ABSTRACT

Purpose. To compare efficacy of balloon kyphoplasty in restoring vertebral height and correcting kyphosis in patients having vertebra plana with or without osteonecrosis.

Methods. 12 women and 3 men (mean age, 76 years), who had a complete vertebra plana with or without osteonecrosis (n=8 vs n=7), underwent balloon kyphoplasty. No external manoeuvres were performed before or during balloon kyphoplasty, except for positioning the patients in a prone posture on the operating table. The anterior, middle, and posterior vertebral height and the kyphotic angle were measured pre- and post-operatively with a digital imaging system. The vertebral height was measured as a percentage of the adjacent normal vertebral height.

Results. Respectively in vertebra plana patients with or without osteonecrosis, the mean corrections of (1) kyphosis were 10º and 4º (p=0.099), (2) anterior vertebral height were 33% and 5% (p<0.001), (3) middle vertebral height were 38% and 18% (p=0.004), and (4) posterior vertebral height were 19% and 2% (p=0.031).

Conclusion. In patients with vertebra plana, it is important to identify any osteonecrosis, which is an indication for balloon kyphoplasty to restore vertebral height and correct kyphosis.

Key words: bone cements; fractures, compression; osteonecrosis; osteoporosis; spinal canal

INTRODUCTION

Minimally invasive stabilisation techniques for the osteoporotic spine include vertebroplasty and balloon kyphoplasty. Both are reported to confer great pain relief, but balloon kyphoplasty offers better outcomes for kyphotic deformity and older fractures.1–3 These procedures are generally not indicated for advanced vertebral collapse (vertebra plana), because restoration of vertebral height is difficult. Balloon kyphoplasty has been shown to correct deformity in vertebral compression fractures; best results have been achieved for fractures without total collapse. When osteonecrosis and pseudarthrosis were evident with vertebra plana,4,5 vertebroplasty was considered more suitable.6,7

We retrospectively reviewed and compared the efficacy of balloon kyphoplasty for vertebra plana...
with or without osteonecrosis.

MATERIALS AND METHODS

Between August 2002 and January 2005, 12 women and 3 men (mean age, 76 years; standard deviation, 5 years), who had a complete vertebra plana with or without osteonecrosis, underwent balloon kyphoplasty (Kyphon, Sunnyvale [CA], USA). Inclusion criteria were (1) a collapse of ≥2/3 of the anterior part or whole vertebral body, and (2) a painful fracture evident on magnetic resonance imaging (MRI). Based on the standing anteroposterior and lateral radiographs assessed by 2 independent examiners, 8 patients were classified as having osteonecrosis (group 1, Fig. 1) and the remaining 7 as not having osteonecrosis (group 2, Fig. 2). In cases of disagreement, patients were classified into group 2. The intra- and inter-observer variability (Kappa) was calculated.

Standing anteroposterior and lateral radiography and MRI were used to diagnose osteoporotic fractures and osteonecrosis. In cases of emergency, only radiography was performed as MRI was not readily available. If there was doubt, prone radiography was immediately performed to assess the reducibility of the fracture, which was the prerequisite for insertion of the balloon catheter.

The treatment scheme developed by the Swiss Society of Spine Surgery for balloon kyphoplasty was adhered (Fig. 3). It leaves enough room to include conservative treatment. In cases of osteonecrosis, early surgery is advised to avoid vertebral collapse. Most of our patients had kyphotic deformity, and were eligible for immediate balloon kyphoplasty.

Closed reduction was performed by positioning patients in a prone position on the operating table; no external manoeuvres were performed before or during balloon kyphoplasty. The anterior, middle, and posterior vertebral heights and the kyphotic angle were measured before and after (day 2) surgery with a digital imaging system. The vertebral height was measured as a percentage of the adjacent normal vertebral height.

Secondary measurements included pre- and post-operative (day 2) visual analogue scale (VAS) scores for pain, as well as pre- and post-operative (week 6) Short Form-36 (SF-36) scores for health, and the Oswestry Disability Index (ODI) for pain and disability assessment.

Statistical analysis was performed using the non-parametric Mann-Whitney U test and paired t-test. The general linear model was used to
determine differences in means. A p value of <0.05 was considered significant; between 0.05 and 0.1, marginally significant. Partial $\eta^2$ was reported as a measurement of the magnitude of a treatment effect for variables in the general linear models. Effect size of 0.01 relates to a small effect, 0.06 to a medium effect, and 0.14 to a large effect.\(^8\)

### RESULTS

The mean age of patients in groups 1 and 2 was 80 and 72 years, respectively ($p<0.02$). The mean period of conservative treatment before surgery was 8 weeks (group 1, 10 weeks; group 2, 6 weeks; $p=0.8$). The treated vertebrae were T7 (n=1), T9 (n=1), T11 (n=2), T12 (n=2), L1 (n=6), and L2 (n=3).

