BURST-FRACTURES AND CEMENTOPLASTY

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SUMMARY

Percutaneous acrylic cement vertebroplasty is known for its pain-relieving effect in spinal tumors and recently in osteoporotic vertebral collapse. To our knowledge no study has been published reporting the treatment of acute high energy post-traumatic fracture (mainly single burst fracture) by vertebroplasty. Our purpose was to evaluate the technical feasibility of the cement injection at this acute phase, assess its impact on the pain and monitor spinal stability, by quantifying potential kyphosis modification. Twelve patients with relative contraindication of the orthopaedic treatment were treated by early injection after the trauma for an A type fracture of the Magerl classification, without neurological sign. Patients surveys revealed a significant pain reduction within the first day. Half of them reduced the kyphosis angle, and the anterior height vertebral body significantly improved after the vertebroplasty. The mean reduction in the kyphosis angle was 8°. No complication occurred except one extravertebral asymptomatic leak, with secondary increase of the kyphosis. Vertebroplasty performed in reduction position may allow a complete stabilization without pain and furthermore can reduce the kyphosis angle.

Key words: bone cement, A type vertebral compression fracture, vertebroplasty, spinal trauma, kyphosis correction, burst fracture.

RÉSUMÉ

Cementoplastie des fractures du rachis

La vertébroplastie percutanée par injection de ciment acrylique est connue pour son effet antalgique sur les tumeurs rachidiennes et plus récemment dans les fractures vertébrales ostéoporotiques. À notre connaissance, il n’existe pas d’étude publiée sur le traitement des fractures post-traumatiques aiguës à haute énergie par vertébroplastie. Notre but est d’évaluer la faisabilité technique de l’injection de ciment à cette phase aiguë, mesurer son impact sur la douleur et quantifier la stabilité rachidienne en recherchant les éventuelles modifications de cyphose. Douze patients, présentant des contre-indications relatives à un traitement orthopédique, ont été traités par une injection précoce de ciment après le traumatisme pour des fractures de type A de la classification de Magerl. Le suivi de ces patients a montré une réduction significative de la douleur dans les 24 h après la procédure. La moitié d’entre eux ont réduit leur angle cyphotique et la hauteur antérieure de la vertèbre a été significativement augmentée après vertébroplastie. La réduction moyenne de l’angle de cyphose était de 8°. Aucune complication n’est survenue en dehors d’une fuite extra-vertébrale conduisant à un mauvais remplissage de la vertèbre suivi par un retassement avec aggravation de la cyphose. La vertébroplastie, en condition de réduction, peut autoriser une stabilisation complète antalgique et de plus permet, dans certains cas, de réduire la cyphose résiduelle.

Mots-clés : ciment acrylique, fracture vertébrale de type A, vertébroplastie, traumatisme rachidien, correction de cyphose, burst fracture.

INTRODUCTION

Acrylic cement vertebroplasty (P.M.M.A.) is a common treatment of painful debilitating conditions in the spine [2, 3]. However, though vertebroplasty has become a widespread therapeutic approach in dealing with such conditions, the use of this technique in the treatment of acute high-energy post-traumatic fractures (accidents in public places, patient falling from a height) has never been researched.

This study involves twelve patients, all of whom exhibited relative contraindications for orthopedic or surgical procedures. Its purpose is three-fold: test the technical feasibility of a cement injection during the acute phase of a traumatic fracture, assess the impact on pain, and monitor spine stability by quantifying potential kyphosis modifications immediately after the procedure and again six months later.

In the treatment of vertebral traumas, we believe that there is room for minimally-invasive techniques of vertebral consolidation (vertebroplasty) or of vertebral reexpansion with consolidation such as kyphoplasty alongside orthopedic and surgical techniques. Eventually these techniques, whether current or still developing, will probably include the use of bone substitutes to facilitate a more physiological reconstruction of the vertebra.
brace and four patients were active elderly individuals for whom a protracted decubitus was not recommended.

