectiveness of surgery, indicating limits of the method application to 1–2 years after VCF. This refers both to the question of pain reducing effect and possibility of body height increase after treatment. Results of the above research suggest that it is impossible to set a clear timing of PVP application after the fracture. In the majority of cases of the present study, patients suffered from fractures long time ago (table 1) and still correction did not differ significantly from the ones with more recent fractures.

Table 1. Average kyphosis correction angles in groups depending on the time from fracture to PVP

Time between fracture and PVP	up to 3 months	up to 6 months	more than 12 months	chronic
Mean decrease of kyphosis [°]	4.667	3.667	6.308	3.619

Specificity of vertebral compression fracture and healing of osteoporotic bone suggests that in selected cases mobility of fragments occurs even after a long period of time after injury. These vertebral bodies might be reduced and deformity corrected (body height, kyphosis reduction) during vertebroplasty. The mobility of vertebral body fragments may be demonstrated comparing lateral X-ray of the spine in a patient laying prone in hyperextension and standing [15]. In case of the lack of clear mobility MRI examination may be helpful. The image of fractured vertebra in MRI changes depending on time. Recent fractures, as well as those in healing stage are characterised by marrow oedema and in T1 and STIR imaging by hyperintensive area. When classifying old fractures or when it is difficult to precisely establish the moment of fracture, with the use of MRI we can establish recommendations for the treatment – it has been proven that discovery of bone marrow oedema is in direct correlation with clear pain reducing effect of vertebroplasty [16].

In some fractured vertebral bodies, spaces or clefts filled with fluid, gas and sclerosis may be revealed. The discovery of such an image is related to bone avascular necrosis, called Kümmel's disease [6], [7]. It is now considered that the pathological image corresponds to late, post-traumatic ischemic necrosis, often occurring together with its collapse [17] and takes place much more often than assumed. According to MCKIERNAN and FACISZEWSKI [18] this phenomenon occurs most frequently in vertebras of thoraco lumbar junction (Th11-L2), the area of high overloads and most frequent osteoporotic compression fractures. They estimate that it may refer even to 1/3 of the patients after VCF of this spine area. Pathology is not always visible on X-rays, however MRI is very helpful for diagnosis and assessment of treatment results [19], [20]. It has been noticed that in patients with intervertebral clefts, leakage of cement occurred more

often (usually asymptomatic) but clearly better correction of vertebral height and thus kyphosis reduction was observed [21]. Unfortunately, the authors of this study did not analyse the impact of Kümmell's disease on the treatment results, however, it can be suspected that precisely this phenomenon is responsible for good effects in group with inveterate or chronic fractures (table 1).

The results obtained in the present paper are comparable to ability of kyphosis correction obtained with the use of kyphoplasty. The essence of this method lies in correction of deformation, increase of vertebral body height with the use of a balloon and cement injection under low pressure. Despite the assumptions, correction of deformation, recreation of vertebral body height as well as the clinical effect of kyphoplasty may differ. According to GARFIN [22] kyphoplasty reduces kyphosis on average by 6–18° (in recent fractures on average by approx. 14°). In research on cadavers vertebral height increase was found in 47% of cases but kyphosis correction solely in 10% [23]. Other authors give similar data; vertebral height increase in 10–20% of cases and deformation correction, if it occurs, ranges from 6° to 9° [24]–[26]. The results presented by authors of this work suggest advantage of vertebroplasty over kyphoplasty. PVP procedure is less complicated, surgery kit cheaper and in the context of available literature PVP offers the same ability of post-traumatic kyphosis correction and pain reducing effects as kyphoplasty.

However, what biomechanical and clinical significance does a small, usually several degree correction have? As Keller suggested on the example of the spine deformation model, kyphosis increase above 10° of the middle part of thoracic region (T7-T8) causes a forward shift of cervicothoracic part of spine by 15.1 cm [27]. This increases compression pressure by 19% and increases tension of erector spinae and posterior ligament system by 40%. This suggests that pain reducing effect of vertebroplasty beside direct effect of cement on the vertebral body (stabilising effect) consists also of the reversion of unfavourable biomechanical conditions. Kyphosis reduction leads to additional reduction of complaints and suppressing further development of deformation. There is no literature, however, regarding the correlation between kyphosis reduction after PVP and chest mobility even though the authors expect positive effect in this matter.

In conclusion, percutaneous vertebroplasty is a minimally invasive procedure which in addition to advantages widely described in literature is able to reduce kyphotic deformation and their consequences after vertebral compression fracture. No correlation of treated spine level and correction ability was found. Kyphosis decrease was obtained when performing PVP long time after the fracture, so despite certain opinions found in literature the authors think that the ability to reduce post-traumatic kyphotic deformation with the use of vertebroplasty is not strictly connected with the time from the fracture to procedure.

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