Cementoplasty in the Treatment of Avascular Necrosis of the Hip

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ABSTRACT. ***Objective.*** This retrospective study evaluated the role of percutaneous cementoplasty in the treatment of avascular necrosis (AVN) of the hip in order to postpone or avoid total hip replacement.

Methods. The study population comprised 40 patients (47 hips) with mean age of 46 ± 4.7 years and mean body mass index of 26.7 ± 4.6 kg/m^2. AVN was classified according to the Ficat-Arlet classification as one stage I, 30 stage II, and 16 stage III. The minimum followup was 9 months.

Results. It was found that 74.5% of hips were secondarily operated for total hip replacement a mean of 19.9 ± 15 months (median 14 mo) after cementoplasty. As well, 94% of patients with stage 3 AVN and 68% with stage 2 AVN underwent surgery. Twelve hips were not operated, with a mean followup of 39 ± 19.2 months. Pain decreased by more than 80% after cementoplasty in two-thirds of patients, but the mean pain-free interval was only 8.1 ± 6.6 months (median 5 mo). Nineteen of the 29 working patients were able to transiently return to work. The outcome was more unfavorable with radiological stage III AVN, joint effusion, and/or a double-line sign around the lesions on magnetic resonance images.

Conclusion. Despite early relief of pain, the results of the cementoplasty technique were disappointing, with need for arthroplasty surgery in most cases within 2 years. Alternative percutaneous techniques using different filler materials with osteoinductive properties should be evaluated in further studies. (First Release Dec 15 2008; J Rheumatol 2009;36:385–9; doi:10.3899/jrheum.080363)

Key Indexing Terms:
AVASCULAR NECROSIS CEMENTOPLASTY HIP

Avascular necrosis (AVN) of the femoral head raises 2 difficult problems: its prevention and especially its management. This disease occurs in young, usually active, men between the ages of 30 and 50 years; it is essential to postpone total hip replacement, which, although it provides excellent results, has a shorter lifespan in young, active patients with the possible need for repeated replacement of the prosthesis, and more uncertain longterm clinical results[1].

The approach of symptomatic treatment by offloading has been abandoned, as collapse of the femoral head is observed within 4 years in more than 80% of cases[2]. Many conservative surgical techniques have been proposed, with variable and controversial results. Core decompression, used for several decades, is designed to decrease the pressure inside the zone of necrosis, to promote vascular invasion and facilitate regeneration of the necrotic tissue[2,3]. It has been associated with other techniques such as injection of bone marrow[4,5] or bone morphogenetic proteins[6], cancellous bone[7-9], or vascularized fibula grafting[10]. These techniques have been evaluated in a number of studies with variable results, partly due to recruitment bias and lack of appropriate control groups.

Another approach would consist of reinforcing the zone of necrosis to prevent its collapse, thereby preventing progression to rapidly evolving and disabling osteoarthritis. One proposed technique consists of intraoperative injection of methylmethacrylate cement into the subchondral dissection space to restore a roughly spherical femoral head. Good short-term results on pain were reported, but the 7-year survival rate was only 25%[11]. The need for arthrotomy and traction on an orthopedic therapy table were possible factors

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involved in this deterioration of the results. The same group reported better results in another small series of AVN secondary to sickle cell disease, with 14 of 16 hips still improved at a mean followup of 5 years and 2 total hip arthroplasties[12].

We therefore proposed the use of percutaneous cementoplasty for the treatment of AVN of the hip. This technique has been largely validated in the treatment of vertebral fractures secondary to neoplastic or vascular disease[13], and was subsequently extended to the treatment of neoplastic bone lesions in other sites[14,15], and to certain osteoporotic vertebral fractures refractory to conventional analgesics[16,17]. The expected benefits of this technique in the treatment of AVN appeared to be adapted to this clinical setting, with an immediate analgesic effect, rapid resumption of weight-bearing allowing a return to work and social life, and finally, the possibility to significantly postpone total hip replacement.

We report the results of a retrospective review of 47 cases of AVN of the hip treated by cementoplasty in our institution since 1999 with a minimum followup of 9 months.