All patients exhibited A type fractures (A1, A2 and A3) according to MARGEL’s classification [6] compression fractures of the vertebral body, mainly via A1 collapse (n = 2), A2 separation (or butterfly like) (n = 2) and A3 comminutive fractures (or Burst-fractures) (n = 9) (figure 1). One patient exhibited also an increased interpedicular distance.

All patients had a healthy spinal column with no previous fracture or known osteoporosis condition except for two with new and sudden painful collapse of the vertebra that was already fractured, in one case after bracing only (figure 2), and in the other after bracing and surgical fixation (figure 3). In both cases, this complication occurred within two months. Another patient exhibited two contiguous T12 and L1 fractures after a car crash. There was no indication of a set medullar or radicular compression. The intensity of pain was above 5 on the Visual Analogue Scale a scale of 0 to 10 with 10 indicating the highest level of intensity.

Fractures with nerve lesions (medullar or radicular signs) and fractures that affected two or three columns (anterior discocorporeal column and facet column), which are known to be unstable, are excluded. Fractures that involve a loss of substance (A2) in the course of the reduction procedure are treated. Static deformities of more than 20 degrees at the fracture site are also excluded, except in the case of an inoperable patient with a T11 fracture and a 30-degree angulation. A reduced diameter of the canal caused by a receding posterior cortex does not constitute an exclusion factor. However, no patient is found to have canal reduction above 50%.

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Fig. 1. – Thoraco-lumbar fractures: “A type” compression fracture according Magerl’s classification. A1 pure fracture, A2 butterfly like fracture, A3 or burst-fracture.

Fig. 1. – Les types de fractures thoracolombaires : A lésion du corps vertébral par compression selon la classification de Magerl. Les groupes du type A : A1 tassement pur, A2 fracture-séparation (diabolo), A3 fracture-éclatement (burst).

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Fig. 2. – 58 year old male, obese, L1 fracture after falling from a ladder. Orthopedic treatment with brace. Note a vacuum in the vertebral body due to osteonecrosis (a). Sudden painful refraction during the second month with increase of the kyphosis angle (b). 3D. CT. before vertebroplasty showing retrupulsion of the posterior cortex and vacuum below the superior endplate (c). Post vertebroplasty, cement filling in the anterior part of the body on CT scan (d) and the kyphosis angle was corrected from 17° to 7°.

Fig. 2. – Homme de 58 ans, obèse, fracture de L1 après chute d’une échelle. Traitement orthopédique avec corset ; noter un gaz intrasomatique en rapport avec une ostéonécrose (a). Tassement douloureux d’apparition brutale au 2e mois avec aggravation de la cyphose (b). TDM 3D sagittal pré-vertébroplastie montrant un recul du mur postérieur et un gaz sous le plateau supérieur (c). Après vertébroplastie remplissage antérieur du ciment sur la TDM de contrôle (d) et diminution de l’angle cyphotique de 17° à 7° (e).
All patients were treated within eight days at the most following the occurrence of the trauma (average waiting time was six days). Decisions regarding treatment were made jointly with neurosurgeons and anesthetists as soon as all the tests were completed and the patient was informed and gave her consent.

All patients underwent 3D. CT. (three dimensional Computed Tomography) before and after the cementoplasty as well as radiographs in a standing position. The significance of the vertebral collapse is measured at the junction of the anterior third and the medium third and expressed as a percentage of loss of the initial height (average = 50%) (extremes 10 to 70%). The recession of the posterior cortex fragment within the canal is measured as a percentage of the canal’s anteroposterior diameter (average = 30%, extremes 0 to 50%) (figure 4). The lateral cortex was involved in all patients but one (table I).

The T.R.A. angle (Traumatic Regional Angulation = traumatic regional kyphosis – physiological kyphosis) is measured before and after the procedure by using the Cobb method on a lateral view of the spine (figure 5); the measurement is correlated with the vertebral reexpansion capacity (figure 6).

