Postero-lateral approach with open view vertebroplasty - "eggshell" technique

E.Fl. Exergian[1], I.Fl. Luca-Husti[2], D. Şerban[1]

[1]Spine Surgery Department, Emergency Clinical Hospital "Bagdasar-Arseni", Bucharest
[2]Neurosurgery Department, Sanador Hospital, Bucharest

Abstract

Since august 2008 we used in Spine Surgery Department, Emergency Clinical Hospital "Bagdasar-Arseni", Bucharest, a new technique for the surgical treatment of thoraco-lumbar burst fractures. This technique is based on a postero-lateral approach of the thoraco-lumbar spine, reconstruction of anterior column using cement (PMMA) and stabilization of posterior column using metallic instrumentation uni- or bilateral.

The paper presents the technical and biomechanical data of this spinal procedure.

Key words: "egg shell" technique, postero-lateral approach.

Introduction

The major indication of vertebroplasty was the treatment of vertebral hemangiomas, as described in 1987 by Galibert. The indications were later enlarged to vertebral tumoral lesions and to vertebral fractures (especially for the osteoporotic fractures). Intraoperative vertebroplasty means insertion of cement, polymethylmethacrylate (PMMA), into the vertebral bodies in order to increase their strength. The purpose is to prevent vertebral collapse, angulation and pain by regaining the stability of the vertebral column and allowing early patient's mobilization.

Usually the acrylic cement is injected percutaneous, in an image-guided fashion, as a minimally invasive procedure, but it can also be used for vertebral lesions, during open surgical procedures.

The benefits of vertebroplasty in cases of osteoporotic fractures made us use the introduction of cement inside the fractured vertebral bodies to strenghten them and to fight against the long term risks of late spinal deformities. The existence of some studies about efficiency of ballon-kyphoplasty together with posterior instrumentation gives us more reasons to apply this technique in our practice.

The introduction of acrylic cement is made „open-view" in an open surgical procedure, transpedicullary inside the vertebral body, after the decompression and the reduction of the misalignment were achieved.

Epidemiology

The traumatic lesions of the vertebral column represent about 2/3 of all causes of spinal compressions, including here, beside the trauma, the degenerative diseases, tumors and infections.

Moreover, from all cases of traumatic injuries of the vertebral column, about half occur at the thoracic and lumbar levels.

From these, more than 60% affect the thoracic-lumbar junction (T11-L2). This epidemiological data shows the importance of this junction area and the need to assure an efficient therapeutical attitude for the traumatic lesions that occur at this level.

The burst fractures occur more frequently in the lumbar region because of the natural lordotic posture of the column in this area that makes the excessive axial load forces to cause fracture of vertebral body in multiple fragments. The centrifugal force exerted on these fragments produces a burst fracture. The migrated bone fragments can affect the spinal canal with a decrease in its diameters. The main characteristic of the burst fractures is disruption of the posterior wall of the vertebral body. Frequently, the burst fracture also implies the disruption of the neural arch of the vertebral bodies.

From the neurological point of view, the burst fractures have great neurogenic potential, more than 35% of them being associated with neurological deficits of different degrees.

Biomechanics

The most frequent traumatic mechanism for burst fractures is pure axial loading. Some of the cases may associate axial loading flexion and hyperflexion forces. Generally, in these cases the column is more angulated, it is affected predominently the anterior part of the vertebral bodies and can be also classified as compression fractures.

By biomechanical point of view, the axial load forces are absorbed mostly by the vertebral bodies, especially by the cancellous bone which has trabecullar architecture (about 55% of the force is absorbed at this level in individuals under 40 years old, but the percentage decreases after this age) and by the intervertebral discs. The posterior elements of the vertebral bodies (neural arch and articular facets) are less implied, their implication being dependent on the position assumed at the moment of trauma (between 0% when the column is in hyperflexion and 33% in hyperextension).

According to the AO classification based on the biomechanical concept with 2 vertebral columns developed by Holdsworth, the burst fractures are type A3 fractures. The fracture damages the anterior column and it is unstable in axial loading and hyperflexion.

This leads to the conclusion that the strength of the vertebral bodies is essential for the patient's prognosis on a long term. The therapeutical attitude must be focused on regaining the stability of the vertebral body.

Possible ways of treatment

The natural evolution of these lesions without any treatment, according to biomechanics principles, is to increase the angulation. The treatment modalities for these traumatic lesions vary from exclusively non surgical attitude to complex surgical operations with extensive, combined, both anterior and posterior approaches.

