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ORIGINAL ARTICLE

Treatment of typical amyelic somatic fractures with kyphoplasty and calcium phosphate cement: a critical analysis

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Abstract
Purpose Vertebroplasty and more recently kyphoplasty are recognized as techniques in the treatment of osteoporotic vertebral fractures and in case of pathological fracture like in secondary tumors. The recent introduction of calcium phosphate cement (CPC) that offers, at least theoretically, an osteointegrative capacity, absent in polymethyl methacrylate (PMMA), has generated interest for its use in the treatment of traumatic fractures (type A) even in young patients.
Methods In this study, type A fractures without neurological signs were treated. A total of six male patients, of age between 21 and 55 years (mean age 38 years), were included. Fracture treatment was performed with kyphoplasty with balloon (Kyphon) and injection of calcium phosphate cement for a total of seven procedures.
Results The results were evaluated according to the regional kyphosis angle and the local kyphosis angle. The postoperative X-ray control showed an average improvement of the regional kyphosis angle of 7.4°; however, this value was reduced by an average of 6.6° after 45 days with regard to the postoperative control. The local kyphosis angle showed an average improvement of 9° at the postoperative control with an average worsening of 9.2° in the control after 45 days.
Conclusions While kyphoplasty with the use of CPC in the treatment of type A traumatic fractures was effective in the treatment of pain, it has not been so far effective concerning the maintenance of the reduction obtained intra-operatively and its osteointegrative effect.

Keywords Kyphoplasty · Calcium phosphate cement (CPC) · PMMA · Compression fracture

Introduction

Vertebroplasty and more recently kyphoplasty are considered effective and secure techniques for the treatment of osteoporosis fractures or fractures due to vertebral secondary tumors [1]. The use of polymethyl methacrylate (PMMA) represents the gold standard for the treatment of these fractures. Some authors suggest the use of this material even for the treatment of fractures in younger patients. Such a choice may be controversial: in spite of its excellent biomechanical capacity, it has no osteointegrative characteristics [2]. The use of a crystal, calcium phosphate cement (CPC), seems to be more interesting given its good biocompatibility and theoretical osteointegration: it should be reabsorbed slowly with time and "substituted" with bony tissue. Its use in kyphoplasty with the balloon has, theoretically, opened new horizons for the treatment of type A fractures in young patients. Ninety percent of all traumatic spinal fractures occur in the thoracolumbar region, 66% of which are compression fractures type A [3]. In this type of fracture, the height of the vertebral body is reduced, but the posterior ligamentous complex is intact. There is non-consensus about standard treatment: internal fixation, non-operative care with brace, kyphoplasty with PMMA and now CPC are used all over the world. The goal of this article is to present our experience in the treatment of type A fractures in young patients with kyphoplasty with CPC.

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Materials and methods

We have treated exclusively type A fractures (A1.1, A1.2, A1.3). All fractures have been classified on X-rays and CT scans according to Magerl [3].

In the study, six patients of age between 21 and 55 years (mean 39 years), all male patients, were included. The treatment of the fractures was performed with kyphoplsty with balloon (Kyphon Inc.) and injection of calcium phosphate (Kyphos) for a total of seven procedures (one patient had both T11 and T12 fractures). Surgery was performed with general anesthesia within 10 days from the trauma. The fractures were located at T11 in two cases (A1.2), T12 in one case (A1.2), L1 in two cases (A1.2), L2 in one case (A1.3) and L5 in one case (A1.3). Patients underwent standard X-ray and CT before and after surgical treatment. In all cases, a bilateral transpedicular approach was used. Attention was paid not to move patients from the surgical table until 30 min after the completion of the surgical procedure; subsequently, patients maintained a supine decubitus position for 24 h from the end of the surgical procedure to guarantee the complete crystallization of CPC. After 24 h, patients were maintained in erect position with Camp C35 brace. CT scan control was performed at 48 h. The brace was maintained in an erect position for 60 days. Subsequent X-ray controls were performed at 45–60 days, at 3, 6 and 12 months after surgery and successively at yearly intervals.