MATERIALS AND METHODS

Patient characteristics. This was a retrospective study based on 47 hips in 40 patients undergoing cementoplasty for AVN in our institution between 1999 and 2006. Patients received information on the potential benefits and risk of the technique and gave their consent to the procedure. The population was predominantly male (34 men, 6 women) with a mean age of 46 ± 4.7 years and a mean body mass index (BMI) of 26.7 ± 4.6 kg/m^2.

AVN was classified according to the following Ficat and Arlet classification: stage I: no radiologic sign; stage II: mixed areas of subchondral osteoporosis and sclerosis; stage III: subchondral fracture ("crescent sign"), minimal or local depression of articular surface; and stage IV: collapse of joint surface and subchondral bone ("flattening"), with secondary osteoarthritis.

All patients having symptomatic stage I to III AVN of the hip seen in departments of orthopedics or rheumatology during the defined period were included in the study. There was one patient with stage I, 30 with stage II, and 16 with stage III AVN. Cases with stage IV AVN were excluded because of the higher risk of cement leak. AVN was bilateral in 7 patients (17.5%).

Among the known risk factors for AVN, chronic alcoholism was present in 62.5% of cases, followed by dyslipidemia (50%), steroid therapy (27.5%), diabetes (10%), and a history of trauma (10%; Figure 1). Sixty percent of patients had at least 2 associated risk factors, and one of the 3 main risk factors (alcoholism, dyslipidemia, and steroid therapy) was present in more than 80% of patients. In terms of socioeconomic status, 6 patients had retired at the time of diagnosis, 4 were receiving a disability pension for other diseases, 1 was unemployed, and 29 patients continued to work.

Description of the technique. Cementoplasty was performed in an interventional radiology room, under strict aseptic conditions, under general anesthesia with spontaneous breathing, with the patient in the supine position. The site of necrosis was identified by fluoroscopy and computed tomography. Cement combined with gentamicin and tungsten (to make the cement radio-opaque) was injected into the zone of necrosis with an 11-gauge needle (diameter 3 mm) under manual pressure. The goal was to fill the necrotic area and prevent further collapse, but not to restore sphericity of the femoral head.

No other treatment was used except analgesia and a rest period of 24 hours after the cementoplasty procedure.

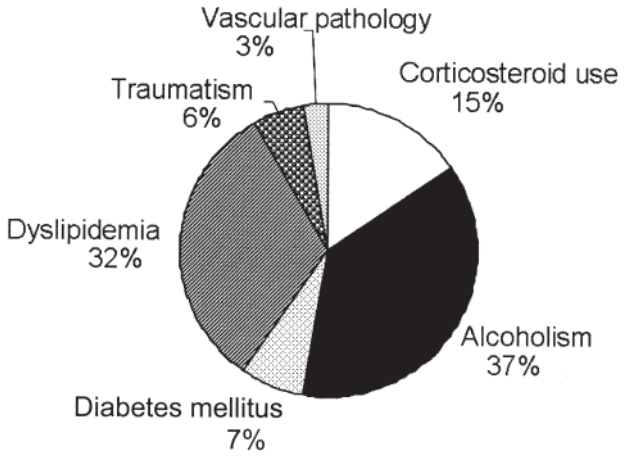

Figure 1. Risk factors for avascular osteonecrosis.

Clinical endpoints. The primary endpoint was the number of patients not subsequently requiring total hip replacement. Secondary endpoints were the interval (months) between cementoplasty and arthroplasty; the analgesic effect, measured by 100 mm visual analog scale (VAS), before the cementing procedure and 1 month later; the pain-free interval after cementing, i.e., the period when the analgesic result was maintained (variation of VAS < 20 mm); the walking distance reported by the patients before and 1 month after cementing; and the socioeconomic effects of cementing: return to full-time work, part-time work, job reclassification, disability, retirement or pre-retirement.