1. Conservative treatment

This treatment can be applied only when it is not necessary to decompress the neural structures. The exclusive conservative treatment implies an absolute bed rest immobilization for a minimum of 6 to 8 weeks and provides a minimal (or not) correction of the angulations by postural reduction. The non surgical managment doesn't reduce the risk of late angulation. These risks can be partially reduced by applying a corset early before the moment

of the patient's mobilization.

The disadvantages are the long period of immobilization with the need for prevention of pressure sores and the need for a person or a team dedicated for satisfying the personal needs of the patient which cannot leave the bed.

2. Percutaneous vertebroplasty

Is a way of treatment that can also be applied when decompressing the neural structures is not necessary. It provides a better reduction of the risk of late angulation by increasing the strength of the vertebral bodies. The use of this procedure allows early patient mobilization, useful especially for elderly patients.

This type of treatment has the advantage of taking less time and having minimal surgical risks, but it does not correct kyphosis. The correction of kyphosis can be done by kyphoplasty.

This procedure can also be done when the risks of an open surgical procedure overlap the benefits, in case of patients with a severe illness as well as when the neural structures decompression is not compulsory.

3. Open surgical procedures

Indications for using the open surgical procedures are the need for decompression of the neural structures, the correction of angulation and the regain of stability in the vertebral column. There are controversies about the optimal therapeutically means for the burst fractures with minimal or no neurological signs, and yet there is radiological evidence of significant misalignment or decrease of the spinal canal diameters.

A recent analysis of the treatment choices for burst fractures without neurological signs shows that the natural evolution is to increase the angulation in time, both at patients treated surgically and non-surgically, yet the evolution is less significant at the surgically treated patients. This conducts to the conclusion that a posterior type of instruments is a better way of treatment for these lesions in comparison to conservative treatment.

In terms of surgical management the posterior approach for decompression alongside posterior fusion doesn't completely eliminate the risk of late angulation. On the other hand the early patient's mobilization is compromised when taking this risk.

The biomechanical principles show that for better results it is necessary to include in the therapeutically attitude a modality to increase the strength of the anterior column made by vertebral bodies.

The reconstruction of the vertebral body is compulsory when the patient is allowed to be mobilized early after the procedure (the day after surgery). This is generally done with cages or plates by an anterior approach and it is followed by a posterior approach for stabilization. This type of surgical procedures, with combined anterior and posterior approaches is too extensive in our opinion and too traumatic for the patients, because in most cases, they are victims of politraumas. This combination added obvious severe surgical and general risks to the patients, according to the length of the procedures, without a significant benefit in terms of vertebral stability.

The efficiency of vertebroplasty for patients with osteoporotic fractures gives us reasons to believe that the use of acrylic cement increases the strength of the vertebral bodies and benefits burst fractures as well.

The technique that we propose combines the benefits of posterior instrumentation as well as the advantages of using bone cement for vertebral body reconstruction. This technique we suggest represents an original method developed in our department in the last three years. Our goal is to merge the benefits of posterior instrumentation with the use of acrylic cement in order to increase the vertebral body strength, both achieved in a single approach by a postero-lateral way.

Materials and methods

From August 2008 till June 2011, 77 cases were treated using the "eggshell technique in our department.

The proposed "eggshell" technique

For the treatment of burst fractures we use the postero-lateral approach with artro-pediculo-transversectomy in lumbar region or costo-transversectomy for lesions that occurred in the thoracic region. This approach has the advantage of providing a good exposure of anterior epidural space for the decompression of the neural structures and impaction or removal of bone fragments that occupies this space. It also gives the possibility to suture a posterior dural tear. The approach we use makes possible the "open view" reduction of the misalignment and the reconstruction of the vertebral bodies.

The exposure of the dura is followed by reducing the intra-operative misalignment using hyperextension. This procedure makes the decompression of the neural structures easier by impaction associated or not with the removal of compressive bone fragments. The next step is the impaction of the cancellous bone inside the vertebral body in order to achieve a cavity and to have a more condensed bone structure at the anterior part of the vertebral body.

The reconstruction of the vertebral body is now made by filling the cavity we have reached with cement. We called this technique open view "eggshell" vertebroplasty because the vertebral bodies border are similar to an egg-shell that is directly filled, without the need of needle bone cement injection or radiological survey.

The last part of procedure consists in making posterior transpedicullar instrumentation with screws and rods, most frequently short and unilateral if the ligaments and the posterior elements on the other side are unaffected.

This means that we reached both intended aims, vertebral stabilization by transpedicullar screws and rods and reconstruction of the vertebral body, in a single approach. This technique is considerably less extensive and takes significantly less surgical time and has less surgical risks than combined anterior and posterior approaches.