Results

Surgery has always been performed with general anesthesia. The mean time for the surgical procedure was 45 min (including 20 min of waiting at the end of surgery). There has been no case of leakage of cement, or peri or postoperative complications. The postoperative period was characterized by a rapid remission of pain. The mean follow-up was 21 months (min. 2, max. 46). The results were evaluated on the basis of the regional kyphosis angle (the angle between the superior endplate of the vertebra above and the inferior endplate of the vertebra below) and on the basis of the local kyphosis angle (the angle between the superior and inferior endplates of the fractured vertebral body). The postoperative X-ray control showed an average improvement of 7.4° of the regional kyphosis angle; this value worsened with regard to the postoperative control by an average of 6.6° at 45 days. The local kyphosis angle showed an average postoperative improvement of 9° with a subsequent average worsening of 9.2° on the 45th postoperative day control. Clinically, patients remained asymptomatic in five cases; in one case, a local fracture pain persisted. All patients were discharged from the ward on the 1st postoperative day. During the postoperative control with X-ray and CT scan, no convincing signs of osteointegration or of substitution of the CPC with new bone was observed.

Discussion and conclusions

The marketing of CPC permits extending the range of action of the kyphoplasty procedure with balloon even for the treatment of type A fractures according to Magerl in young patients, an alternative to the treatment with POP casts without offering inferior morbidity risks with regard to classical surgical treatment [4]. The advantages of this mini-invasive technique are the early return to working activity and the reduction of pain in treated patients, with low surgical risks. The technique reproduces entirely the procedure used in the treatment of osteoporosis fractures in elderly patients with PMMA, even if the introduction of the CPC is more difficult; this is essentially due to the rapid crystallization of the latter by the time it comes in contact with biological tissues, and due to its different chemical and physical characteristics (the viscosity) that make a satisfactory distribution of the cement onto bone trabeculae in order to provide an adequate primary stabilization difficult. With regard to the results, the literature data are controversial. After the initial optimism in which the biomechanical characteristics of the CPC were described as comparable to those of the PMMA [5–7], in contrast other recently published articles underline the poor biomechanical and osteotintegrative characteristics of CPC [8–11]. In spite of the simple procedure with the encouraging initial impression, the results obtained by us show a poor result of kyphoplasty with CPC in the treatment of type A fractures, in particular because of the loss of both the local and the regional kyphosis angles in the postoperative period: the contemporary reduction of these two angles seems to exclude the role of the intervertebral discs (eventually damaged during the trauma) in the poor results obtained, incriminating hence the biomechanical characteristics of the CPC.

Given that the CT scans performed postoperatively have demonstrated the effective difficulties of obtaining a real reduction of the whole vertebral body fracture by means of the balloon, the transpedicular approach provides a reductive effect only to the part of the vertebral body close to the pedicles, with poor or even null possibility of the control of the vertebral body parts medial and lateral to that zone. In spite of a discrete operative reduction, the postoperative phase has demonstrated a rather rapid loss of the reduction; such a loss would be unacceptable, in our opinion, and probably attributable to the CPC (Fig. 1a–g).

First of all, the CPC provides a poor "diffusion" capacity to the trabecular bone matrix, possibly due to its

