

Percutaneous Injection of Bone Cement (Cementoplasty) for the Treatment of Symptomatic Subchondral Cysts

Anne-Sophie Bertrand^{1*}, Heidy Schmid-Antomarchi², Pauline Foti¹, Yasir Nouri¹, Emmanuel Gérardin³ and Nicolas Amoretti⁺

¹University Hospital of Nice, interventional scanner unit, route de Saint Antoine de Ginestière 06200 Nice, France

²National Center for Scientific Research Nice, unit 7277, section 28, route de Saint Antoine de Ginestière 06200 Nice, France

³Rouen University Hospital, Department of Radiology, 76000 Rouen, France

Abstract

Objective: To evaluate percutaneous computed tomography (CT) and fluoroscopy-guided injection of bone cement for the treatment of symptomatic subchondral cysts of the appendicular skeleton.

Methods: A single-center prospective study involving 13 consecutive patients with symptomatic subchondral cysts was done (8 women, 5 men). The average age was 67 years. Patients were treated by percutaneous CT-guided injection of bone cement into the subchondral cysts. Surgical treatment was not indicated or not wished by the patients who underwent cementoplasty. The lesions were all located in weight-bearing bones, involving the femoral head, femoral condyle, tibial plateau, talus and calcaneus respectively and consisting of subchondral cysts resulting from degenerative lesions or aseptic osteonecrosis. The clinical course of pain was evaluated using the Visual Analog Scale (VAS) before treatment, at one month and three months after treatment, with long-term follow-up from 2 months to 43 months (average follow-up: 22 months).

Results: Patient follow-ups in our series show supportive results: within 13 patients, 12 patients were satisfied with a long-lasting result after the procedure had been performed, and would recommend the intervention to relatives. The average evaluation of pain was 8/10 (SD: 0,49) before treatment, 3/10 (SD: 0,66) one month after treatment and 1/10 (SD: 0,60) three months after treatment. Our results show a significant decrease of the pain felt by patients between -before procedure and one month after the procedure- ($p=0,002$), -before procedure and three months after the procedure- ($p=0,002$), one month after the procedure and three months after the procedure ($p=0,011$). There were no immediate or delayed complications. We observed one asymptomatic para-articular cement leakage at the knee. One patient was not relieved after the procedure and underwent hip surgery.

Conclusions: Percutaneous injection of bone cement under CT and fluoroscopy guidance seems to be an effective and safe procedure in the treatment of symptomatic subchondral cysts with a significant decrease of patient's pain and a mini-invasive approach compared to classical surgical treatment. Thus we recommend that it should be considered as a first choice of treatment for symptomatic subchondral cysts.

Keywords: Subchondral cyst; Cementoplasty; Interventional radiology; Pain

Introduction

Since its first use thirty years ago [1], vertebroplasty, consisting of percutaneous injection of bone cement under imaging guidance [2], has been used in numerous variations for the treatment of several lesions such as vertebral metastases [3], osteoporotic or traumatic vertebral fractures [4,5], but also cementoplasty of malignant osteolyses in the appendicular skeleton [6-8].

There are few articles related to cementoplasty for the treatment of articular degenerative lesions in the literature. To our knowledge, only one article describes the aim of these interventions [9] on a small population of heterogeneous patients.

The objective of our study was to tell our experience in the treatment of degenerative subchondral cysts by percutaneous injection of bone cement, on a population of homogeneous patients presenting with incapacitating functional disability and for whom a surgical approach by implementation of prosthesis was not wished or not indicated considering the presence of comorbidities.

Materials and Methods

Patient population and selection

We present a prospective observational study on 13 consecutive

patients (five men, eight women, mean age of 67 years) suffering from symptomatic degenerative subchondral cysts of the appendicular skeleton. From October 2011 to October 2013, 13 patients were enrolled with no traumatic or surgical history noted. Most patients were suffering from intense mechanical pain and disability for walking. The lesions were located in the hip (femoral head: four cases), knee (tibial plateau: four cases; femoral condyle: two cases), ankle (talus: two cases) and calcaneus (one case). These subchondral cystic lesions were the results of degenerative changes caused by arthrosis in seven cases, and the consequence of aseptic osteonecrosis in six cases.

A pre-operative magnetic resonance imaging (MRI) was available for all patients before treatment, which showed or confirmed the presence of the degenerative subchondral cyst and the bone marrow

***Corresponding author:** Anne-Sophie Bertrand, University Hospital of Nice, interventional scanner unit, route de Saint Antoine de Ginestière 06200 Nice France, Tel: 06 18 91 62 45; E-mail: asbertrand3@hotmail.com

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edema. A request of Institutional Review Board approval was obtained and informed consent was obtained for each patient, including the risk of articular cement leakage.