Another advantage of this technique is the fact that it makes possible the early mobilization of the patient even in the first postoperative day and that it has a good absorption of axial loading by the cement, while also maintaining a satisfying height of the vertebral body.

There were 31 females (40 %) and 46 male (60 %) patients.

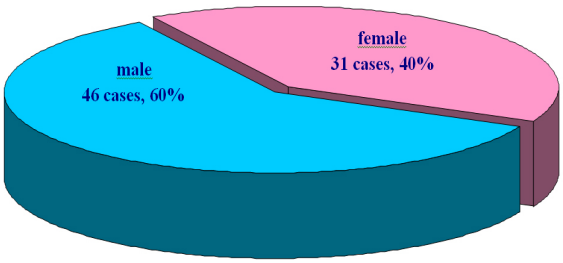

Figure 1
Distribution of cases by sex

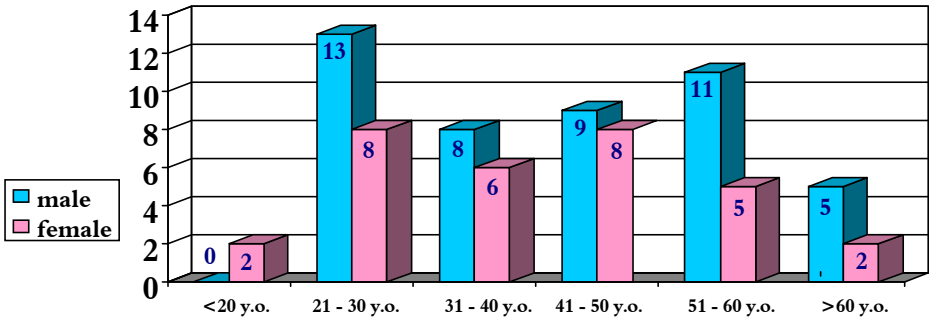

Figure 2
Distribution of cases by age

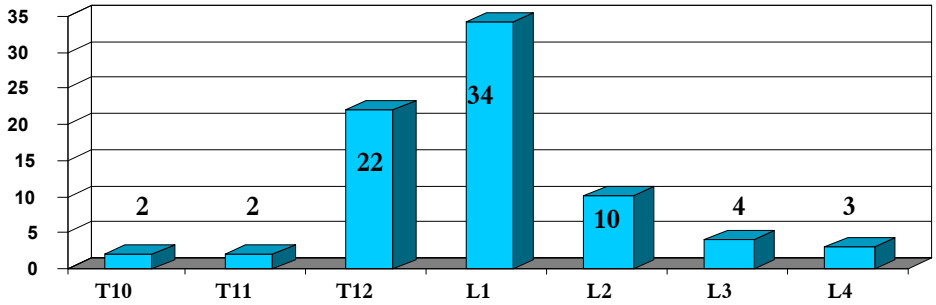

Figure 3
Distribution of cases by affected level

The distribution of cases respects the general traumatic case distribution. Almost all patients were between 20 and 60 years old and most of the cases involved the thoraco-lumbar junction as illustrated in the figures 2 and 3.

In 2008 only 2 procedures took place, but in the next 2 years 61 procedures were performed: 25 in 2009 and 36 in 2010. In 2011 until the end of June, 14 cases were managed.

Unilateral metallic instrumentation was used for the majority of the cases (86 % - 66 cases), the bilateral ones were necessary for the rest of the cases (14% – 11 cases). The use of bilateral instrumentation was necessary due to the fact that the posterior ligaments and the other side articular facets were affected and the absence of stability in the bilateral instrumentation could have been compromised.

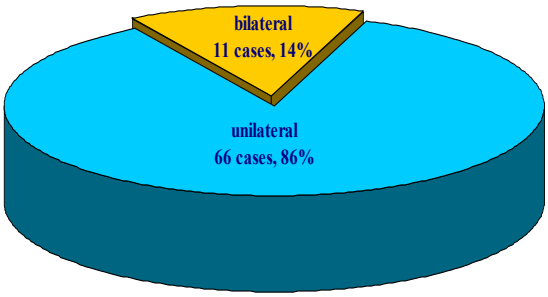

Figure 4
Metallic instrumentation (uni- or bilateral)

The assessment of postoperative results was made frequently by a plain X-ray imaging in the first postoperative day and at least another plain X-ray exam at 2 months postoperative.

