Prospective study of standalone balloon kyphoplasty with calcium phosphate cement augmentation in traumatic fractures

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Abstract Prospective consecutive series cases study to investigate the clinical and radiological results of standalone balloon kyphoplasty and cement augmentation with calcium phosphate in traumatic fractures. Independent observer evaluation of radiological and computer tomography results, visual analogue scale (VAS), Roland–Morris score and complications with acute traumatic compression fractures type A, treated with a standalone balloon kyphoplasty and cement augmentation with calcium phosphate (CalcibonTM); follow-up time at a mean of 30 months (24–37 months). From August 2002 to August 2003, consecutive patients with traumatic compression fractures (Magerl type A) without neurological deficit underwent standalone kyphoplasty with Calcibon. We report here the pre-, post-operative and the follow-up results, applying the VAS (0–10) for pain rating, the Roland–Morris (0–24) disability score, *CT-scan examination*, detailed radiographic evaluation of vertebral body (VB) deformity and segmental kyphosis measurement. The pre-operative X-ray measurements, VAS and the 7 days Roland–Morris scores are compared with the post-operative and the 30 months follow-up findings. Twenty-eight patients with 33 treated fracture levels were included in this study. The mean initial vertebral deformity (VB kyphosis)

was 17°, corrected to a post-operative of 6°. We noted a loss of correction at the follow-up in comparison to the post-operative standing X-ray at 24 h of 3° vertebral deformity and 3° segmental kyphosis. The VAS score demonstrates a decrease over time from a mean of 8.7–3.1 at 7 days and to 0.8 at the last follow-up. The Roland–Morris disability score demonstrates a similar improvement. We noticed no major complications related to the procedure. The mean cement resorption after 1 year was 20.3% (0.3–35.3%) and is related to the individual biological resorption process and is not predictable. All patients with vertebral fractures as sole medical problem were discharged within 48 h. All active patients returned to the same work within 3 months with the same working ability as before the accident. Standalone balloon kyphoplasty is a potential alternative mini-invasive technique to reduce the fractures. However, due to the intrinsic characteristic of calcium phosphate cement (Calcibon) we recommend the application of this biological cement for standalone reduction and stabilisation only in fractures type A1 and A3.1 in young patient. In case of higher destruction levels of the VB, we propose the utilisation of Calcibon associated with posterior instrumentation. Having regard to the pointed out indications, our preliminary results demonstrate a new possibility to treat this kind of fractures, allowing a rapid handling of pain, early discharge and return to normal activities.

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Introduction

Ninety percent of all traumatic spinal fractures occur in the thoracolumbar region, 66% of them are compression fractures type A (A1 35, A2 3.5, A3 27.5%) [20]. Type A fractures involve mainly the vertebral body (VB). The posterior column presents, if at all, only minor injuries. The height of the VB is reduced, but the posterior ligamentous complex is intact. Translation in the sagittal plane does not occur. Typically axial compression with or without flexion causes this type of injury. The incidence of neurological injuries increases to approximately 32% in burst fractures type A3 [20] (Fig. 1). Although, this is a very common fracture, there is no consensus for a standard treatment. Various opinions are expressed on the best appropriate treatment for those fractures without neurological deficit and it remains a subject of controversy [29, 32]. Internal fixation offers immediate stability and the possibility to correct a major deformity, if necessary even with decompression of neurological structures. Daniiaux developed and promoted transpedicular spongionoplasty with autologous bone grafts to increase the stiffness of anterior column in addition to posterior instrumentation [5]. However, a recent study demonstrated that this technique does not prevent the recurrence of kyphosis [30]. With non-operative care, brace or body cast, the same possibility of stability with lesser correction of deformity is given [21, 29, 30]. Wood published in 2003 long-term results of a randomised study comparing the conservative treatment to the surgical instrumented technique and did not find any advantage for surgery [37].

