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Original Research Article

Characteristics of osteonecrosis in osteoporotic vertebral fractures and the efficacy of balloon kyphoplasty treatment

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Osteonecrosis in osteoporotic vertebral fractures (OVFs) may lead to a continued source of chronic pain and disability for patients. This study aims to describe the characteristics of the osteonecrosis in OVFs and the efficacy of balloon kyphoplasty (BKP) for the osteonecrosis. This was a prospective study of 61 patients with the osteonecrosis in OVFs who underwent BKP. Their mean age was 68 years (55 to 90). All the patients received radiography, MRI and CT examination before BKP, and were performed a histological analysis of biopsies obtained from OVFs. Efficacy was assessed by changes in anterior vertebral body height, a visual analogue pain scale and the Oswestry Disability Index at one day preoperative, two days postoperative and final follow-up assessments. All the patients had back pain more than six weeks before surgery. The back pain had a certain feature that was distinctly proportional to activity and position. 54% of the osteonecrosis showed intervertebral clefts in radiography, 73% of the osteonecrosis showed intervertebral clefts in CT. 98% of the osteonecrosis showed a well-defined signal intensity in the location of the osteonecrosis on T2-weighted and short tau inversion recovery (STIR) in MRI. Histological examination revealed osteonecrosis in the 61 patients. Significant improvements in all efficacy measures were observed at the postoperative versus preoperative assessments; no significant differences were observed between the postoperative and final follow-up assessments. The osteonecrosis in OVFs can be diagnosed according to the pattern of back pain and the imaging characteristics, especially MRI. BKP is one of minimally invasive, safe and effective procedures for the disease.

Key words: osteonecrosis, osteoporotic vertebral fractures, diagnosis, kyphoplast

INTRODUCTION

As the geriatric population increases, the incidence of osteoporotic vertebral fractures (OVFs) has been increasing. It is estimated that 1.4 mil¬lion OVFs come to receive clinical attention (Johnell and Kanis, 2006). Most symptomatic fractures are adequately managed with a short period of rest or activity modification, narcotic analgesics, and a brace. However, approximately 150,000 OVFs every year in the United States are refractory to these measures and require hospitalization (Riggs and Melton, 1986). An intravertebral cleft in OVFs occurs in some of these patients, and will be a continued source of chronic pain and disability for the patient Yoon et al. (2005). It has become an interesting topic of focus. Other terms have been used to describe the same condition, including intravertebral vacuum cleft, intravertebral vacuum sign, intravertebral vacuum phenomenon, linear intravertebral vacuum, intravertebral vacuum cleft sign, intravertebral cleft, and intraosseous vacuum phenomenon, rendering the

concept of the disease ambiguous (Maldague et al.,1978); (Golimbu et al., 1986);(Libicher et al., 2007); (Bhalla and Reinus, 1998); (Theodorou, 2001); (McKiernan and Faciszewski, 2003) and (Peh et al., 2003). Given that the above-mentioned diseases all involve underlying avascular necrosis, we term the disease "osteonecrosis" in this study.

The osteonecrosis in OVFs is regarded as a benign lesion Ito et al. (2002), but vertebral collapse and kyphosis in some osteonecrosis vertebrae are progressive, becoming the source of symptoms (Lee et al., 2008). In the early stages, the affected vertebra is intact or has only a minor compressive fracture, then in the intermediate stages the vertebral body collapses, with the fracture being dynamically mobile. This is followed in the later stages by collapse of the posterior body wall with ensuing cord compression, resulting in prolonged back pain and/or paraparesis (Kim et al., 2003); (Jang et al., 2003).

Therefore, it is important to diagnose this disease earlier and use surgical intervention to prevent further vertebral collapse and kyphosis. BKP has been proved to be an effective treatment for OVFs, even for patients with cleft (Yang et al., 2014). The purpose of this study was to provide the characteristics of the osteonecrosis in OVFs to be diagnosed, and to evaluate the efficacy of BKP in patients with the osteonecrosis.

METHODS

Ethical approval for the study was obtained and written informed consent was obtained from all patients. This was a prospective study on the patients with the osteonecrosis in OVFs who underwent BKP.