Figure 5
Case 1 (C.O.) plain X-rays

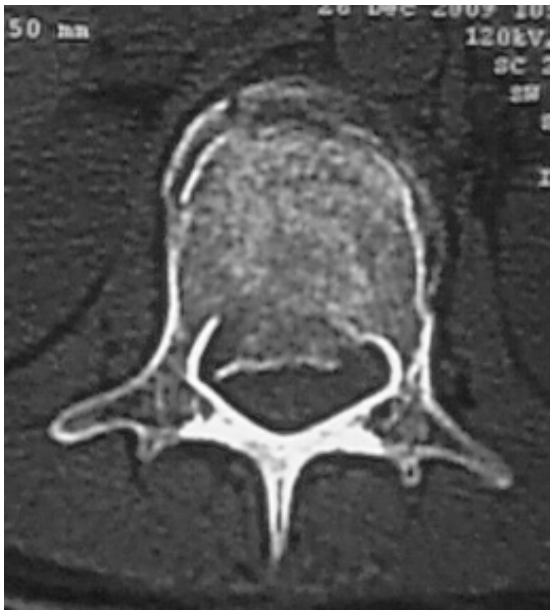

Figure 6
Axial CT image of L1 body

Results and illustrative cases

There were 77 patients treated using the "eggshell" approach. Only 6 of them (7.6 %) came back for failure of metallic instrumentations and necessitated instrumentation removal. There was no postoperative neurological worsening.

We present below some illustrative cases.

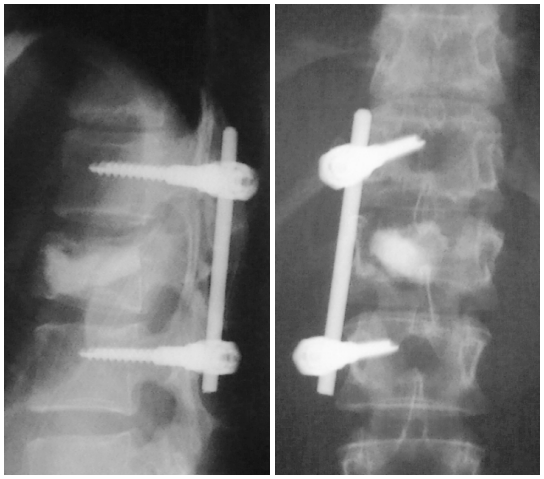

Figure 7
Case 1 (C.O.) plane X-rays imaging studies in the first postoperative day

Case 1. C.O., female 25 years old

She was a victim of a traffic accident, with a burst fracture of the L1 vertebral body. The CT exam showed a decrease of the A-P diameter of the spinal canal 45 %. The patient's neurological status at admittance was classified as Frankel D.

The approach was made on the right side, with unilateral metallic T12-L2 instrumentation. The postoperative course was amelioration of the neurological status. The next day postoperative imaging studies are illustrated in Figure 7.

The imaging studies after 1 year and 2 month postoperative (figures 8 and 9) show that the vertebral column remained stable. And the patient did not have any neurological complaints.