This technique is implemented in procubitus on a Castaing mattress (ref. 1000-5600 Macquet) (7/12 patients) under analgo-sedation with spine extended by upper chest an pelvic padding, via right unilateral route (eleven patients), seven transpedicular, five unilateral latero pedicular approach and once via left posterolateral route. A 10-gauge beveled needle (Escoffier Frères SA. Trocart vertébroplastie) is always used in the injection of polymethylmetacrylate (P.M.M.A) as bone cement (Osteopal V. Biomet Merck (n = 10) and Osteo-firm bone cement. Cook. Danemark (n = 2)). The injection is performed manually with 1- and 3-cc syringes. The needle was ideally positioned at the junction of the anterior and medium third of the vertebral body. The procedure is controlled with a C-arm fluoroscopy (n = 11) and in one case via a CT./ C-arm combination (T1 vertebra).

Fig. 3. – 66 year old male, car accident. A 2 type fracture of L1 with osteosynthesis (a). Sudden refracture after 2 months. Note the displacement of the superior screw in the vertebral body and the increase of the kyphosis (b). CT scan showing the coronal fracture before (c) and after the instrumentation (d). The filling of cement in the area of the fracture is weak with asymptomatic leakage into the adjacent disk spaces but the kyphotic angle is decreased (e).
The post-procedure C.T. assesses the T.R.A. after the cementoplasty as well as potential leaking of acrylic cement and for burst-fractures the potential displacement of the loose fragment inside the canal. An assessment of pain relief is conducted after 24 hrs and then after three and six months.

The need for bracing after release from the hospital for 15 days is variable (7/12) according to anatomic conditions and associated injury.

**RESULTS**

All procedures achieved optimal filling of the vertebra, except in one case (patient with 2 adjacent fractures) because of lateral leakage in the psoas muscle that led to a premature cessation of the procedure and thus to insufficient filling. Filling was correct 12/13 times localized in the two anterior thirds of the vertebral body for A3 fractures and total or partial for the other types of A1 and A2 fractures (figure 3d, 4c, 5d).

No local or general complications were observed per-procedure and during follow-up.

In addition to discal leaking (6/13, 5 toward the upper disk), a minor, asymptomatic leak in the psoas muscle was confirmed in the post-procedure C.T. There was no leaking through cracks above 2 mm in the normal contour of the vertebra.

Six patients exhibited an increase of the initial vertebral height an average 50% of the initial height (extremes 10-80%). The height restoration was concomitant with a T.R.A. reduction of 8 degrees on the average (extremes 3-16 degrees) (figure 7).

At the time of discharge from the hospital, 2 days after the procedure, all patients were completely relieved (Visual Analogue Scale below 2). The impact on pain was stable for all patients throughout the follow-up period (three and six months).

Though there was no occurrence of pain, a patient underwent surgery after three months because of a deterioration of the kyphosis observed on radiographs taken after two months (figure 8). This patient was the one with two T12 and L1 fractures and insufficient filling of the L1 vertebra due to leakage.

Half the patients wore a safety brace whenever possible for 15 days according to the anatomic status. All patients were discharged from the hospital after 2 days.

**DISCUSSION**

In Western countries, the annual incidence of spinal fractures is of 60 for 100,000 inhabitants. In France, more than 10,000 post-traumatic thoraco-lumbar fractures are treated every year. Two thirds of these fractures are not accompanied by neuro-

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**TABLE I. – Descriptive data of Burst-fractures. * Prior vertebra collapse treated by orthopedic treatment or osteosynthesis with sudden new collapse after 2 months.**

<table>
<thead>
<tr>
<th>No</th>
<th>Age/sex</th>
<th>Circumstances</th>
<th>Vertebra level/type</th>
<th>Relative Contra-Indication</th>
<th>Fracture of lateral cortex</th>
<th>% of canal compromise</th>
<th>Delay between trauma and vertebroplasty</th>
<th>Leak</th>
<th>Expansion of cortex</th>
<th>Brace</th>
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<td>1</td>
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<td>Falling</td>
<td>L1/A3</td>
<td>Obesity sudden collapse</td>
<td>Yes</td>
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<td>5 days*</td>
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<td>M 66</td>
<td>Car injury</td>
<td>L1/A2</td>
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<td>No</td>
<td>4 days*</td>
<td>Discal</td>
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<td>3</td>
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<td>Falling</td>
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<td>4</td>
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<td>Car injury</td>
<td>L2/A3</td>
<td>Cocaine abuse</td>
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<td>6 days</td>
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<td>F 64</td>
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<td>L1/A3</td>
<td>Polytrauma</td>
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<td>20%</td>
<td>8 days</td>
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<tr>
<td>6</td>
<td>F 73</td>
<td>Falling</td>
<td>L1/A1</td>
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<td>Discal</td>
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<td>Thrombembolism</td>
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<td>8 days</td>
<td>Discal</td>
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<tr>
<td>9</td>
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<td>30%</td>
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<td>5 days</td>
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<td>No</td>
<td>6 days</td>
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logical signs; 60% are dealt with via orthopedic treatment and only 30% are surgically treated [1].