Thus, the subjects of this study were 61 patients (41 women and 20 men) with the osteonecrosis who had been treated using percutaneous BKP between January 2006 and January 2011. Their mean age was 68 years (55 to 90). All the patients had severe back pain with no evidence of nerve damage. The symptoms, which had an insidious onset, had persisted from six weeks to two years (average nine weeks) and were refractory to conservative therapy. The inclusion criteria: (1) Osteoporosis was confirmed preoperatively using dual-energy X-ray absorptiometry; (2) Pathological analysis of the vertebral body tissue confirmed osteonecrosis. Exclusion criteria: (1) The osteonecrosis in patients with underlying malignancy was excluded from this study; (2) Patients without radiography, computed tomography (CT) or magnetic resonance imaging (MRI) were excluded before operation; (3) Patients with neurologic deficits excluded.

All patients had preoperative radiographs, MRI and CT scan reconstruction. MRI examination consists of T1-weighted imaging, T2-weighted imaging and short tau inversion recovery (STIR) sequences.

Percutaneous BKP was performed on the patients under general anesthesia with fluoroscopic guidance. A biopsy of the osteoporotic vertebra was obtained. Patients were assessed one day preoperatively, two days postoperatively and at the final follow-up. The anterior heights of the necrotic vertebra were measured on a lateral radiograph. Cement leakage was observed on post- operative CT scans. Axial sections and coronal and sagittal reconstructions of CT were performed on all the levels of cement injection. In addition, a visual analogue scale (VAS; 1-10, where 1 = no pain and 10 = the worst possible pain) and the Oswestry Disability Index (ODI) were used to evaluate the severity of pain and its influence on the subject's daily life.

The significance of differences between the one day preoperative and two days postoperative assessments, and the significance of differences between the two days postoperative and final follow-up assessments were evaluated by using paired sample t-tests (Statistical Package for the Social Sciences version 13.0; SPSS, Chicago, IL, USA), with a p-value of ≤ 0.05 considered statistically significant.

RESULTS

According to Figure 1a-1b, 54% of the osteonecrosis in VCFs showed a radiotranslucent zone on plain standing radiographs. 73% of the osteonecrosis showed an intravertebral cleft on CT-scans (Figure 1c-1d). All the osteonecrosis showed a low signal intensity in the location of the osteonecrosis on T1-weighted images, 98% of the osteonecrosis showed a well-defined signal intensity in the location of the osteonecrosis on T2-weighted and STIR in MRI (Figure 2a-2c). (90% of the osteonecrosis showed a well-defined high signal intensity on T2-weighted and STIR in MRI, and 8% of the osteonecrosis showed a well-defined low signal intensity on T2-weighted and STIR.)

According characteristics of clinical situation, the cardinal symptom was back pain with a certain feature that was distinctly proportional to activity and position. 68% patients in this study suffered back pain when walked or rested in bed, but the pain became severe when walked. The pain in 32% patients was almost completely relieved by rest, while symptoms returned as soon as the spine was loaded in an attempt to sit, stand, or walk.

All patients tolerated the procedure well (Figure 3a-3d) and experienced partial or complete relief of their back pain and mobilized satisfactorily. The mean follow-up was 27.4 months (18 to 53). There were significant improvements in the anterior heights of the necrotic vertebra, VAS and ODI at the two days postperative and final follow-up assessments compared with the one day preoperative values (Table 1). There were no significant differences between the two days postoperative and final follow-up assessments (Table 2). No major peri-operative complications were recorded, such as compression of the spinal cord, pulmonary embolism, or infection.