Radiological endpoints. The following radiological indicators were analyzed: Ficat-Arlet radiological stages; preoperative magnetic resonance imaging (MRI) criteria: i.e., area of necrosis (measured using 2D MRI in a coronal T1 plane, and expressed as the ratio of the largest necrotic area to femoral head area), bone marrow edema, double-border or double-line sign due to a chemical shift phenomenon[18], and joint effusion; and post-cementoplasty radiological assessment with evaluation of the quality of filling (volume of cement and site).

RESULTS

Secondary surgery for total hip replacement. It was found that 74.5% of cemented hips subsequently underwent total hip replacement after a mean of 19.9 ± 15 months (range 4–58 mo), median 14 months. It was found that 94% of patients with stage 3 AVN and 68% with stage 2 AVN underwent surgery. No significant difference in the time to total hip replacement was observed between these 2 stages of AVN. Twelve cases of cemented AVN (25.5%) did not undergo subsequent surgery, with a mean followup of 39 ± 19.2 months (range 9–60 mo): one stage I, 10 stage II, and one stage III.

Pain and functional assessment. The mean VAS pain score was 72 ± 49 mm (median 72.5 mm) before cementing (Figure 2) and 18 ± 17 mm (median 12.5 mm) 1 month after cementing (Figure 3). Pain resolved completely in 21% of cases. Almost 64% of patients reported a greater than 80% reduction of their initial pain after cementoplasty, while fewer than 10% of patients reported less than 50% reduction of their initial pain. However, this good immediate result was not maintained over time, with a mean pain-free inter-

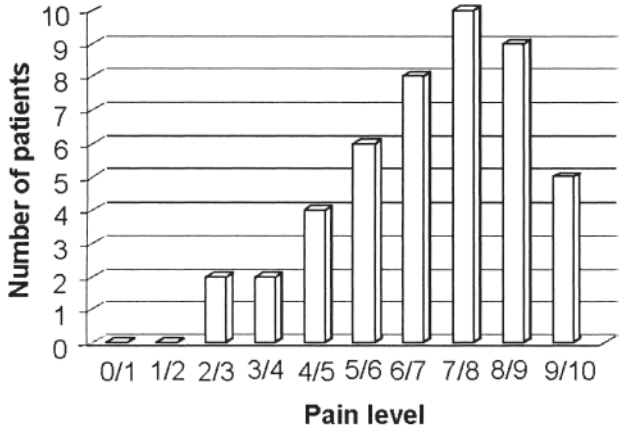

Figure 2. Pain assessed by visual analog scale before cementoplasty.

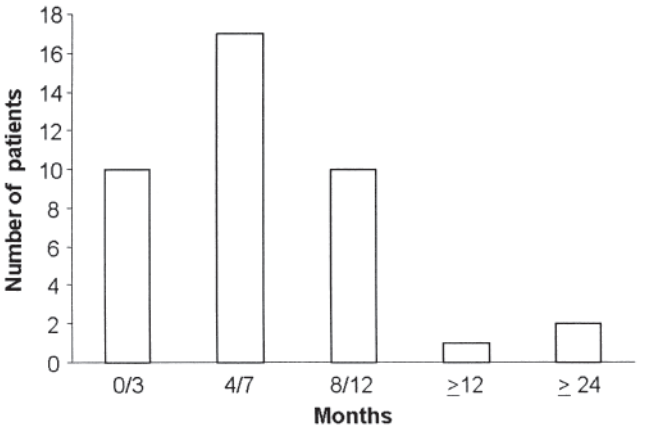

Figure 4. Duration of pain-free interval after cementoplasty.

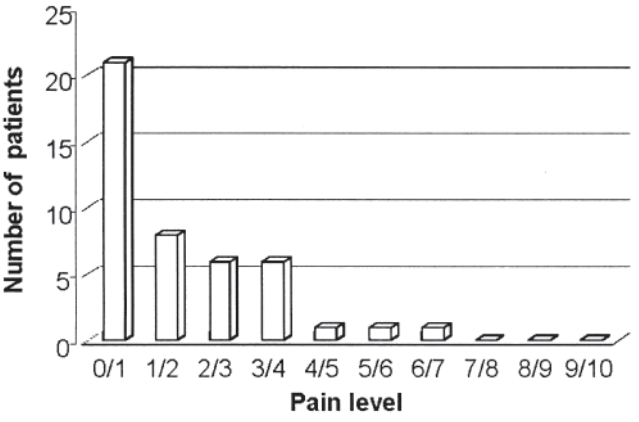

Figure 3. Pain assessed by visual analog scale 1 month after cementoplasty.