Surgery indications depend on 3 main criteria: the existence of potential neurological disorders directly related to the extent of recession of the posterior wall in the spinal canal, the level of kyphosis above the fractured vertebra correlated with the significance of the collapse and the stable or unstable nature of the fracture (Magerl’s classification).

For patients with neurological disorders, surgery is required in order to help the lesions stabilize and to recalibrate the canal. In the area of the dorsolumbar junction, surgery is also necessary in incidences of kyphosis above 20 degrees to curb corporeal collapse and prevent the onset of neurological disorders and/or of chronic low back pain. The stable or unstable nature of the lesions is assessed by checking for the occurrence of interpedicular listhesis, involvement of the posterior wall or disruption of the spinal arch.

The surgical procedure consists in conducting radicular decompression via a laminectomy at the site of the fractured vertebra and a fixation via a short or long arthrodesis with instrumentation at the site of the dorsolumbar junction.

With the usual orthopedic treatment, a brace is worn for three months, which produces consolidation within an average three to four months. The kyphosis must be between 10 and 15 degrees and the retropulsion of the bone fragment within the canal must be under 50%.

However, obese patients and/or patients with multiple traumas are commonly treated via reduction-fixation surgery because of the difficulty such patients have in wearing a brace.

Regardless of its nature, the selected treatment has to stabilize the fracture, reduce the kyphosis as much as possible, prevent a secondary displacement toward the spinal canal and reduce pain.

Wood and al. [11] have shown that both treatments surgical or orthopedic applied to stable burst-fractures limit the long-term development of the kyphosis by 2 to 3 degrees compared to the initial post-traumatic kyphosis. It must also be noted that 25% of treated patients experience debilitating residual pain.

This important point leads us to believe that a procedure of instant stabilization by P.M.M.A. injection can yield at least equivalent results regarding spinal static. Furthermore, vertebroplasty has already significantly proven its impact on spinal pain, with an improvement of over 80% while in one case out of four the treatment of pain lasted only 1 day [4].

In our series, the first two patients we treated exhibited in one case a new collapse of L2 that had occurred while the patient was wearing a brace following orthopedic treatment and in the other a flat-shaped

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**FIG. 4.** – L1 burst-fracture with dramatic decrease of the height of the vertebra (a) and important retropulsion of the posterior cortex fragment in the spinal canal (50% of the diameter) (b) without neurological symptoms.

Filling of the anterior 2/3 of the vertebral body without displacement of the free fragment (c). After 1 week follow-up radiographs show the stability of height restoration on the lateral view (d) and antero-posterior view (e) with a safety brace.

**FIG. 4.** – Burst-fracture de L1 avec diminution importante de hauteur du corps vertébral (a) et recul significatif du mur postérieur de 50 % du diamètre canalaire (b) sans signe neurologique. Remplissage des 2/3 antérieur du corps vertébral sans déplacement du fragment libre (c). Les radiographies de contrôle à 1 semaine montrent la stabilité de la restauration vertébrale de profil (d) et de face (e) avec un corset de sécurité.
FIG. 5. – 52 year old drug addict with L2 Burst-Fracture (a). Retropulsion of posterior cortex fragment by about 40% (b). Cement injection straight up the superior endplate (c) with no movement of the fragment in the spinal canal (d). The injection is performed in the anterior part of the vertebra.