Fig. 1 Twenty-six-year-old patient with L1-fracture type A3.2 after car accident

Failed stability after pedicle screw fixation and specifically after removal of instrumentation, or after conservative management are possibly due to lesions of the disc and later to disc degeneration with decreased anterior column support [22, 23]. Restoration of vertebral height and preservation of the endplate may prevent the secondary risk of kyphotic deformation as well as decreasing the risk of chronic pain. The fluoroscopic assisted kyphoplasty is an improved technique for the reduction of painful osteoporotic compression fractures, for VB height restoration and cement augmentation with a decreased complication rate compared to vertebroplasty [12, 19]. The introduction of calcium phosphate (Ca-P) cement (CPC) with superior biocompatibility [3, 4, 6, 8, 10, 11, 16, 17, 18, 31] over PMMA and with optimal resistance under compression [31] enables, in association with kyphoplasty, a new treatment in type A fractures in young patients.

Calcium phosphate cements consist of a powder containing one or more solid compounds of calcium and/or phosphate salts and a cement liquid that can be water or aqueous solution [2]. If the powder and the liquid are mixed in an appropriate ratio, they form a paste that at room or body temperature sets by entanglement of the crystals precipitated within the paste [31, 33]. The material can be shaped for several minutes and is, depending on the liquid–powder ratio, injectable via syringe [3, 4]. One of the most important characteristics of CPC is the ability to be osteoconductive and degradable [6, 7, 17, 18].

Although, numerous reports on in vitro and in vivo investigations dealing with CPC have been published, there are still some problems to overcome [9, 36]. These mainly involve the setting time, the compressive strength reached after setting and the degradation rate of the cement in vivo [11]. A CPC, which is mainly composed of 61% alpha-tricalcium phosphate (TCP), 26% calcium-hydroxyphosphate, 10% calcium-carbonate and 3% hydroxylapatite is used. This alpha-TCP cement originally called biocement D, is now marketed as CalcibonTM (Biomet Merck), and is available since June 2002 for clinical utilisation. Mixed with a liquid (disodium-hydroxyphosphate) to powder ratio of 0.35, a paste is obtained with a cohesion time of 1 min, an initial setting time of 3 min, a final setting time of 7.5 min at 37°C without exothermic reaction. A compressive strength of 30 MPa is reached at 6 h and 60 MPa at 3 days [24, 35]. A biologic improved osteotransduction capacity after 6 months without cellular toxicity or mutation was confirmed in animal study [25, 26, 27, 28, 34].

Materials and methods

Consecutive patients with acute traumatic compression vertebral fracture without neurological deficit were treated with standalone balloons kyphoplasty (Kyphon Inc.) technique and cement augmentation with Calci-bon. Informed consent was obtained in all cases. Patients with accompanying traumatic injury were also included in the study. The fracture was classified on the CT-scan following the classification from Magerl et al. [20]. All patients suffering acute traumatic fractures were included during a 1-year period, according to following inclusion criteria:

- traumatic fracture type A1, A3.1, A3.2;
- fracture involving vertebral bodies from T5 to L5;
- fracture with at least 15° VB deformity (angle inferior versus superior plate) in mono trauma lesion or 10° VB deformity in polytraumatised patients or with multilevel fractures;
- patient without any neurological deficit.

The exclusion criteria applied were:

- thoracic fracture level above T5;
- fracture of type A2 with a split larger than 2 mm;
- fracture type A3.3;
- fracture type B and type C;
- fracture older than 3 weeks;
- pathological fractures;
- pregnancy, infection and contraindication for general anaesthesia.

When there was doubt for a type B lesion in A3 fracture with severe kyphosis we a MRI was also performed pre-operatively.

