Treatment of Sickle cell disease’s hip necrosis by core decompression: A prospective case-control study

M. Mukisi-Mukaza\textsuperscript{a,b,*}, O. Manicom\textsuperscript{a}, C. Alexis\textsuperscript{c}, K. Bashoun\textsuperscript{a}, M. Donkerwolcke\textsuperscript{d}, F. Burny\textsuperscript{d}

\textsuperscript{a} Orthopaedics-Traumatology Unit, Pointe-à-Pitre University Hospital Center (UHC), CHU de Pointe-à-Pitre, 97159 Guadeloupe, France
\textsuperscript{b} Guy-Mérault Caribbean Drepanocytosis Center, Pointe-à-Pitre UHC, Pointe-à-Pitre, Guadeloupe, France
\textsuperscript{c} Radiology Unit, Pointe-à-Pitre UHC, Pointe-à-Pitre, Guadeloupe, France
\textsuperscript{d} Orthopaedics-Traumatology Unit, Brussels University Clinics, Erasme Hospital, Brussels, Belgium

Accepted: 20 July 2009

Summary

Introduction: The young age of patients, total arthroplasties complications risks, and implant costs justify evaluation of the results of core decompression in the treatment of sickle-cell disease avascular necrosis of the femoral head (ONFH).

Hypothesis: In sickle-cell disease necrosis, core decompression offers good relief from pain and delays the use of total arthroplasty in comparison to a conservatively treated control group by a simple non-weight bearing protocol.

Materials and Methods: From 1994 to 2008, among 215 drepanocytic adults, 42 patients (22 genotype SS, 20 genotype SC; 15 men, 27 women) presented symptomatic ONFH. We report the data from a prospective study of two patients’ groups: a non-operated group (16 patients aged 36.5\(\pm\)6.5 years, 23 hips) and an operated group (26 patients aged 30.3\(\pm\)2.8 years, 42 hips). The results were considered on the basis of change in clinical status according to the numeric evaluation of pain scale, the functional score of Merle d’Aubigné-Postel (MAP), the radiological progression of lesions, and the time delay to total arthroplasty.

Results: Twenty-three hips were conservatively treated by discharge (a pair of canes). After a follow-up period of 13.4\(\pm\)0.5 years, no pain improvement was noted \((p=0.76)\), and MAP score was unchanged \((p=0.27)\). Out of 23 hips managed by discharge, 9 stage IV hips (degenerative arthritis, 39.1\%) underwent arthroplasty after an average delay of 2.6\(\pm\)2.4 years.

Forty-two hips were treated by core decompression. The duration of follow-up was 11.3\(\pm\)1.8 years. Postoperatively, pain reduction and MAP score improvement were significant.
Treatment of Sickle cell disease’s hip necrosis by core decompression: A prospective case-control study

499

From 1994 to 2008, out of 215 drepanocytic adults at the Caribbean drepanocytosis centre (Pointe-à-Pitre UHC), 42 patients (22 genotype SS, 20 genotype SC; 15 men, 27 women, aged over 16 years) were symptomatic carriers of ONFH evolving to stages I, II or III (with sub-chondral dissection) according to the classification of Arlet et al. [12], adapted for modern imaging [13].

All patients in this series presented hip pain. A supplementary report included bone scintigraphy, simple tomography, tomodensitometry (TDM) or magnetic resonance imaging (MRI) [1,3,6,7]. Evolution of the lesions was studied by repetition of MRI and TDM at 6 weeks. The patients were divided into two groups:

- 16 non-operated patients, who refused surgery or presented a poor general state with numerous crises, pulmonary arterial hypertension, renal failure, skin ulcers (infectious risk) or immediate post-partum. These 16 patients (23 hips) were treated by temporary discharge during 2 to 3 months;
- 26 surgery patients, who underwent simple drilling (42 hips). Preoperative preparation was completed in consultation with physicians, anaesthetists and medical specialists in sickle cell disease.

Evaluation of the clinical results

Clinical signs reminiscent of drepanocytic ONFH were characterized by pain, caused especially by internal hip rotation, lameness, associated or not with limitation of joint mobility. Pain intensity was evaluated on a numeric pain evaluation scale (NPS): 0 (minimal) to 100 (maximal). The assessment of pain in hyperalgic patients was difficult, as some of them tended to under-evaluate or over-evaluate their pain. To make the NPS more reliable, it was necessary to correlate pain with taking antalgics according to three levels (levels I, IIa, IIb, III) to ascertain pain intensity more precisely [14,15]:

- level I: non-opioid peripheral antalgics (paracetamol; anti-inflammatory agents);

Discussion: Core decompression had a favorable clinical and radiological outcome superior to surgical abstention. Stages I and II ONFH remained stable after drilling, necessitating no arthroplasty (considered as a failure of drilling). The Koo and Kim Index above 30° in the non-operated group was a significant indicator of lesions degradation (p = 0.002). In addition to the indolence obtained by core decompression, the benefit of drilling was manifested by the prolonging theadjournment before arthroplasty end-point. It was respectively 7.4 ± 2.7 years in the operated group versus 2.6 ± 2.4 years in the non-operated group (difference of 4.8 years, p < 0.01).

Conclusion: The technique of core decompression remains a valid option in the treatment of ONFH. It may be especially recommended in under-equipped regions where drepanocytosis and its osteo-articular complications are frequent.