DISCUSSION

The osteonecrosis in OVFs is considered a rare disease in

Figure 1a Figure 1b Figure1c Figure 1d

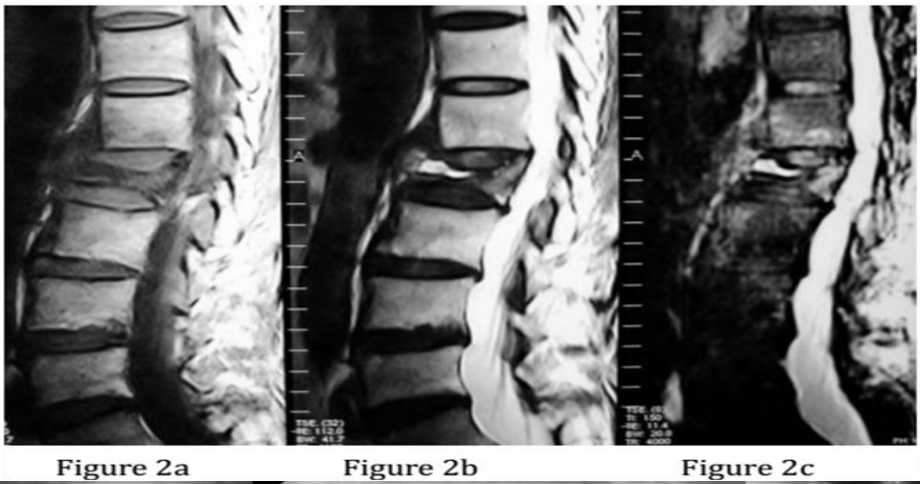

Figure 2a Figure 2b Figure 2c

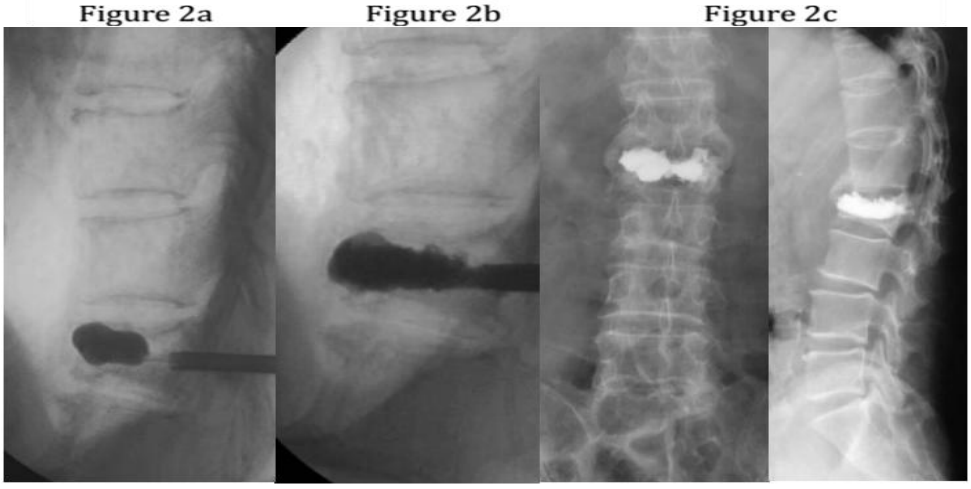

Figure 3a Figure 3b Figure 3c Figure 3d

Figure 1-3: A 75-year-old man has suffered from back pain for three months. Lateral X-ray film (Figure 1a) and posterior–anterior X-ray film (Figure 1b) showing severe compression fracture at L2. CT coronal and sagittal reconstruction images (Figure 1c-1d) showing an intravertebral cleft at L2. Sagittal T1-weighted MR image showing a low signal intensity in the location of the osteonecrosis in the body of L2 (Figure 2a). The sagittal T2-weighted MR image (Figure 2b) and short tau inversion recovery (STIR) image (Figure 2c) showing a well-defined high signal intensity in the location of the osteonecrosis. Balloon kyphoplsty was performed on the patient, expanding balloon (Figure 3a) and injecting cement (Figure 3b). Post-operative radiographs (Figure 3c-3d) showing cement filling the osteonecrosis well without leakage.