FIG. 5. – Héroïnomane de 52 ans avec fracture de type A3 de L2 (a). Recul de 40 % du mur postérieur (b). L’injection de ciment redresse le plateau supérieur (c) sans modifier le fragment endocanalaire (d). L’injection se fait dans la partie antérieure de la vertèbre.

FIG. 6. – Polytrauma with L1 fracture. No brace possible. On 3D CT scan, the measurement of the height of the vertebra is done at the junction of the anterior third and the middle third and the Cobb angle is drawn, before vertebroplasty (a) and after (b). The cement filling has to avoid the posterior part of the vertebral body (c).

FIG. 6. – Polytraumatisé avec fracture de L1. Pas de corset possible. Sur la TDM 3D pré-vertébroplastie on mesure la hauteur vertébrale au 2/3 antérieur du corps et l’angle de Cobb est tracé avant (a) et après vertébroplastie (b). Le remplissage doit respecter la partie postérieure du corps vertébral (c).
secondary collapse after osteosynthesis. The other patients displayed various, traumatic or medical, associated pathologies for which the interdisciplinary debate that included the anesthetist, the surgeon and the neuroradiologist had led to recommend a treatment that minimized the period of confinement to bed and hospitalization.

The treatment involves mainly A3 or Burst fractures with fragment retropropulsions within the canal of up to 50% associated with multiple fracture features. Injections at the acute stage are considered risky because of these non-organized osseous cracks, but no symptomatic perivertebral leaking was observed in any of the patients who received early treatment in the week following the trauma. In particular, there was no visible trace of endocanal leakage of cement despite a ruptured posterior cortex. Moreover, the endocanal fragment was stable with no receding movement observed on CT scan performed before and after treatment. A2 fractures (butterfly like) with loss of substance presented no particular difficulty despite more significant discal leaking and only partial filling. This is an important point because these fractures are usually an indication for fixation surgery.

From a technical point of view, we have found it important to position the needle in the anterior third of the vertebra in the lower zone and for burst-fractures stop the injection after the two anterior thirds were filled without seeking to reconstruct the posterior wall, so as to prevent the possibility of intracanal displacement of the posterior cortex fragment.

The controlled plasticity of cement over time makes it possible to change the position of the needle or of the bevel if necessary and to wait for a hardening if cement begins to leak rapidly through a crack. We have felt that the performing of the injection is more delicate here than in the common debilitating spinal pathologies or tumoral lesions and must be carried out by an experienced professional who has had ample exposure to these techniques. Discal leaking is a frequent occurrence, especially at the level of the upper disk, and does not require that the injection be stopped. However, the injection must be repositioned or stopped in case of lateral or perivertebral leaking. A unilateral approach, usually latero pedicular right, allows a homogeneous injection throughout the vertebra by a single needle.

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As early as the next day, all patients had experienced relief from pain. This lasted throughout the follow-up period (three to six months), similarly to what is reported in debilitating vertebral pathologies. No patient developed a recurrence of the back pain even the patient with the refracture after treatment. This preliminary study did not have the purpose of correcting kyphosis but just to have a good stabilization in a long term. Orthopedic literature shows that this is rarely achieved and that at the most deterioration in this type of kyphosis is simply curbed by the conservative techniques (surgical or orthopedic). Other recent techniques such as kyphoplasty [9] provide the hope that this type of kyphosis can be sizably reduced if the results achieved with osteoporotic fractures kyphotic correction of approximately 14 degrees are duplicated in acute traumatic pathologies. Regarding vertebroplasty, Mu Huo Teng has shown that this also can produce a reduction of the kyphotic angle [8]. In our serie or 7 patients out of 12 we used a Castaing mattress, thanks to which a patient in procubitus who is reclining on the upper thorax and the iliac crests can be brought to a lordosis. This setup associated with the injection of cement under pressure produces in 5/7 cases a reexpansion of vertebral height that results in a significant reduction of an average 8 degrees of the kyphotic angle. This point is essential because the
residual kyphosis is a factor of comorbidity, mainly via respiratory and abdominal consequences and also probably chronic back pain [5].