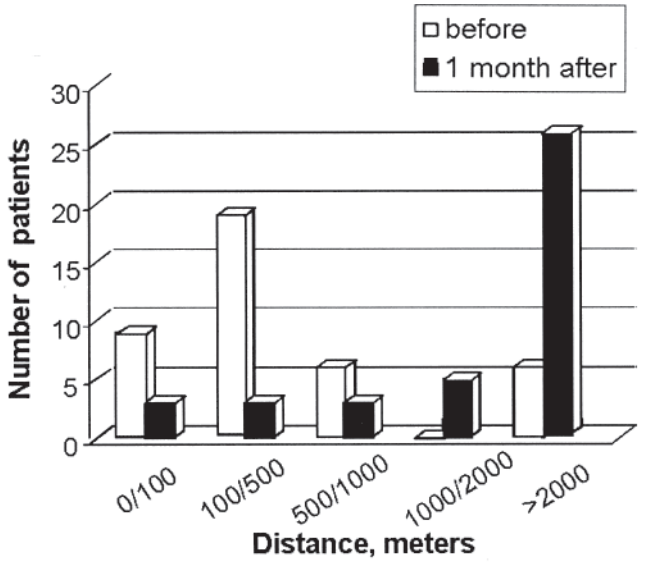

Figure 5. Evaluation of walking distance before and 1 month after cementoplasty.

val of 8.1 ± 6.6 months (median 5 mo; Figure 4). Only 2 patients did not report recurrence of pain.

The functional result assessed during this pain-free interval was also satisfactory, as almost 65% of patients regained a walking distance > 2000 meters, versus ≤ 500 meters before treatment in 79.5% of patients (Figure 5). This result deteriorated in parallel with the recurrence of pain.

We found that 41% of the patients subsequently requiring total hip replacement received at least one intraarticular steroid injection following recurrence of pain, but with no lasting result, and the mean interval between cementing and total hip replacement was not significantly different in this subgroup of patients.

Socioeconomic effects. Among the 29 patients working before the cementoplasty, 9 were able to return to full-time work, 4 returned to part-time work, 6 were reclassified, 8 were placed on a disability pension, and 2 retired or were placed on pre-retirement. Overall, 65% of patients were able to return to work, at least temporarily. As most patients were sedentary, the influence of treatment on sport or leisure activities could not be evaluated.

Radiological prognostic criteria. The data showed that 67% of patients with stage II AVN and 94% of patients with stage III AVN subsequently underwent total hip replacement. It was found that 81.8% of hips with MRI signs of joint effusion before cementing required total hip replacement, versus 67% without joint effusion. As well, it was found that 85.7% of cases with a double-line sign versus 65% without this sign required total hip replacement; and 90.9% of hips were operated when both these MRI criteria were present versus 44% in the absence of the 2 criteria, with a mean followup of 32 months. No correlation between Ficat stages and MRI criteria was observed.

In contrast, no significant difference was observed according to whether the necrosis area was less than or greater than 40%. No case had a necrosis area < 20% and the largest group had a necrosis area in the range of 30% to 40%

of the size of the femoral head (Figure 6). Bone marrow edema and site of the necrosis in a weight-bearing zone were present in almost all patients. The volume of necrotic space was, on average 40% filled (range 10%–80%). The results were not significantly different according to the filling of the necrosis area.

Complications of cementoplasty. Six intraarticular cement leaks were reported (including 5 patients with stage III AVN), and one case of acute chondrolysis was observed after cement leakage requiring total hip replacement within 6 months. One needle rupture occurred during cementoplasty, with no subsequent complication. No influence of cementoplasty on subsequent total hip replacement was observed.