Table 1. Efficacy outcomes (mean; max~min) at one day pre-operative and two days post-operative assessments (n=61)

	Pre-operative	Post-operative	t	*p*
Anterior vertebral body height(%★)	34.7(18 ~ 53)	54.7(35~75)	-12.43	<.0001
Visual analog scale for pain	7.9(6~9)	2.4(0~4)	21.03	<.0001
Oswestry disability index	80.9(73~90)	31.4(15~45)	18.49	<.0001

★Anterior vertebral body height (%) = Fracture vertebra body height/ [(Upper Vertebral body height + lower Vertebral body height)/2]

Table 2. Efficacy outcomes (mean; max~min) at two days post-operative and final follow-up assessments (n=61)

	Post-operative	Final follow-up	t	*p*
Anterior vertebral body height(%★)	54.7(35~75)	53.1 (33~71)	2.12	0.0601
Visual analog scale for pain	2.4(0~4)	1.9(0~3)	1.82	0.0965
Oswestry disability index	31.4(15~45)	25.3(13~40)	2.01	0.0671

★Anterior vertebral body height (%) = Fracture vertebra body height/ [(Upper Vertebral body height + lower Vertebral body height)/2

Figure 4a Figure 4b Figure 4c

Figure 4: Sagittal MR images of common osteoporotic vertebral fractures showing a low signal intensity in the location of the fracture in the body of L1 on T1-weighted image (Figure 4a), a diffusional high signal intensity on T2-weighted MR image (Figure 4b)and short tau inversion recovery (STIR) image (Figure 4c).

the past (Kumpan et al., 1986). However, with the development of medical imaging and minimally invasive spine surgery, the disease is common (Stäbler et al., 1999). The osteonecrosis has a significant correlation with the phenomena of intravertebral clefts, its sensitivity up to 85% and specificity up to 99% (Libicher et al., 2007). The radiography is a basic examination method of the osteonecrosis, but its value is limited. These clefts indicating the osteonecrosis can easily be missed on standing lateral radiographs. This study shows the "cleft" phenomena occur in only 54% of patients with the osteonecrosis on lateral view radiographs. However, the "cleft" can be accentuated on lateral view radiographs with hyperextension (McKiernan and Faciszewski, 2003). It is reported that clefts were detectable by standing lateral radiography in 14% of OVFs, by supine cross-table radiography in 64% (McKiernan and Faciszewski, 2003). Therefore, for a suspected osteonecrosis, extension lateral

radiography can be taken to improve the sensitivity of diagnosis. CT is more sensitive than radiography in detecting the intravertebral cleft. This study shows the cleft is detectable by CT in 73% of the osteonecrosis, more sensitive than by radiography. Compared with radiography and CT, MRI is the most sensitive method of the diagnosis of the osteonecrosis. Mckiernan and Faciszewskireport hyperextension lateral radiography can find 64% of cleft, while MRI can find 96% of cleft in a prospective radiology study (Theodorou, 2001). This study shows the characteristics of the osteonecrosis are an area of well-defined signal intensity on the sagittal T2-weighted MR image and short tau inversion recovery (STIR) image. Sagittal T1-weighted MRI shows a low signal intensity change in the location of the osteonecrosis in this study, sagittal T2-weighted MRI and STIR show a clearly defined high signal intensity in 90% of the osteonecrosis, while a clearly defined low signal intensity in 8% of the osteonecrosis. The changes of high or low signal intensity on MRI depend on whether the osteonecrosis contains fluid or gas (Lafforgue et al., 1997). The osteonecrosis is different from common OVFs. It shows a well-defined signal intensity on MRI, while common OVFs show diffusional signal change (Figure 2a-2c, Fig 4a-4c). According to these characteristic changes of the MRI, the osteonecrosis can be earlier diagnosed to take effective measures to prevent vertebral body further collapse and kyphosis, and to avoid spinal cord compression.

The patients in this study have suffered back pain for a long time with over six weeks. The cardinal symptom is back pain with a certain feature that is distinctly proportional to activity and position. The pain in some patients is almost completely relieved by rest, most often in a lateral decubitus position, while symptoms return as soon as the spine is loaded in an attempt to sit, stand, or walk. The pattern of the pain is helpful in the diagnosis of osteonecrosis. The back pain may be attributed to pseudarthrosis or to spinal deformity Mirovsky et al. (2005).