The patients were up the next day. At the beginning of the experiment a safety brace was recommended for fifteen days whenever technically possible. Now, a patient with satisfactory radiological results who is pauci-symptomatic on the first day is released without bracing.

This preliminary series has demonstrated the very high tolerance of the P.M.M.A. injection at the acute phase of a trauma, and in particular the absence of the often-feared complications. On the other hand, antalgic stability after six months is satisfactory but it remains to be assessed over a longer period, which should prompt us to randomize our patients and include younger patients with no relative contraindications for an orthopedic procedure.

CONCLUSION

Because of the complications involved in the surgical or orthopedic treatment of A type fractures

Fig. 8. – Post-traumatic L1 and L2 fractures before vertebroplasty (a). The fractures were shown by the axial CT scan (b). The cement filling was mild because a lateral leak occurred required termination of the injection (c). The follow-up CT scan demonstrates the origin of the leak (d to f). L2 asymptomatic refracture with moderate increase of the kyphosis angle (g). Post-vertebroplasty osteosynthesis with no reduction of the kyphosis (h).

Fig. 8. – Fractures L1 et L2 post-traumatique avant vertébroplastie (a). Les brèches osseuses sont visualisées par la TDM axiale (b). Le remplissage est modéré en raison de l’apparition d’une fuite latérale conduisant à l’arrêt de l’injection (c). La TDM de contrôle confirme l’origine de la fuite (d à f). Refracture asymptomatic de L2 avec discrète augmentation de cyphose (g). Ostéosynthése post-vertébroplastie sans réduction de cyphose (h).
with recollapse, vertebroplasty as a response to high-energy spinal traumas now plays a very important role in our daily practice. Not only does it allow us to achieve the objectives of the orthopedic treatment stability, pain reduction but it also makes a correction of the kyphosis possible. This technique is of particular relevance in the case of patients who should be encouraged to regain their mobility within a short time, such as elderly patients with a first traumatic fracture. Lastly, if these results are confirmed, the eventual use of bioactive, for example phosphocalcic cement, will constitute a major asset in obtaining the most physiological type of bone reconstruction that it is possible to achieve, especially with young patients.

REFERENCES


COMMENTAIRE

JACQUES CHIRAS

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Il faut remercier les auteurs d’avoir colligé et insisté sur l’intérêt de la vertébroplastie dans les fractures traumatiques du rachis [1]. Il s’agit en effet, d’une indication méconnue de cette méthode thérapeutique, qui devrait rendre de très grands services en pathologie traumatique, mais il nous apparaît important de préciser certains points :

— le traitement précoce des fractures n’intéressant que les plateaux vertébraux supérieurs et inférieurs, ne pose pas de problème technique particulier, le ciment se répartissant harmonieusement dans le corps vertébral ;

— en revanche, il en est tout autrement des fractures intéressant les corticales postérieures, latérales ou antérieures du corps vertébral. En effet, dans les 15 premiers jours, le ciment ne peut être injecté sous pression dans le corps vertébral et il existe un risque important de fuite péritrachidienne ou intracanaulaire.

Il nous apparaît donc important d’insister sur le respect d’un délai de l’ordre de 15 jours à 3 semaines pour permettre au cal osseux de se former au niveau des corticales latérales et postérieures et éviter ainsi un risque de fuite potentiellement iatrogène et une impossibilité de remplissage d’un corps vertébral qui pourrait être responsable d’un échec thérapeutique.

Il apparaît donc essentiel de distinguer les fractures survenues à l’occasion d’un traumatisme mineur chez des patients ostéopéniques qui peuvent bénéficier d’un traitement précoce, des fractures traumatiques vraies pour lesquelles le traitement par vertébroplastie est élegant, très efficace, mais dans notre expérience doit être réalisé après un délai d’attente de l’ordre de 15 jours à 3 semaines pour permettre un début de cicatrisation et éviter ainsi les fuites extrarachidiennes.

Enfin pour ce type de fracture, survenant chez une population active à longue espérance de vie, le méthyl méthacrylate n’est probablement pas le ciment le plus adapté et des recherches doivent être faites pour la mise au point de ciment ostéo-inducteurs facilement injectable.

RÉFÉRENCE