All patients were evaluated with plain supine X-rays pre-operatively (Fig. 1) and standing at 24 h, 7 days, 2, 6, 12 and 24 months (Fig. 2) post-operatively. Two independent observer (radiologists) analysed all imaging grouped at the evaluation time. They mea-

sured the Cobb angle of the VB kyphosis (angle between the superior and inferior endplate of the fractured body), segmental kyphosis (superior endplate of the VB above/inferior endplate of the vertebral endplate below the fractured body) and the Beck Index (anterior VB height/posterior VB height). A CT-scan was performed pre-operatively (Fig. 3), at 24 h, 12 and 24 months (Fig. 4). A clinical evaluation with neurological examination and visual analogue pain scale (VAS) (0 = non to 10 = severe pain) and the Roland–Morris disability surveys (0 = normal and 24 = disabled) was applied pre-op, at 7 days, 2, 6, 12 and last follow-up. Data of the surgical technique, post-operative care and time elapsed until patients were able to return at the same work was recorded. The pre-operative, post-operative and 24 months follow-up results with X-ray measurements (vertebral deformity, segmental kyphosis and Beck Index) and VAS were compared using a Wilcoxon test, also the Roland–Morris disability score at 7 days post-operative and at the last follow-up ($P < 0.05$ is considered significant).

Surgical technique

The kyphoplasty procedure is performed in the operating room under general anaesthesia and antibiotic prophylaxis to enable conversion to an open procedure in the event of cement extravasation in the spinal canal or insufficient correction. A fluoroscopic C-Arm is set to be able to perform AP and lateral images. The patient is in prone position with slight lordosis to facilitate the spontaneous reduction of the fracture and sometimes already resulting in a reducing of the posterior fragments. Just like in standard balloon kyphoplasty (Kyphon) procedure, an inflatable bone tamp (IBT or balloon) is used to restore the VB height, the spinal deformities and correct the VB endplate before cementation. Compared to the standard kyphoplasty

Fig. 2 Pre-operative CT-scan

Fig. 3 Pre-operative reduction of the fracture with the IBT balloons

Fig. 4 Post-operative standing X-rays at 24 h (a), 1 year (b) and 3 years (c)

for osteoporosis, there are some main differences: After the correct identification of the involved level, Yamshidi cannulas are placed under fluoroscopy in a trajectory parallel to the fracture line, ideally into it, either via a trans- or extrapedicular route, taking care to stay a few millimetres under the fractured endplate. The planning of procedure and trajectory of cannulas, also the choice of the trans- or extrapedicular way is depending on the fracture location and anatomy as it can be seen on the pre-operative CT-scan. The Yamshidi has to penetrate into the VB a few millimetres. Guide pins are introduced in the fracture line and fluoroscopy (AP and lateral view). Then we place the working cannulas, perform the boring of the VB and insert two IBT. The choice of the IBT size depends on the VB size, the amount of reduction needed and the type of fracture. For example, in a A3 fracture a 4-cc balloon is preferred and placed in the anterior third portion of the vertebrae to minimise the risk of a posterior fragment displacement in the canal. Simultaneous, both IBTs, filled with radio-opaque medium, are inflated up to 50 PSI and then we progressively inflate by 0.5 ml, under fluoroscopy control (Fig. 5). In young patients with acute fractures and good bone quality, high pressures of 300 PSI are quickly obtained,

with a low volume of IBT. With an optimal position of the balloons and a little bit of endurance, a progressive displacement of the trabeculae and a correction of the fracture is obtained and the initial high pressure should decrease while the balloons reduce the fracture and expand themselves. Operative time is proportional to the type of the fracture, the age of fracture and VB kyphosis, and may take up to 1 h. Maximal pressure of 400 PSI and a respective total volume must not be exceeded to avoid a rupture of the balloons. When a satisfying reduction of the fracture is obtained, both IBTs are removed, the bone cavity created by the IBT is filled with cement. In case of loss of correction after removal of the balloons, a two-time cementation is used: One balloon is refilled without contrast and replaced in the VB on the side of the most important deformity. Thus, the endplate is restored again and we cement the other half of the VB first and after removal of the balloon the second half is cemented.