A prospective follow-up was made, consisting of a post-operative MRI at one month to evaluate the decrease of bone marrow edema, and a quantification of pain was done by each subject on an 11-point numeric visual analog scale (VAS) with values from 0 to 10 (where 10 indicates the strongest pain ever experienced and 0 indicates absence of pain) by an independent evaluator. A difference in VAS > 2 points was considered a clinically significant result [10]. A clinical examination was made before treatment and at one month and three months after treatment to evaluate pain evolution.

Statistical analysis

The VAS score was measured at these three follow-up examinations. Pre and post operative scores were compared using the non parametric Wilcoxon signed-rank test for paired data. $P < 0,05$ was considered statistically significant. Statistical analyses were performed by using SPSS® Statistical Software (SPSS 11.0 for Windows).

Technique

All procedures were performed in a dedicated CT room for musculoskeletal radiological interventional procedures, using CT (Lightview 8-MDCT scanner, GE Healthcare, Waukesha, WI, USA) guidance and fluoroscopy (Stenoscop C-arm, GE Healthcare) guidance. All patients were treated by a senior interventional radiologist.

Volumetric CT acquisition with 1-mm slices was performed at level of the degenerative subchondral cyst involved, and then three-dimensional reconstructions allowed us to plan the procedure to abort the subchondral cyst by direct draining. The site of entrance assigned was located on the inferior part of the degenerative subchondral cyst, to avoid as best as possible intra articular cement leakage during the progressive filling of the cyst.

Patients were placed in a supine position on the CT table (Figure 1). Under aseptic surgical conditions and after local anesthesia, a 13-gauge 10-cm trocar (t'AM; Thiebaud, Thonon-les-Bains, France) was inserted under fluoroscopic and CT-guidance until it reached the inferior intracystic part of the subchondral cyst. A CT scan (SmartStep system, GE Healthcare) was used to confirm the correct positioning of the tip of the trocar.

Then, radiopaque cement (PMMA, Biomet V; Biomet, Warsaw, IN) was injected at the time its viscosity was high. The cyst was progressively filled from the most distal part of the joint until the cement reached the portion of the cyst adjacent to the articular surface (Figure 2). The injection was performed slowly and carefully, to avoid intra-articular cement leak. The mean amount of cement injected was 3 or 4 ml by patient.

A volumetric acquisition by CT scan was performed at the end of the procedure to confirm the optimal filling of the subchondral cyst and the absence of cement leakage.

Results

Data are summarized in Table 1.

Procedure

Treatment was technically successful in 13 cases and clinically successful in 12 cases (Figure 3-5). After percutaneous injection, all

the lesions were totally filled with bone cement. The feasibility of the procedure was 100% in our study. We reported one case with para-articular asymptomatic cement leak at the knee. There were no other immediate or delayed complications observed. One patient had no relief of his pain after the treatment and underwent hip surgery.

Follow-up

Patient follow-ups in our series show supportive results: within 13 patients, 12 patients were satisfied after the procedure had been performed, and would recommend the intervention to relatives. The average evaluation of pain was 8/10 (SD: 0,49) median 8/10 before treatment, 3/10 (SD: 0,66) median: 2/10 one month after treatment and 1/10 (SD: 0,60) median 0/10 three months after treatment (Figure 6). Our results show a significant decrease of the pain felt by patients between -before procedure and one month after the procedure- ($p = 0,002$), -before procedure and three months after the procedure- ($p = 0,002$), and -one month after the procedure and three months after the procedure- ($p = 0,011$).

The average follow-up period was 22 months (2-43 months). The MRI done one month after the treatment showed optimal filling of the lesions by the cement, and persistence of a small edema around lesions (Figure 7) corresponding to lasting inflammatory post-operative process.

Discussion

The etiology and pathogenesis of subchondral cysts still remain unknown [11]. Several theories have been postulated to explain their pathogenesis. Schajowicz and co-workers suggested there were two fundamental types of subchondral cysts [12]. First is "primary" or "idiopathic" subchondral cyst that arises de novo within the bone. This may occur due to intramedullary metaplasia followed by mucoid degeneration with intraosseous cyst formation. Alternatively, repeated microtrauma near the bone end may lead to local vascular disturbance and aseptic osteonecrosis. The revitalization of these areas produces fibroblastic proliferation and subsequent mucoid degeneration. The second form of subchondral cyst is thought to arise from an extraosseous stimulus by penetration of a soft tissue ganglion into the underlying bone, and represents the most important cause of subchondral cysts.