In addition, the patients in this study received long term conservative management with pain control, bracing and bed rest but with no improvement in the symptoms. This phenomenon shows that the osteonecrosis is refractory to conservative treatment, and bed rest is extremely dangerous for elderly patients for a long time. Once OVFs with osteonecrosis have progressed into serious collapse, there is an increased risk of nerve injury (Chou and Knight, 1997); (Baba et al., 1995). Lafforgue et al., (1997) reported that in 19 cases of VCF with a cleft there were five with nerve injury, including compression of a lumbar nerve root, the cauda equina syndrome, and spastic paralysis. Thus, earlier surgical intervention is required to relieve symptoms and to prevent further vertebral collapse. Open surgery such as bone grafting and internal fixation can be used to treat the disease (Swartz and Fee, 2008); (Li et al., 2007), but it is not the first choice because osteoporotic bone does not fuse well and is often too weak to support instrumentation (Evans et al., 2003). Open operation is mainly reserved for osteoporotic fractures with neural compromise, when decompression is needed. With the development of minimally invasive spine surgery, a less invasive procedure is preferable for most patients who are elderly and severely osteoporotic (Peh et al., (2003); (Grohs et al., 2006); (Kim et al., 2004). BKP was used to treat VCFs with osteonecrosis in this study. The intravertebral instability at the site of osteonecrosis can disappear after injection of the cement. All patients had achieved partial or complete pain relief and an improvement in the level of daily activity. There was also a certain degree post-operative correction of the kyphosis and restoration of the vertebral height, which were largely maintained during follow-up. The results suggest that this procedure is effective for the treatment of OVFs with the osteonecrosis. Some studies have found that patients with osteonecrosis experience less reduction of pain and more difficulty with the activities of daily living after vertebroplasty than those without osteonecrosis, and that there is some loss of the postoperative kyphotic correction and height restoration at the final follow-up (Ha et al., 2006); (Peh et al., 2003). It seems that BKP might be more effective than vertebroplasty for VCFs with the osteonecrosis. Clearly, in order to compare kyphoplasty against vertebroplasty for the treatment of OVFs with the osteonecrosis, a prospective randomized controlled study is necessary.

Limitation of this study is that this study did not include the patients with vertebral fracture clefts that did not have osteonecrosis on the biopsy or did not have a biopsy.

CONCLUSIONS

In conclusion, this study demonstrates that the osteonecrosis in OVFs is a source of the back pain in patients with OVFs, refractory to conservative management. The osteonecrosis can be diagnosed according to the imaging characteristics, especially T2-weighted and STIR in MRI, combined with the pattern of back pain. BKP is one of minimally invasive, safe and effective procedures for the disease.

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Conflicts of interest

The authors have no conflicts of interest to declare in relation to this article

REFERENCE

Baba H, Maezawa Y, Kamitani K, Furusawa N, Imura S, Tomita K (1995). Osteoporotic vertebral collapse with late

neurological complications. Paraplegia., 33:281-289.Crossref

Bhalla S, Reinus WR(1998). The linear intravertebral vacuum: a sign of benign ertebral collapse. Am J Roentgenol., 170:1563-1569.Crossref

Chou LH, Knight RQ (1997). Idiopathic avascular necrosis of a vertebral body: case report and literature review. Spine., 22:1928-1932.Crossref

Evans AJ, Jensen ME, Kip KE, DeNardo AJ, Lawler GJ, Negin GA, Remley KB, Boutin SM. Dunnagan SA (2003). Vertebral compression fractures: pain reduction and improvement in functional mobility after percutaneous polymethylmethacrylate vertebroplasty: retrospective report of 245 cases. Radiology., 226:366-372.Crossref

Golimbu C, Firooznia H, Rafii M (1986). The intravertebral vacuum sign. Spine.,11:1040-1043.Crossref

Grohs JG, Matzner M, Trieb K, Krepler P (2006). Treatment of intravertebral pseudoarthroses by balloon kyphoplasty. J Spinal Disord Tech., 19:560-565.Crossref

Ha KY, Lee JS, Kim KW, Chon JS (2006). Percutaneous vertebroplasty for vertebral compression fractures with and without intravertebral clefts. J Bone Joint Surg., 88:629-633.Crossref

Ito Y, Hasegawa Y, Toda K, Nakahara S (2002). Pathogenesis and diagnosis of delayed vertebral collapse resulting from osteoporotic spinal fracture. Spine J., 2:101-106.Crossref