We kept Calcibon in a refrigerator and mixed it just before use to delay crystallisation time. Mixing is always performed with pouring liquid first then adding the powder and stirring 60 s to obtain viscous consistence. Kyphon 1.5 cc bone filler are pre-filled quickly, and the distal end obtruded with bone wax to protect

Fig. 5 Post-operative CT-scan at 24 h (a), 1 year (b) and 3 years (c) of an A3.2 fracture

the cement from early contact with blood, as blood also increase crystallisation. Cementation of VB starts in the anterior part, going posterior, under constant fluoroscopy, paying special attention to posterior fragments in type A3 and of split in the A3.2. This very short phase takes approximately 2 min, is difficult to perform and necessities a large experience with the conventional PMMA cement to prevent complications. After crystallisation, cannulas are removed, final fluoroscopy check is performed and the skin is sutured.

Post-operative care

All patients with isolated spine fractures are mobilised after 6 h without brace. A CT-scan and standing X-rays were performed at 24 h. For 2 weeks, we advise not to lift any weight, and make no physical effort. We prescribe physiotherapy with relaxing massage, isometric muscular reinforcement and standard advices for back posture. After 2 weeks, the patient may return to work and his usual activities and sports.

Results

From August 2002 to August 2003, 28 patients (10 female and 18 male) with 33 acute traumatic vertebral type A fractures without neurology under the mean age of 38 (17–64) were treated. The follow-up with a mean of 30 month was 100%. Six patients had additional fractures. The affected levels were T11 (4), T12 (4), L1 (6), L2 (9), L3 (7), L4 (2), L5 (1). The types of fractures were 3 A1.1, 21 A1.2, 7 A3.1 and 2 A3.2 and the operation was performed at a mean of 3.4 (1–21) days after injury. The mean surgery time was 60 (35–90) min. The final pressure of IBT was 233 (180–400) PSI and in all cases substantial reduction of fractured endplate was achieved. The mean volume of Calcibon injected was 6.8 (4.5–9) ml. The blood loss was insignificant. No adverse haemodynamic events were detected per-operatively. The mean initial pre-operative

vertebral kyphosis, measured in supine position, was 17° (0– 24°), the reduction obtained per-operative was at a mean of 5° (0– 9°). We noticed a loss of correction from a mean of 6° (0– 11°) in the standing X-rays at 24 h to a mean of 9° (0– 17°) at the last follow-up (Table 1, $P = 0.001$).

The mean segmental kyphosis in supine position was 3° (– 36° to $+26^\circ$) pre-operative, per-operative at a mean of -6° (– 28° to $+20^\circ$), post-operative at 24 h (standing X-rays) measured to -1° (– 38° to $+22^\circ$), and also with a mean of -1° (– 32° to 28°) at the last follow-up (Table 1, $P = 0.071$).

The height restoration (Beck Index) was 0.70 (0.50–0.90) pre-operative, per-operative corrected to 0.90 (0.81–1) and post-operative at 24 h it was 0.87 (0.81–1) and 0.84 (0.76–1) at the last follow-up ($P = 0.002$). The loss of correction was not significantly correlated with the clinical outcome.

The VAS score demonstrated a decrease over time from a mean of 8.7 (7–10) pre-operative, to 3.1 (0–5) at 7 days and 1 at the last follow-up (0–4) (Table 2, $P = 0.001$).

The Roland–Morris disability score demonstrated a similar improvement during the follow-up from a 3 (0–12) at 7 days to a mean of 2 (0–9) at the last follow-up (Table 2, 7 days-post and at 2 years, $P = 0.004$). Only the post-operative Roland–Morris data are reported because most of the patients are young and presented a normal score before the accident.