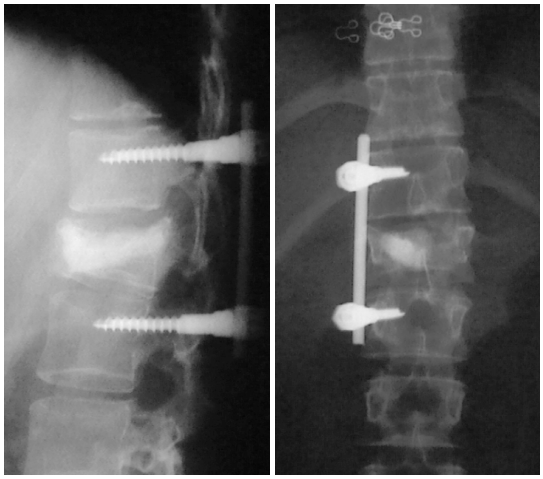

Figure 8
Case 1 (C.O.) – plain X-rays, 2 months postoperative

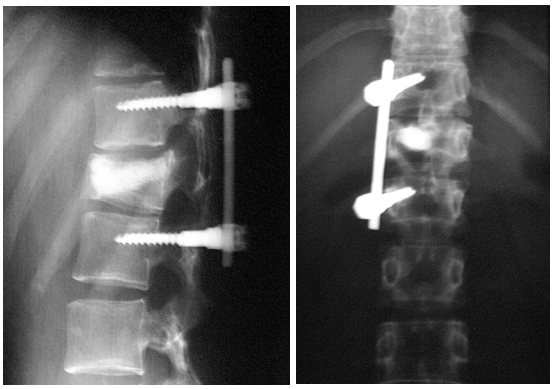

Figure 9
Case 1 (C.O.) – plain X-rays, 1 year postoperative

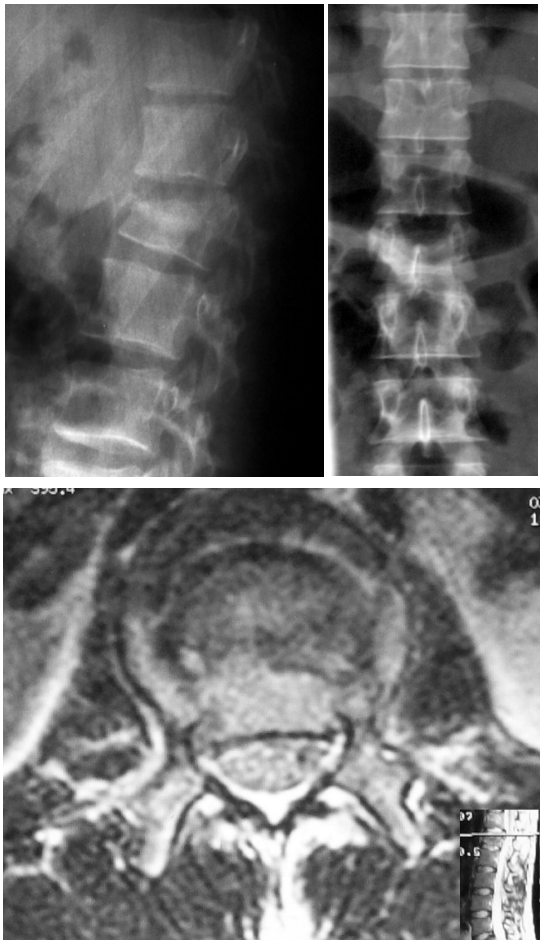

Figure 10
Case 2 (M.M.) – plain X-rays and MRI exams at admittance

Case 2. M.M., male, 29 years old

He was a victim of a fall (paragliding accident). The plain X-ray and MRI exam (figure 10) showed a L1 burst fracture with a decrease of about 40% of the

antero-posterior spinal canal diameter. The neurological status of the patient was classified as Frankel E, without any objective neurological sign. The patient's complaints were local pain, increased by movements.

The approach was at the right side with unilateral T12-L2 metallic instrumentation. The immediate postoperative X-ray exam (figure 11) showed a slight hyperextension, without any neurological discomfort for the patient.

The patient did not come back for the 2 month follow-up visit, but came back 1 year after the procedure. The plain X–ray made at that time (figure 12) showed a good alignment of the vertebral column.

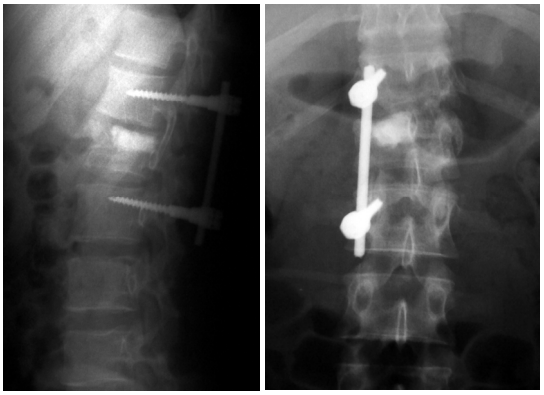

Figure 11
Case 2 (M.M.) – plain X-rays in the first post-operative day

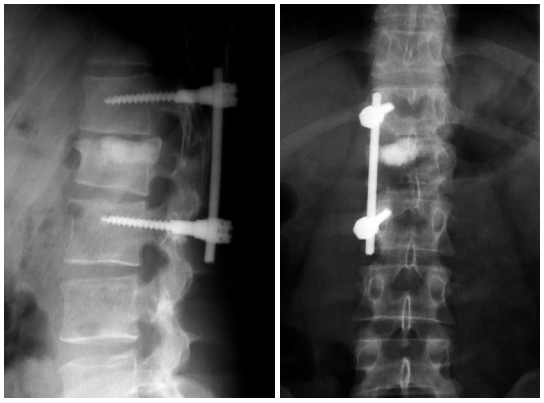

Figure 12
Case 2 (M.M.) – plain X-rays 1 year post-operative

Case 3. N.G, male, 55 years old

The patient was victim of an accidental fall (about 2-2.5 m). The radiological exams made at admittance showed an L1 burst fracture (figure 13) with significant decrease of the spinal canal diameters, but with minimal neurological deficits.