Jang JS, Kim DY, Lee SH (2003). Efficacy of percutaneous vertebroplasty in the treatment of intravertebral pseudarthrosis associated with noninfected avascular necrosis of the vertebral body. Spine., 28:1588-1592.Crossref

Johnell O, Kanis JA. An estimate of the worldwide prevalence and disability associated with the osteoporotic fractures, Osteoporos Int. 2006, 17:1726-1733.Crossref

Kim DY, Lee SH, Jang JS, Chung SK, Lee HY (2004). Intravertebral vacuum phenomenon in osteoporotic compression fracture: report of 67 cases with quantitative evaluation of intravertebral instability. J Neurosurg., 100,1Suppl Spine, 24-31.Crossref

Kim KT, Suk KS, Kim JM, Lee SH (2003). Delayed vertebral collapse with neurological deficits secondary to osteoporosis. Int Orthop., 27:65-69.

Kumpan W, Salomonowitz E, Seidl G, Wittich GR(1986). The intravertebral vacuum phenomenon. Skeletal Radiol., 15:444-447.Crossref

Lafforgue P, Chagnaud C, Daumen-Legre V, Daver L, Kasbarian M, Acquaviva PC (1997). The intravertebral vacuum phenomenon ("vertebral osteonecrosis"). Migration of intradiscal gas in a fractured vertebral body? Spine., 2:1885-1891.Crossref

Lee SH, Cho DC, Sung JK (2008). Catastrophic intramedullary hematoma following Kümmell's disease with large intravertebral cleft: a case report. Spine J., 8:1007-1010.Crossref

Li K, Li A, Hsieh C, Liao T, Chen C (2007). Another option to treat Kümmell's disease with cord compression. Eur Spine J., 16:1479-1487.Crossref

Libicher M, Appelt A, Berger I, Baier M, Meeder PJ, Grafe I, Dafonseca K, Nöldge G, Kasperk C (2007). The intravertebral vacuum phenomen as specific sign of osteonecrosis in vertebral compression fractures: results from a radiological and histological study. Eur. Radiol.,17:2248-2252.Crossref

Maldague BE, Noel HM, Malghem JJ (1978). The intravertebral vacuum cleft: a sign of schemic vertebral collapse. Radiology., 129:23-29.Crossref

Malghem J, Maldague B, Labaisse MA, Dooms G, Duprez T, Devogelaer JP, Vande Berg B (1993). Intravertebral vacuum cleft: changes in content after supine positioning. Radiology., 187:483-487.Crossref

McKiernan F, Faciszewski T (2003). The intravertebral clefts in osteoporotic vertebral compression fractures. Arthritis Rheum., 48:1414-1419.Crossref

Mirovsky Y, Anekstein Y, Shalmon E, Peer A (2005). Vacuum clefts of the vertebral bodies. Am J Neuroradiol., 26, 1634-1640.

Peh WC, Gelbart MS, Gilula LA, Peck DD (2003). Percutaneous vertebroplasty: Treatment of painful vertebral compression fractures with intraosseous vacuum phenomena. Am. J. Roentgenol.,180:1411-1417.Crossref

Riggs BL, Melton LJ 3rd(1986),. Involutional osteoporosis. N Engl J Med. 314:1676-1686.Crossref

Stäbler A, Schneider P, Link TM, Schöps P, Springer OS, Dürr HR, Reiser M(1999). Intravertebral vacuum phenomenon following fractures: CT study on frequency and etiology. J. Comput Assist Tomogr., 23:976-980.Crossref

Swartz K, Fee D(2008). Kümmell's disease: a case report and literature review. Spine., 33: E152-155.Crossref

Theodorou DJ (2001). The intravertebral vacuum cleft sign. Radiology., 221:787-788.Crossref

Yang H, Pan J, Wang G (2014). A review of osteoporotic vertebral fracture nonunion management. Spine. ,39 , b4-6. Crossref

Yoon ST, Qureshi AA, Heller JG, Nordt JC 3rd(2005). Kyphoplasty for salvage of a failed vertebroplasty in osteoporotic vertebral compression fractures: case report and surgical technique. J. Spinal Disord Tech., 18:S129-S134.Crossref