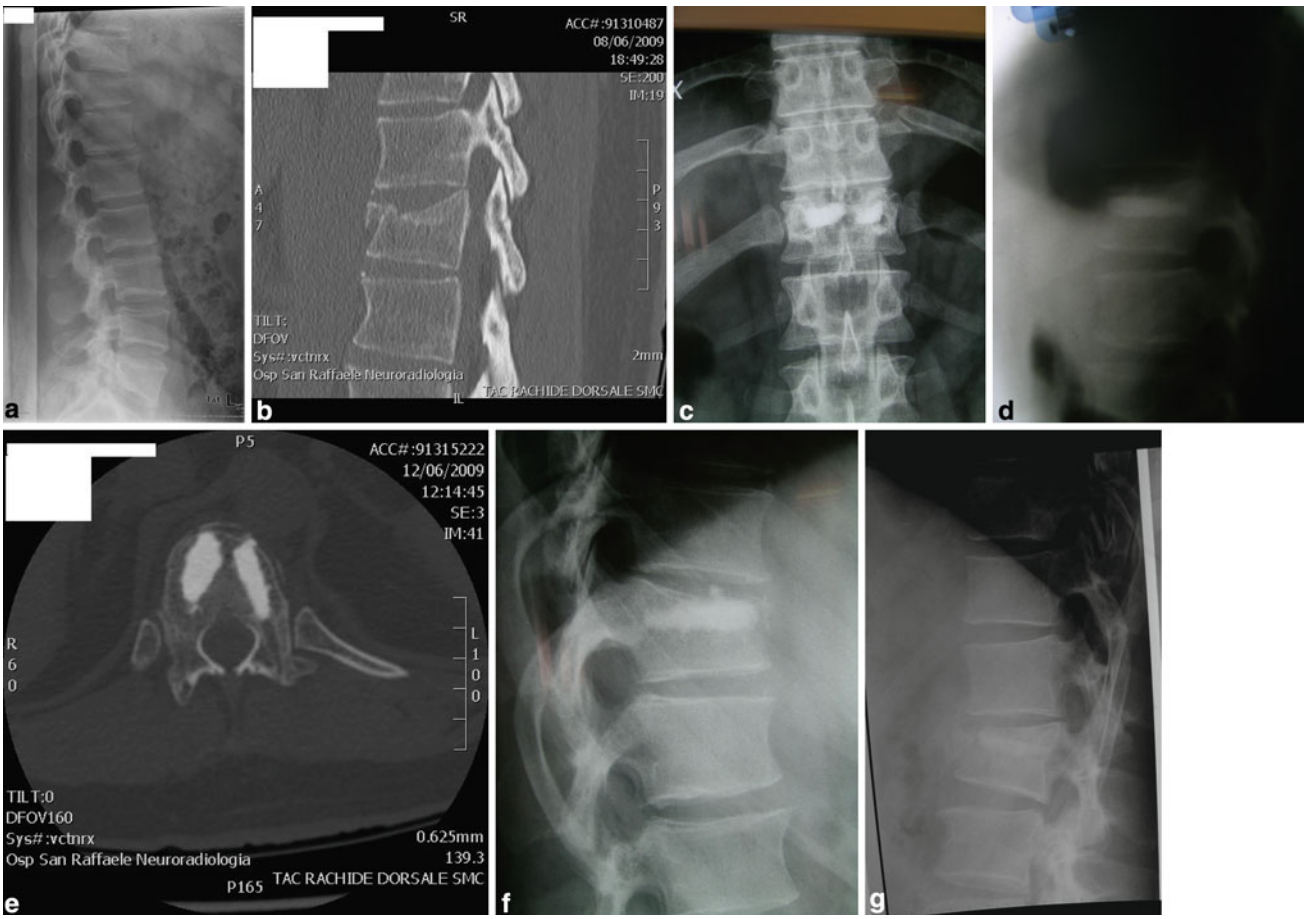

Fig. 1 **a** 33-year-old male with T11 type A1.2 fracture; lateral view. **b** 33-year-old male with T11 type A1.2 fracture; preoperative CT scan. **c** 33-year-old male with T11 type A1.2 fracture; postoperative AP X-ray. **d** 33-year-old male with T11 type A1.2 fracture; postoperative lateral X-ray. **e** 33-year-old male with T11 type A1.2 fracture; postoperative CT scan that shows the poor expansion of CPC in the vertebral body. **f** 33-year-old male with T11 type A1.2 fracture; 3 postoperative months lateral X-ray: loss of the local and regional kyphosis angles. **g** 33-year-old male with T11 type A1.2 fracture; further worsening of the correction after 6 months

immediate initial crystallization as soon as it leaves the filler: such an effect leads to the impossibility of creating solid cohesion between the bone fracture fragments.

Another problem is the fragility of the CPC, described in scientific literature [11] which, generating fracture phenomena, permits the composition of the fracture fragments not yet consolidated by a real reparative process.

Improvement of more adequate instruments, with the target of obtaining a better reduction, could be possible to realize. It seems more difficult to modify the characteristics of the CPC to make it correspond to the requirements of such a role, given that its present characteristics have provided rather disappointing results, such results agree with Blattert results [10] and are not superior to the results obtained with a common conservative treatment.

Conflict of interest None.

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