The approach was at the left side, again with unilateral metallic instrumentation, with good both imagistic and neurological results immediately postoperative (figure 14). Postoperatively a CT exam was also made which showed how the cement was inserted inside the vertebral body (figure 15).

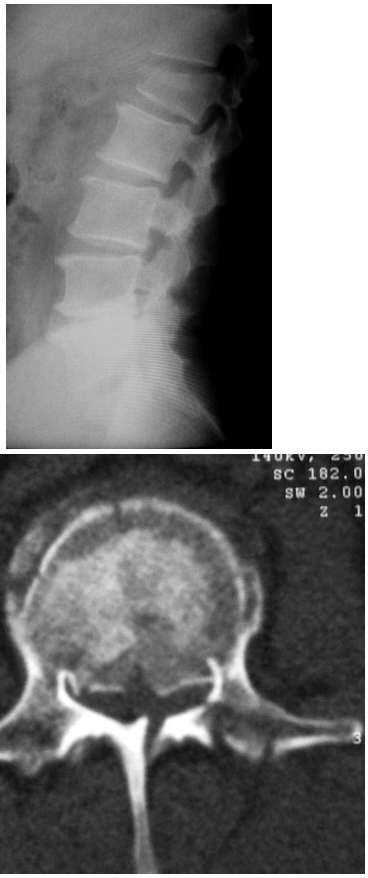

Figure 13
Case 3 (N.G) – plain X-ray and CT imaging studies at admittance

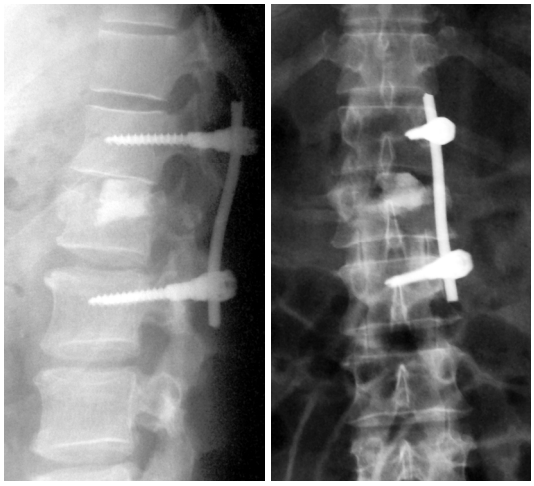

Figure 14
Case 3 (N.G) – plain X-rays first postoperative day

At the 2 month follow-up visit the patient came back with a little more pain than preoperative, but without any new objective neurological sign. The plain X-ray exam (figure 16) showed an increased angulation of the fracture site.

The column was so angled because the cement was introduced too posterior and didn't cross to the anterior half of the vertebral body. We decided to perform a percutaneous vertebroplasty that aimed the anterior half of the body from the right side, in order to obtain more strength for the vertebral body and to increase its stability. Figure 17 shows the aspect obtained, 2 weeks after vertebroplasty. Unfortunately the patient didn't come back for any other follow-up visit, so we assume that he is doing well and the vertebral column didn't angle further.