These subchondral cysts often occur near a degenerative joint and are known to be associated with osteoarthritis [13]. Proposed theory of the pathogenesis of subchondral cyst formation in osteoarthritis include bony micro contusions leading to necrosis, increased intra-articular pressure leading to extension of synovial fluid into the subchondral bone through tiny gaps in the articular surface (*bone contusion theory*) or the proliferation of myxomatous tissue within the bone marrow (*synovial breach theory*). Then, in the synovial fluid intrusion theory, the communication with the joint is an early feature, and a possible late feature in the bony contusion theory [14].

Subchondral cysts are benign para-articular intraosseous cyst, consisting histologically of a cavity of a variable size, without an epithelial or synovial lining, and containing mucoid viscous material [9]. They are non neoplastic bone lesions; they occur in the skeletally mature at all ages with a peak incidence in the 4th and 5th decade and have a minor male preponderance. They are mostly located in weight-bearing long bones of the lower limb [9].

Subchondral cyst, intraosseous ganglia and geodes are terms interchangeably in the literature. Subchondral cyst originally said to be rare, appears now to be a relatively frequent lesion. Confusing



Figure 1: Patients placed in a supine position on the CT table for the procedure done under CT and fluoroscopic guidance.



Figure 2: Image showing the injection of radiopaque cement at the time its viscosity was high; then the filling of the cyst was made slowly and carefully from the most distal part of the joint until adjoin the articular surface, to avoid intra-articular cement leak

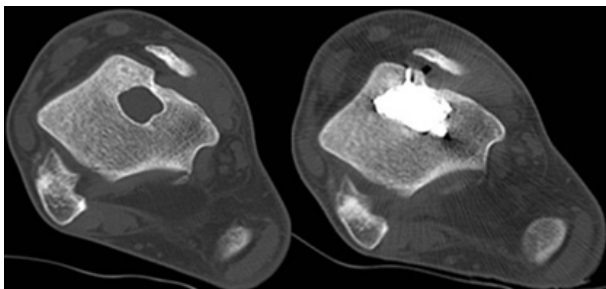


Figure 3: Axial CT images showing a subchondral cyst of the talus before the procedure and after the procedure, with a complete filling of the cyst by the cement.

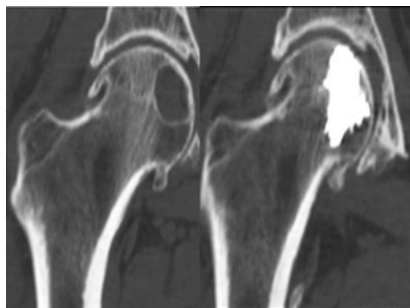


Figure 4: Axial CT images demonstrating an optimal filling of a subchondral cyst of the femoral head, and the absence of cement leakage.

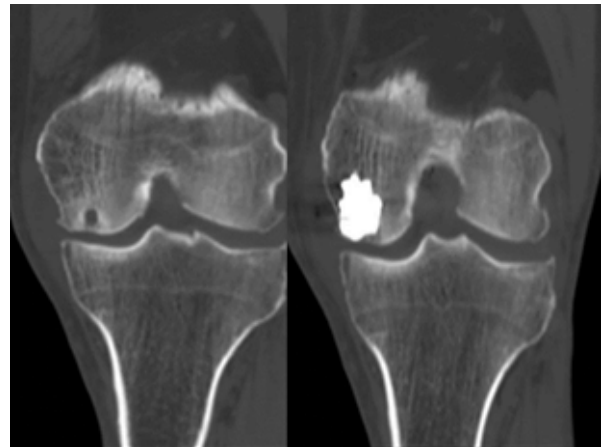


Figure 5: Axial CT images showing a subchondral cyst of the femoral condyle before and after the procedure, with an optimal filling of the cyst.