DISCUSSION

The primary objective of treatment of AVN by cementoplasty was to provide an alternative to arthroplasty surgery. However, this objective was not achieved, as almost 75% of hips required surgery after a median of 14 months, independent of radiological stage. Twelve cemented hips were not subsequently operated, with a mean followup of 39 months after the procedure (range 9 months to 5 years). However, stable and satisfactory results in terms of pain and functional results and ability to return to work were obtained in only 5 of these hips, with return to full-time work after a brief recovery period not longer than 1 month. Notably, in 2 of these 5 cases, the cementoplasty procedure was performed preventively on an asymptomatic hip, while total hip replacement was indicated for the contralateral hip with symptomatic AVN. It is therefore difficult to assess the specific effect of cementoplasty in these 2 cases. Jergesen and Khan[19] reported results after a 5-year followup of 46 patients with AVN of one hip, and described clinical stability for 19 out of the 23 who had an asymptomatic contralateral hip without radiographic evidence of involvement. However, there was no demonstration of AVN in these contralateral asymptomatic hips. Inversely, Hernigou, *et al*[20] prospectively followed 40 patients with asymptomatic stage I AVN for 10 years: 35 (88%) became symptomatic and 29 (73%) developed collapse of necrotic zone. Depending on the series, collapse of the femoral head occurs in about 50% of cases, ranging from 32% to 79%[20-25].

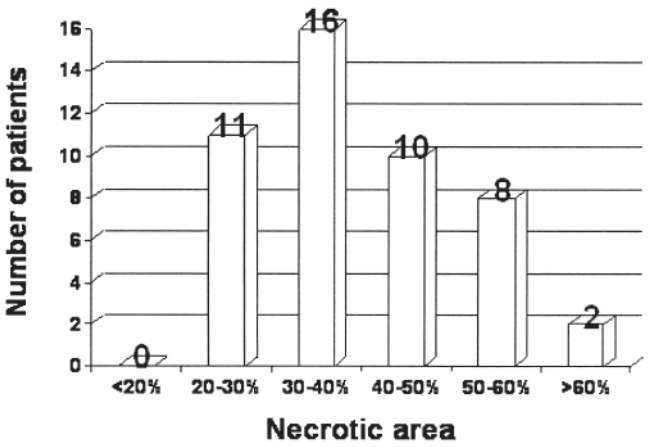

Figure 6. Distribution of population depending on size of the necrotic area, expressed as ratio of the largest necrotic area to the femoral head area.

Cementoplasty did not allow longer postponement of total hip replacement compared to data in studies evaluating other treatment options. In data in a metaanalysis of the core decompression technique based on 24 studies and 1206 hips[26], the best results were obtained for Ficat-Arlet stages I and II, with 84% and 65% with satisfactory results, respectively, after a mean followup of 30 months. Several studies subsequently confirmed these results, showing survival rates ranging from 75% to 100% for stage I, 50% to 70% for stage II, and 15% to 35% for stage III, with a mean followup of 24 to 72 months in various studies[3,10,27]. Bone marrow[4,5] or bone morphogenetic protein[6] injections, cancellous bone grafts[7-9], or vascularized fibula[10] were then proposed in combination with core decompression; but the results, although they were consistently better than symptomatic treatment, were variable as well and the real efficacy of these combined techniques has not been demonstrated. Compared to simple decompression, only vascularized fibula grafting[10] appeared to improve the 50-month survival after drilling for stage II AVN (89% vs 65%), but this is a major surgical technique and is not widely used. Injection of bone morphogenetic protein in combination with core decompression appears to be a promising technique, but insufficient data are available to date. Based on a small series, Lieberman, *et al* reported satisfactory results (Harris score > 80), with no total hip replacement for 14 out of 17 hips (82%) with a mean followup of 53 months[6].