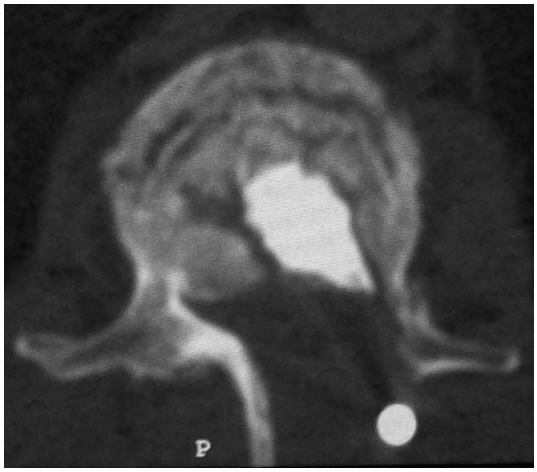

Figure 15
Case 3 (N.G) – CT exam immediately post-operative

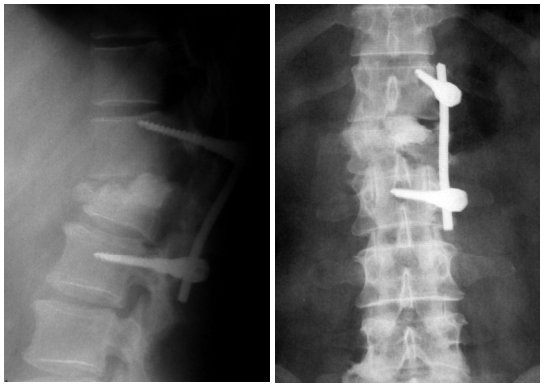

Figure 16
Case 3 (N.G.) – plain X-rays 2 months post-operation

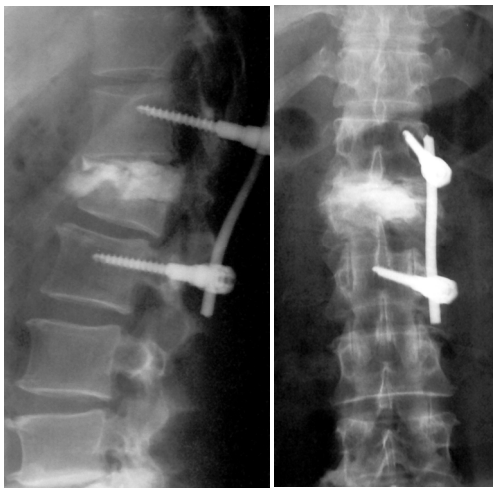

Figure 17
Case 3 (N.G.) – plain X-rays 2 weeks after percutaneous vertebroplasty

Case 4. I.G., male, 30 years old

This patient was victim of a fall (about 1.5 m). The radiographic studies showed a T12 burst fracture (figure 18), with a decrease of about 50% of the antero-posterior diameter of the spinal canal and hyper intense intramedullar signal in the T2-weighted images at the level of the fracture site (figure 19). The neurological status of the patient was classified as Frankel C at admittance.

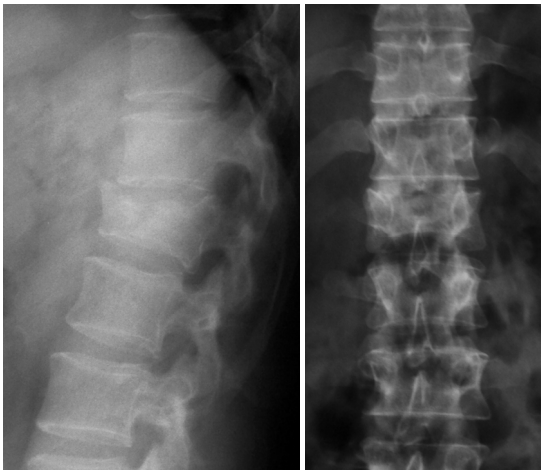

Figure 18
Case 4 – (I.G.) – plain X-rays at admittance

Figure 19
Case 4 (I.G.) – CT and MRI images at admittance

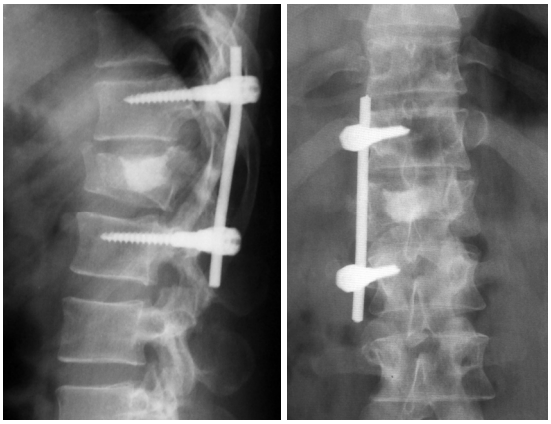

Figure 20
Case 4 (I.G) – plain X-rays, first operative day

The approach was from the right side with unilateral metallic instrumentation. The postoperative neurological status of the patient was ameliorated, with decreased neurological deficits, but still unable to walk. The postoperative plain X-ray images showed an incomplete filling of the vertebral body with cement (only the posterior half) (figure 20).

In order not to have a similar result as in case 3 we decided, 1 week after open surgery, to perform a percutaneous vertebroplasty from the T12 left side.

The image from the day after vertebroplasty (figure 21) and the follow-up visits after 2 weeks (figure 22), 2 months (figure 23) and 6 months (figure 24) after vertebroplasty showed a good stability of the vertebral column.