We noticed some technical operative complications: two anterior wall perforations by cannulas and six cement leakages. Those leakages are defined as any cement contact in the disc space that can be observed on the post-operative radiographs or on the CT-scan. In one case, we observed a small leakage in the lateral portion of the spinal canal without clinical significance. Those leakages certainly occur through fracture lines since we never noticed any leakage in veins or pulmonary embolism. All patients with isolated vertebral fractures ($N = 22$) recovered uneventfully without neurological deficit and were discharged within 48 h and returned to the same work with the same working

Table 1 Descriptive statistics and significance: all fractures ($N = 33$)

	Minimum	Maximum	Arithmetic mean	Standard deviation
Age	17	64	37.6	12.1
Follow-up time	24	37	30.1	3.9
Vertebral kyphosis pre-op	0	24	17.1	5.1
Vertebral kyphosis post-op	0	11	5.9	3.4
Vertebral kyphosis last follow-up	0	17	9.0	3.8
Segmental kyphosis pre-op	-36	26	2.6	16.7
Segmental kyphosis post-op	-38	22	-1.3	16.0
Segmental kyphosis last follow-up	-32	28	-0.7	16.1
	Vertebral kyphosis last-vertebral kyphosis pre-op	Vertebral kyphosis last-vertebral kyphosis post-op	Segmental kyphosis last-segmental kyphosis pre-op	Segmental kyphosis last-segmental kyphosis post-op
Z	-4.863 ^a	-3.714 ^b	-1.806 ^a	-0.981 ^b
Significance	0.000	0.000	0.071	0.327

^a Based on positive ranks^b Based on negative ranks

ability as before the accident within 3 months. No long-term clinical complications were detected at the last follow-up. In majority of the cases the cement was not completely substituted at the last follow-up. At the

CT-scan control, we found partial cement resorption starting after 6 months without visible bone formation. In the biopsy (Fig. 6) at 6 months, we found an image showing normal fracture healing and new bone for-

Table 2 Data-overview of 28 patients with 33 fractures

Number	Type of fracture	Age	Follow-up	VB_pre	VB_post	VB_last	SK_pre	SK_post	SK_last	VAS_pre	VAS_last	RM_post	RM_last
1	L3 A1.2	35	37	24	10	10	-14	-12	-13	8	1	2	2
2	L2 A1.2	50	35	20	10	13	0	-8	-1	8	1	6	5
3	L2 A3.1	22	35	19	7	10	10	-10	-7	9	0	0	0
4	L3 A1.2	42	35	20	8	8	-26	-26	-30	8	4	8	9
5	L4 A3.1	44	35	20	2	5	-24	-24	-22	9	0	2	2
5	L2 A1.1	44	35	14	7	9	12	12	7	9	0	2	2
5	L3 A1.1	44	35	9	6	9	0	0	0	9	0	2	2
6	L2 A1.2	37	35	20	4	6	8	-9	-10	9	0	1	0
7	L1 A1.1	28	34	14	2	6	2	0	10	8	0	0	0
8	L1 A3.1	24	33	22	2	4	14	0	0	9	0	0	1
9	D12 A3.1	54	32	15	4	9	12	10	14	9	0	0	0
10	D12 A3.1	63	32	20	2	9	26	20	28	9	1	4	0
11	L2 A1.2	64	31	18	0	7	8	1	8	10	1	4	2
12	L1 A1.2	46	30	24	9	12	6	1	1	8	0	2	0
13	L1 A1.2	45	30	21	8	12	2	16	16	9	0	2	2
14	L1 A1.2	47	30	22	10	17	14	10	15	9	2	3	2
15	L2 A1.2	28	29	15	3	8	2	0	-5	8	4	1	3
16	D12 A3.2	30	29	24	10	10	22	20	22	9	1	2	0
16	D11 A1.2	30	29	13	8	11	24	8	8	9	1	2	0
16	L5 A1.2	30	29	0	0	0	-36	-38	-32	8	1	2	0
17	D11 A1.2	52	29	16	7	9	20	22	20	9	1	0	0
18	L2 A1.2	50	29	14	6	10	3	8	-6	9	1	2	0
19	L2 A1.2	33	28	20	5	9	-9	-3	-4	9	0	1	0
20	L4 A3.1	17	28	16	0	1	-30	-30	-24	8	0	0	0
21	D11 A1.2	26	27	22	11	14	18	16	14	9	0	6	0
22	L3 A1.2	31	27	14	9	13	-20	-24	-18	8	0	0	0
23	D11 A1.2	27	26	19	9	14	20	18	20	9	0	0	0
24	L1 A1.2	33	25	20	9	12	20	16	16	10	3	8	9
24	L3 A1.2	33	25	13	6	9	15	-20	-20	10	3	8	9
25	D12 A1.2	51	25	18	9	12	16	12	11	8	1	4	0
26	L2 A1.2	26	25	12	8	11	-12	-10	-12	9	1	12	2
27	L3 A3.2	20	24	15	3	5	-10	-8	-10	8	1	1	0
28	L3 A3.1	33	24	10	1	2	-7	-10	-18	7	0	4	0