The immediate analgesic effect described in the other indications for cementoplasty was also observed in our series. It is suggested that various mechanisms are responsible, including stabilization of the zone of necrosis and destruction of nociceptive nerve termini[13]. Recurrence of pain, after an average of 8 months, is also probably due to various mechanisms. In a subgroup of 19 cemented hips with radiological followup, the return of pain was not necessarily associated with radiological collapse of the AVN site, which occurred either before or after recurrence of pain. Eight hips showed radiological signs of deterioration with collapse of the necrosis, and 2 hips showed joint narrowing, reflecting chondrolysis. Nine of these hips remained radiologically stable, but only 5 of them were not operated.

The 12 nonoperated patients did not present a specific clinical profile in terms of risk factors, BMI, socioeconomic status, or age, which were all similar to those of the total population. As previously shown, stage III of the Ficat-Arlet classification and the presence of joint effusion or a double-line sign on MRI were predictive of poor prognosis. On the other hand, we found no correlation between lesion size and

prognosis. Since most investigators agree that hips with AVN with a volume < 15% have a better prognosis[28], we suggest that this unexpected result is mainly related to the large area of AVN in our population, i.e., > 20% in all cases. In addition, this specific feature of our population may have been responsible for the poor results in our series. Among other reasons, we suggest that constant improvement in technical skills, technical difficulties with small needle size, difficulty in targeting the necrotic area, and partial filling of the necrotic area could be significant, especially since these problems were not addressed in the surgical approach proposed by Hernigou, *et al*, who experienced better outcomes[11,12]. However, we found no clear relationship between clinical results and filling of AVN or any data suggesting an improvement-in-technical-skills response.

Five of the 6 complications due to intraoperative intraarticular leakage of cement were observed in cases with radiological stage III condition. These leaks were poorly tolerated, with night pain in 100% of cases after the cementoplasty procedure. This inflammatory type of pain was due to a foreign-body arthritis mechanism, as shown by MRI and histological findings in these secondarily operated patients.

Our study was designed to retrospectively evaluate an original percutaneous cementoplasty technique carried out in our institution since 1999. In our experience, despite early relief of pain, the results of this technique were disappointing, with a requirement for arthroplasty surgery in most cases within 2 years.