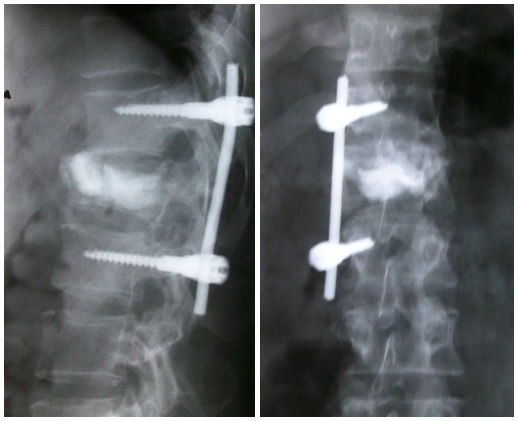

Figure 21
Case 4 (I.G.) – plain X-rays first day after vertebroplasty

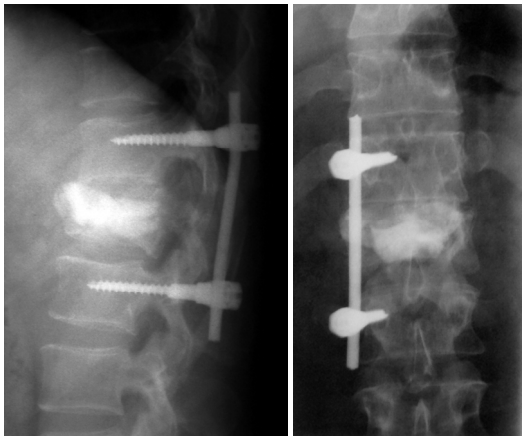

Figure 22
Case 4 (I.G.) – plain X-rays 2 weeks after vertebroplasty

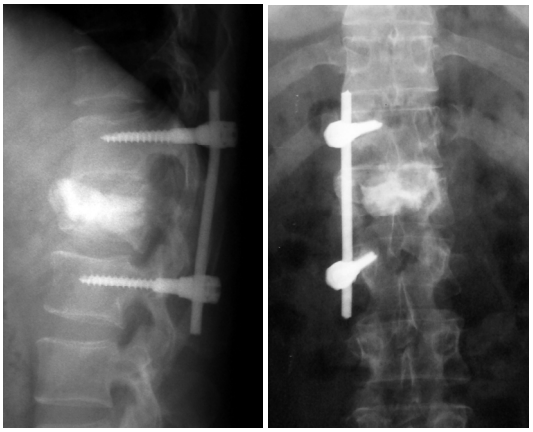

Figure 23
Case 4 (I.G.) – plain X-rays 2 months after vertebroplasty

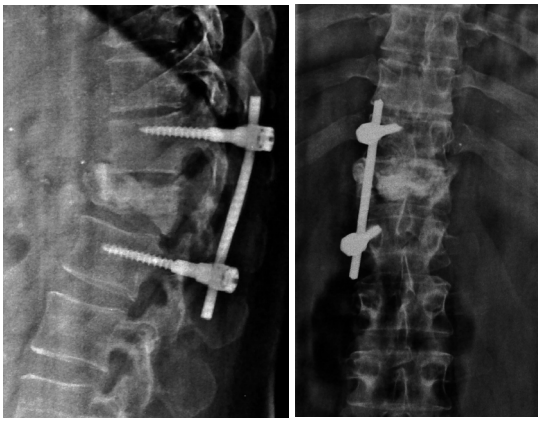

Figure 24
Case 4 (I.G.) – plain X-rays 6 months after vertebroplasty

Discussions and conclusions

Burst fractures are unstable lesions in axial loading and in flexion that make a surgical approach which regards the pathogenical mechanisms necessary. Thus, the surgical treatment has as goals the decompression of neural structures at the level of the fracture and also the restoration as close as possible to normal of the physiological curves of the column, reducing the axial and flexion loading till the fracture site is consolidated. We can reach these goals by using posterior instrumentation joined by a reconstruction procedure of the anterior vertebral column.

The surgical treatment allows early patient's mobilization, even in the first postoperative day, which leads to the possibility of an earlier appliance of a functional recovery treatment, which can be efficient for the patient's social reintegration.

The treatments we propose accomplish these aims by a single approach of the lesion. It lets reduce the surgical time, with a lower surgical trauma for the patient and the diminution of potential side effects of the surgery.

In order to obtain more strength for the anterior spinal column, especially when we have to deal with loose bone structures or when the cement was inserted too posterior, the technique that we propose can be improved by using percutaneous vertebroplasty as a second surgical step.

The cases treated until now suggest promising results regarding the maintenance of the correction achieved intraoperative and a lower risk of late angulation. The reduced number of cases, a lot of them being lost from follow-up at 2 months postoperative, is not enough to achieve an efficient statistical analysis which could emphasize the real benefits of this technique.

The technique we suggest represents an original technique developed in our department that makes possible a restoration of the vertebral strength by a single posterior approach.

Correspondence:
Serban Daniel.
Emergency Hospital "Bagdasar – Arseni"
Bucharest
E-mail: dn.serban@gmail.com

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