In groups 1 and 2 respectively, the mean corrections of (1) kyphosis were 10º and 4º ($p=0.099$), (2) anterior vertebral height were 33% and 5% ($p<0.001$), (3) middle vertebral height were 38% and 18% ($p=0.004$), and (4) posterior vertebral height were 19% and 2% ($p=0.031$) [Table 1]. Postoperative outcomes were more favourable in group-1 patients.

In group 1, a significant further reduction of the...
middle and posterior vertebral height was noted after balloon kyphoplasty, whereas in group 2 this was only found for anterior vertebral height (Table 2). A tendency of restoration of the middle vertebral height was shown in the group 1 only (partial \(\eta^2=0.274\), Table 2). A medium to large treatment effects were achieved after balloon kyphoplasty in restoration of anterior, middle, and posterior heights, which were significantly larger than those in the vertebroplasty group, except the anterior height which reached a large effect.

All clinical outcome scores (SF-36, ODI, and VAS) improved after balloon kyphoplasty, but differences in scores between groups 1 and 2 was not significant (Table 3).

Intra-observer variability was 0.84 (Kappa, 0.68; 95% confidence interval [CI], 0.26–1) and the inter-observer variability was 0.85 (Kappa, 0.68; 95% CI, 0.41–0.96). No complications (such as epidural leakage, spinal cord compression, or pulmonary embolism) were encountered during and after procedure.

**DISCUSSION**

Conservative treatment was considered the gold standard for osteoporotic vertebral fractures, but conferred risks of further vertebral collapse, increased kyphosis, and persisting pain. Vertebra plana with oedema on MRI is difficult to treat with vertebroplasty or balloon kyphoplasty. In severe vertebra plana, open surgery is recommended, but it is more invasive and at risk of peri-operative complications and screw loosening, particularly in elderly patients. Nonetheless, good results have been reported with fibular strut grafts or cages.

Osteonecrosis is also described as vascular necrosis, pseudarthrosis, and Kummel’s spondylitis, which are all different names for the same disease. On radiography or computed tomography, it typically manifests as an intravertebral cleft or ‘gas sign’ with fluid and gas in the intravertebral body (Fig. 4), which is usually benign and does not warrant biopsy. On MRI, it is seen as a dark zone on T1-weighted and a bright area on T2-weighted or short tau inversion recovery images (Fig. 5). It may progress into a vertebra plana or severe kyphosis, particularly in the elderly. Histologically, osteonecrosis shows necrotic granulation and fatty degeneration of the
bone tissue, with a fibrocartilaginous membrane surrounding the fluid and absence of any new endochondral bone. Its risk factors include malignancy, infection, radiation therapy, liver cirrhosis, alcoholism, steroid treatment, and rarely sarcoidosis, haemoglobinopathies such as sickle cell anaemia, or dysbarism after diving accidents. Disruption of anterior vessels after trauma may cause osteonecrosis. Osteonecrotic vertebral fractures may lead to persistent chronic pain.

Balloon kyphoplasty confers a lower risk of complications such as leakage and pulmonary embolism and is effective for pain relief. It is suitable for patients with osteonecrosis who usually have a poor healing capacity and dynamic instability. Significantly more restoration of the vertebral height was found in group 1. In group 2, one patient showed superior restoration of the vertebral height suggesting that osteonecrosis was missed.

In our study, the percentage increase in vertebral height in relation to the adjacent intact vertebra was measured. This makes the results comparable, without depending on the magnification factor of the radiographs. Our results can be compared with those using validated radiological measurements. In our study, restoration of the vertebral height was more marked in the anterior and middle than posterior parts, and was superior in patients with advanced vertebral collapse than with ‘normal’ osteoporotic fractures. In meta-analyses of the whole osteoporotic population, balloon kyphoplasty was reported superior to vertebroplasty for restoring vertebral height and correcting kyphotic deformity.

Closed reduction by prone positioning alone has been reported. Although vertebral height may decrease after deflation of the balloon, restoration of kyphosis and vertebral height was significantly better after balloon kyphoplasty than positioning alone. In osteonecrotic fractures, greater collapse of the vertebral body may occur after removal of the cement. In our study, there was no significant difference in the restored vertebral heights after balloon kyphoplasty or positioning alone. Closed reduction by positioning alone restores vertebral height in patients with osteonecrosis, and balloon kyphoplasty helps restore the middle vertebral height. Therefore, balloon kyphoplasty did not play an important role in restoration of vertebral height in our patients as it did in other series.

Vertebral fractures decrease the pulmonary capacity of these patients, in whom pulmonary disorders are the most common cause of death. This underlines the importance of identifying any osteonecrosis in patients with severe vertebral collapses. Osteonecrosis is therefore an important indication for balloon kyphoplasty to restore vertebral height and correct kyphosis.

REFERENCES