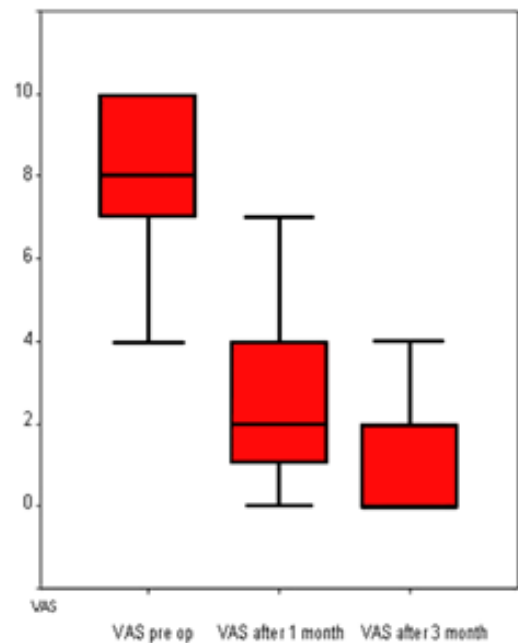


Figure 6: Evolution of the VAS score before and after the procedure

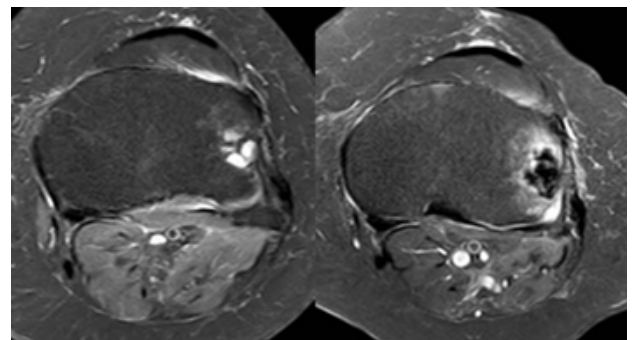


Figure 7: Axial T2-weighted fat-saturated MRI of the knee, showing the bone marrow edema around the multilocular cyst of the lateral tibial plateau before the procedure, and the optimal filling of the cyst by the cement after the procedure with persisting of a small edema around the treated lesion.

Patients	Sex	Age	Location	Cause	VAS before treatment	VAS one month after treatment
Case 1	Female	83 years	Tibial plateau	Degenerative	8/10	2/10
Case 2	Male	66 years	Femoral head	Aseptic osteonecrosis	4/10	4/10
Case 3	Female	75 years	Tibial plateau	Degenerative	9/10	6/10
Case 4	Male	80 years	Femoral condyle	Degenerative	7/10	3/10
Case 5	Male	64 years	Femoral head	Aseptic osteonecrosis	7/10	1/10
Case 6	Female	70 years	Calcaneus	Degenerative	10/10	2/10
Case 7	Female	70 years	Femoral condyle	Degenerative	9/10	0/10
Case 8	Male	45 years	Talus	Degenerative	7/10	1/10
Case 9	Female	61 years	Tibial plateau	Aseptic osteonecrosis	10/10	7/10
Case 10	Female	74 years	Femoral head	Aseptic osteonecrosis	10/10	2/10
Case 11	Male	34 years	Talus	Degenerative	8/10	6/10
Case 12	Female	91 years	Femoral head	Aseptic osteonecrosis	10/10	0/10
Case 13	Female	61 years	Tibial plateau	Aseptic osteonecrosis	7/10	1/10

Table 1: Percutaneous injection of bone cement in the treatment of symptomatic subchondral cysts: population, location, cause and follow-up

nomenclature, with no less than 12 different names [12], has undoubtedly contributed to the perception that these are uncommon. Intraosseous ganglia are histologically indistinguishable from a subchondral cyst arising in association with osteoarthritis and their outcome is similar [9].

These subchondral cysts can be responsible for acute or chronic articular pain in patients suffering from osteoarthritis due to the intraosseous development of the cyst and to the chondrolysis of the articular cartilage. The imaging of osteoarthritis is well known and includes joint space narrowing, cartilage loss, marginal osteophytosis and subchondral bone reaction [15]. After the clinical examination of a subchondral cyst lesion arising near osteoarthritis lesions, it is often difficult to estimate the benefit on patient's pain of a percutaneous injection of bone cement into the cystic lesion. Although subchondral cyst can be symptomatic, it may be difficult to ascertain whether the pain can be attributed solely to their presence. A progressive increase in size, surrounding bone marrow edema, or pathological fracture can indicate "symptomatic" subchondral cysts. Some authors have also demonstrated that subchondral cysts develop in pre-existing regions of subchondral bone marrow edema-like signal [15].

Osteoarthritis lesions and subchondral cysts predominate over weight-bearing bones due to excessive pressure in the articular space. Cementoplasty ensure bone consolidation by filling the cysts and decrease patient's pain. The interest of cementoplasty for the treatment of sub-chondral cyst in non-weight-bearing bones is limited because the stress zones are lower, hence less risk of collapse of the bone matrix and fracture (common complication of subchondral cysts). The interest would therefore be limited to pain treatment, and also must the size of the lesions be sufficient to be accessible to cementoplasty.