Age in years, follow-up time in months

mation without signs of inflammation or necrosis. High variability of cement-resorption was confirmed by CT-measurement (24 h, 1 year). The mean resorption referred to the initial volume of applied cement was 20.3% (0.3–35.3%) and is related to the individual biological resorption process. We found no correlation between the kind of fracture, the clinical outcome and the amount of resorption of the cement. The new bone formation was not measurable. In the patients with A1.1 and A1.2 fracture, we did not see any segmental decompensation at the last follow-up. In the patients with A3.1 and A3.2 fractures (nine cases) we obtained in the worst case (1/9) a spontaneous fusion or partially loss of correction (4/9), in the other cases we did not even notice a decompensation of the disc (4/9).

Discussion and conclusion

In our study, we demonstrate the feasibility and safety of a new less invasive technique to reduce and directly stabilise the anterior column after acute type A VB

fractures. Advantages of this minimally invasive technique are an almost immediate return to daily activities, disappearance of pain, minimal operative risks and maintenance of stability. At the same time having minimal blood loss, this could be a first choice technique in polytraumatised patient needing rapid spine stability, thus improving nursing in the intensive care unit. This technique enables normal mobilisation after 6 h, depending on residual muscular pain, without any brace. The patients can be discharged home the same day. Compared to conservative treatment with brace, patients do not have to bear the inconvenience of wearing a brace, have a better reduction of the fracture and better control of pain under load. Compared to standard surgery this technique offers a lower risk of morbidity [21, 22, 29, 32]. The immediate stability leads to a rapid pain reduction and allows a quicker return to work and sports activity. Our study demonstrates that the treatment of the mentioned type A thoracolumbar fractures with kyphoplasty compares well with the standard therapies. We obtain the benefit of a mini invasive percutaneous technique, with the same

Fig. 6 Image of new bone formation (osteoid, osteoblasts, bone matrix, cartilage, etc.), no inflammation or necrosis in the histology of a biopsy taken 6-month post-operative—H.E. staining—magnification 24–68×

radiological results given by the literature in classical surgical technique regarding final kyphosis, but with better clinical outcomes [2, 31, 33]. A recently published study by Hillmeier et al. [14] comparing kyphoplasty technique with PMMA or with calcium phosphate in osteoporotic and traumatic fractures either in standalone or with associated posterior fixation obtains comparable results. The kyphoplasty technique is an operation, performed under general anaesthesia even if it is a minimally invasive technique and necessitates a large use of fluoroscopy. The technique uses the same approach as kyphoplasty in osteoporotic fracture but the cement application is more difficult. This is due mainly to a short crystallisation time, a difficulty in application, which necessitates a long learning curve. Cement-cracks and lacunas around the cement were observed in all CT-controls after 1 year, without any impact on the clinical findings. Despite histological examinations, we found no reasonable explication for the lacunas. We hypothesise this corresponds to a normal early stage of cement substitution with bone. If the cement-crack appears in the first week, it will increase the risk of acute kyphotic decompensation. This can be explained by a variety of combined factors: On the one hand the severe injury of an A3 fracture leads to an important endplate damage or associated disc ruptures and consecutive disturbed disc-nutrition pathways. On the other hand incorrect cement application could also be the cause of disturbed crystal formation and consecutively change of intrinsic cement property.