REFERENCES

1. Ortiguera CJ, Pulliam IT, Cabanela ME. Total hip arthroplasty for osteonecrosis: matched-pair analysis of 188 hips with long-term follow-up. J Arthroplasty 1999;14:21-8.
2. Mont MA, Carbone JJ, Fairbank AC. Core decompression versus non-operative management for osteonecrosis of the hip. Clin Orthop Relat Res 1996;324:169-78.
3. Mont MA, Ragland PS, Etienne G. Core decompression of the femoral head for osteonecrosis using percutaneous multiple small-diameter drilling. Clin Orthop Relat Res 2004;429:131-8.
4. Hernigou P, Beaujean F. Treatment of osteonecrosis with autologous bone marrow grafting. Clin Orthop Relat Res 2002;405:14-23.
5. Gangji V, Hauzeur JP. Treatment of osteonecrosis of the femoral head with implantation of autologous bone-marrow cells. Surgical technique. J Bone Joint Surg Am 2005;87 Suppl:106-12.
6. Lieberman JR, Conduah A, Urist MR. Treatment of osteonecrosis of the femoral head with core decompression and human bone morphogenetic protein. Clin Orthop Relat Res 2004;429:139-45.
7. Mont MA, Einhorn TA, Sponseller PD, Hungerford DS. The trapdoor procedure using autogenous cortical and cancellous bone grafts for osteonecrosis of the femoral head. J Bone Joint Surg Br 1998;80:56-62.
8. Steinberg ME, Larcom PG, Strafford B, et al. Core decompression with bone grafting for osteonecrosis of the femoral head. Clin Orthop Relat Res 2001;386:71-8.
9. Rijnen WH, Gardeniers JW, Buma P, Yamano K, Sloof TJ, Schreurs BW. Treatment of femoral head osteonecrosis using bone impaction grafting. Clin Orthop Relat Res 2003;417:74-83.
10. Scully SP, Aaron RK, Urbaniak JR. Survival analysis of hips treated with core decompression or vascularized fibular grafting because of avascular necrosis. J Bone Joint Surg Am 1998;80:1270-5.
11. Hernigou P. Traitement des nécroses de hanche par relèvement du séquestre et comblement par du ciment. Acta Orthop Belg 1999;Suppl 1:89-94.
12. Hernigou P, Bachir D, Galacteros F. Avascular necrosis of the femoral head in sickle-cell disease. Treatment of collapse by the injection of acrylic cement. J Bone Joint Surg Br 1993;75:875-80.
13. Deramond H, Darrason R, Galibert P. La vertébroplastie percutanée acrylique dans le traitement des hémangiomes vertébraux agressifs. Rachis 1989;1:143-53.
14. Cotten A, Demondion X, Boutry N, et al. Therapeutic percutaneous injections in the treatment of malignant acetabular osteolysis. Radiographics 1999;19:647-53.
15. Cotten A, Deprez X, Migaud H, Chabanne B, Duquesnoy B, Chastanet P. Malignant acetabular osteolysis: percutaneous injection of acrylic bone cement. Radiology 1995;197:307-10.
16. Cortet B, Flipo RM, Duquesnoy B, Chastanet P. Percutaneous vertebroplasty in the treatment of osteoporotic vertebral compression fractures: an open prospective study. J Rheumatol 1999;26:2222-8.
17. Grados F, Depriester C, Cayrolle G, Hardy N, Deramond H, Fardellone P. Long-term observations of vertebral osteoporotic fractures treated by percutaneous vertebroplasty. Rheumatology Oxford 2000;39:1410-4.
18. Radke S, Kirschner S, Seipel V, Rader C, Eulert J. Magnetic resonance imaging criteria of successful core decompression in avascular necrosis of the hip. Skeletal Radiol 2004;33:519-23.
19. Jergesen HE, Khan A. The natural history of untreated asymptomatic hips in patients who have non-traumatic osteonecrosis. J Bone Joint Surg Am 1998;79:359-63.
20. Hernigou P, Poignard A, Nogier A, Manicom O. Fate of very small asymptomatic stage in osteonecrotic lesions of the hip. J Bone Joint Surg Am 2004;86:2589-93.
21. Hernigou P, Lambotte JC. Bilateral hip osteonecrosis: influence of hip size on outcome. Ann Rheum Dis 2000;59:817-21.
22. Shimizu K, Akita T, Sakamoto M, Suguro T. Prediction of collapse with magnetic resonance imaging of avascular necrosis of the femoral head. J Bone Joint Surg Am 1994;76:215-23.
23. Koo KH, Ko GH, Song HR, Cho SH. Preventing collapse in early osteonecrosis of the femoral head. A randomised clinical trial of core decompression. J Bone Joint Surg Br 1995;77:870-4.
24. Lafforgue P, Dahan E, Chagnaud C, Schiano A, Kasbarian M, Acquaviva PC. Early-stage avascular necrosis of the femoral head: MR imaging for prognosis in 31 cases with at least 2 years of follow up. Radiology 1993;187:199-204.
25. Nishii T, Sugano N, Ohzono K, Sakai T, Sato Y, Yoshikawa H. Significance of lesion size and location in the prediction of collapse of osteonecrosis of the femoral head: a new three-dimensional quantification using magnetic resonance imaging. J Orthop Res 2002;20:130-6.
26. Mont MA, Hungerford DS. Current concepts review: non-traumatic avascular necrosis of the femoral head. J Bone Joint Surg Am 1995;77:459-74.
27. Simank HG, Brocai DR, Brill C, Lukoschek M. Comparison of results of core decompression and intertrochanteric osteotomy for nontraumatic osteonecrosis of the femoral head using cox regression and survivorship analysis. J Arthroplasty 2001;16:790-4.
28. Hungerford DS, Jones LC. Asymptomatic osteonecrosis: should it be treated? Clin Orthop Relat Res 2004;429:124-30.