Our study shows a significant decrease of patient's pain after the treatment by percutaneous injection of bone cement under CT and fluoroscopy guidance ($p < 0,05$) at one and three months post procedure. Twelve elderly patients were significantly relieved of their pain after the procedure. These patients had several co-morbidities and were not indicated for a surgical approach. They were all suffering from intense mechanical pain, with the pain being to severe for the patients to stand on their painful leg. The procedure indication was evaluated very carefully for each patient, as management of symptomatic subchondral cyst depends largely on the clinical symptoms and degree

of degenerative joint disease. All the patients were suffering from a symptomatic subchondral cyst associated with bone marrow edema on the MRI performed before treatment, which indicated the concordance between clinical symptoms and imaging.

The alternative of cementoplasty was surgical treatment, consisting of curettage and bone grafting, which is the current reference standard for reconstruction of bone defects [16,17]. In case of advanced osteoarthritis of the joint, replacement surgery by prosthesis can be sometimes indicated. Success of surgery depends on selection of patients, the key indications for replacement are generally agreed to be end-stage arthritis and persistent severe pain [18,19]. All of our patients refused the classical surgical treatment and were interested in trying percutaneous injection of bone cement after a careful selection for eligibility by a senior interventional radiologist with 15 years of experience.

The procedures were performed under local anesthesia. No immediate or delayed complications were observed. The technique allowed early mobilization of the patients, with a minimal post-operative stay and a fast return to daily life activities. There was no blood loss, no major skin scar, relative absence of post-operative pain following the procedure, and a lowest cost compared to surgical treatment.

At our knowledge, there are few articles in the literature demonstrating the benefit of percutaneous injection of bone cement on subchondral cyst lesion of the appendicular skeleton. Gangi et al. [9] reported 5 cases of successful treatment of symptomatic subchondral cysts. We confirm these results on a larger series of 13 patients suffering from symptomatic subchondral cyst. Cementoplasty seems to be an effective and safe treatment for such lesions. In case of failure with persistent pain, patients can still attempt a surgical treatment. Bone cement is known to provide major pain relief in several benign and malignant conditions of the axial and appendicular skeleton, presumably related to its mechanical and chemical properties [3,6-8].

Our procedure was performed under CT and fluoroscopy guidance which allowed a better control of the progression of the trocar into the lesion. The three-dimension approach was direct with entrance point located at the inferior part of the subchondral cysts. The filling of the cysts was done very slowly and carefully to avoid intra-articular

cement leak. Axial CT images allowed us to plan the procedure and have optimal positioning of the needle and trocar.

We observed one para-articular non symptomatic cement leak at the knee. After 3 months of follow-up, the patient was still asymptomatic and no chondrolysis was observed. Intra-articular cement leak can be very damaging for the joint considering the risk of rapid chondrolysis. Rapid chondrolysis after an intra-articular leak of bone cement was reported in one case in the literature [20], as a rare and unusual complication of percutaneous injection of acrylic cement after the treatment of a benign acetabular subchondral cyst. This study suggests a chondrolytic effect of the acrylic cement due to the exothermic reaction produced by hardening of the cement in contact with the articular cartilage. During the polymerization of methyl methacrylate, there is liberation of residual monomer and free radicals which are potentially cytotoxic [21]. Thus, it seems essential to systematically search for the presence of an intra-articular passage before injecting bone cement into a peri-articular cyst.

Our study has some limitations. First, we did not compare our results to a control group treated conservatively. In fact, it was difficult not to treat demanding patients suffering from intense pain that we could propose a safe and efficient treatment option. Second, long-term clinical outcome still needs to be evaluated, as our average follow-up period was 22 months. Indications and benefits of cementoplasty in the treatment of symptomatic subchondral cysts have to be clearly defined for a usual use by interventional radiologists.

Conclusion

Percutaneous injection of bone cement under CT and fluoroscopy guidance seems to be a rapid, safe and efficient therapeutic option for symptomatic subchondral cysts. Further studies on larger population including a control group will be required to confirm our results. The balance benefits versus risks of this technique seem very satisfying, with significant decrease of patient's pain and advantages of a mini-invasive procedure compared to classic surgery. Thus we recommend that it should be considered as a first choice of treatment for symptomatic subchondral cysts.

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