In case of severe A3.1, A3.2 and A3.3 fractures we don't recommend the utilisation of CPc and kyphoplasty in standalone fashion, because of the low shearing stability due to the intrinsic characteristic of this

biological cement. In this case, we propose to utilise the PMMA to achieve a better shearing stability.

Future cement developing is necessary to improve handling, the intrinsic capacity of shearing resistance and finally the biological osteotransduction.

Verlaan et al. [33] recently presented an animal study about histological reaction from CPc in VB and in contact with the disc in comparison with the PMMA. The study concluded that vertebroplasty with both of these cements can be performed without an increased risk for disc or endplate degeneration even when endplate discontinuity is present. Burst fracture type A3 and in some type A2 are accompanied with fractures of the endplate and lesions of the disc. The endplate is the main nutritional pathway to the disc; a disturbance of this could lead to an impairment of the vascularisation and transport of nutrients. Many studies have demonstrated the progressive degeneration and poor regenerative capacity of the disc once a part of the annulus has been damaged [1, 13, 15]. Oner et al. [22, 23] found in a MRI study that a fracture of the endplate resulted in a redistribution of disc material through the endplate in the VB but did not lead to disc degeneration.

We found no significant loss of segmental correction after 2 years neither in A1 fractures ($P = 0.107$) nor in type A3 fractures ($P = 0.231$) as shown in Table 3.

In our opinion, the restoration of the endplate preserving the mobility of associated segments could maintain the vascularisation and the pump nutrition in the disc, allowing healing of the disc. Only long-term follow-up will confirm this hypothesis.

The initial cost of the balloons kyphoplasty technique is high, due to the price of IBT, but the cost benefit could be balanced by a shorter hospitalisation

Table 3 Descriptive statistics and significance: type A3 fractures ($N = 9$)

	Minimum	Maximum	Arithmetic mean	Standard deviation
Age	17	63	34.1	16.2
Follow-up time	24	35	30.2	4.2
Vertebral kyphosis pre-op	10	24	17.9	4.3
Vertebral kyphosis post-op	0	10	3.4	3.2
Vertebral kyphosis last	1	10	5.6	3.2
Segmental kyphosis pre-op	-30	26	1.4	20.0
Segmental kyphosis post-op	-30	20	-3.6	17.8
Segmental kyphosis last	-24	28	-1.9	19.3
	Vertebral kyphosis last-vertebral kyphosis pre-op	Loss of reduction: vertebral kyphosis last-vertebral kyphosis post-op	Segmental kyphosis last-segmental kyphosis pre-op	Loss of reduction: segmental kyphosis last-segmental kyphosis post-op
Z	-2.668 ^a	-1.783 ^b	-0.681 ^a	-1.198 ^b
Significance	0.008	0.075	0.496	0.231

^a Based on positive ranks

^b Based on negative ranks

and shorter period of inactivity. The high rate of early return to normal daily activities and work is especially appealing. Our 2 years results seem to indicate that kyphoplasty and cementation with Calcibon can be used as a potential alternative therapy of acute thoracolumbar fractures. Long-term studies are needed to assess the maintenance of correction and disc height, and larger studies could determine which sub-types of fracture are better treated this way. When using Calcibon we recommend the standalone balloon kyphoplasty technique only in type A1 and A3.1 acute fractures. For the A3.3 type this kind of technique has to be associated with posterior instrumentation.

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