Level of Evidence: Level III case-control therapeutic study.

© 2009 Published by Elsevier Masson SAS.

Introduction

Drepanocytosis remains the leading cause of osteonecrosis of the femoral head (ONFH) in high-risk regions. Its frequency varies between 30 and 40% in adolescent or adult drepanocytic patients [1–3]. The unpredictable evolution of ONFH lesions conducts orthopaedic surgeons living in these regions to optimize preventive and therapeutic care. Without treatment, ONFH evolves towards arthrosic sequelae that are difficult to control. These joint complications appear at a very young age [1,4].

Treated early, ONFH lesions in sickle cell anemia patients may be reversible and evolve towards healing [5]. The literature reports therapies ranging from medical interventions, associated or not with discharge, to the surgical approach, i.e. core decompression in an early stage (simple drilling or associated with bone marrow or osteoinducing protein injection) or osteotomy [6–9]. These drepanocytic patients cannot support the heavy burden of surgical interventions and are sensitive to infections. The uncertain outcome of orthopaedic treatments and mechanical or infectious complications of total arthroplasties in adults as well as implant-prostheses costs [10,11] justify the evaluation of simple drilling in the approach to ONFH. Our prospective working hypothesis was that core decompression was better in controlling pain and slowing the use of total hip arthroplasty relative to a control group treated by simple discharge.

Materials and methods

Patients

From 1994 to 2008, 27 women, aged over 16 years) were symptomatic carriers of ONFH in 39 out of 42 hips (93%, p < 0.0001). Twenty-nine out of these 42 hips had a favorable evolution. Ten hips (23.8%) progressed to total arthroplasty, after a period of 7.4 ± 2.7 years, longer than the one of the non-operated group (p = 0.0007).

By comparing the two groups (operated and non-operated), the benefit of core decompression appeared very significant (p < 0.0001). In addition to allocating Patients osteonecrosis stages, the Koo and Kim Index estimated the severity and evolution of necrotic lesions in both groups. It indicated decline in the non-operated group (p = 0.002) and improvement for operated patients (p = 0.0002).

Discussion: Core decompression had a favorable clinical and radiological outcome superior to surgical abstention. Stages I and II ONFH remained stable after drilling, necessitating no arthroplasty (considered as a failure of drilling). The Koo and Kim Index above 30° in the non-operated group was a significant indicator of lesions degradation (p = 0.002). In addition to the indolence obtained by core decompression, the benefit of drilling was manifested by the prolonging the adjournment before arthroplasty end-point. It was respectively 7.4 ± 2.7 years in the operated group versus 2.6 ± 2.4 years in the non-operated group (difference of 4.8 years, p < 0.01).

Conclusion: The technique of core decompression remains a valid option in the treatment of sickle-cell disease avascular necrosis of the femoral head (ONFH). It may be especially recommended in under-equipped regions where drepanocytosis and its osteo-articular complications are frequent.

Level of Evidence: Level III case-control therapeutic study.

© 2009 Published by Elsevier Masson SAS.
The results were based on the evaluation of pain intensity (NPS), defined by grade 1 (no pain), grade 2 (less than 50 on the NPS, moderate pain relieved by level I or IIa antalgics), or grade 3 (more than 50 on the NPS, intense pain relieved by level IIb and III painkillers). Pain was assessed before treatment (discharge or drilling) and 6 weeks after treatment. Joint function was evaluated by the Merle d’Aubigné-Postel (PMA) score at 1 year [16].

Evaluation of the radiological results

ONFH was assessed by non-invasive techniques based on an algorithm defined in our centre: standard radiology, technetium 99m diphosphonate bone scintigraphy, TDM and MRI [3,17,18]. Drepanocytic ONFH was classified according to Arlet et al. [12] adapted to modern imaging [13]. Baseline anterior-posterior and lateral view examination highlighted changes in joint pattern, sphericity and congruence (without revealing stage I lesions by preradiological definition). TDM could show evolutive lesions despite the frequent presence of sclerotic images in stage II drepanocytosis. It allowed us to distinguish the seriousness of three types of stage III lesions: sub-chondral dissection, uni- or bipolar rupture without loss of sphericity, bipolar rupture with depression and definitive loss of sphericity of the femoral head. Healing was characterized by non-evolutive images of sclerosis or osteocondensation. MRI, according to the Index of Koo and Kim [19], permitted us to calculate the extent of the necrotic zone considered by criteria of severity. We studied two groups of lesions: group 1 (Koo and Kim Index of 0–30°) and group 2 (Koo and Kim Index above 30°).

Operating technique

The classic auger of Ficat and Grijalvo [20] as well as the Mazabraud trocar [9] were not used, because of cortical hardness at the point of introduction in the trochanteric mass and femoral head sclerosis in drepanocytic patients. A specific stainless steel auger (Carpenter 455) with an external diameter of 8 mm was developed by our Division in collaboration with the GEXFIX® Company (Switzerland). This is a hollow modular trocar with two parts: one that cuts 80 mm with lateral windows and possible extensions of 40, 80 or 100 mm. A tightening wrench to separate the auger from its extender and a graft-remover allow the extraction of core biopsy specimens for histological study (Fig. 1).

Drilling-biopsy was performed by the same operator, following the technique of Ficat and Grijalvo [20], on an orthopaedic table, in the supine position, under image intensifier control assuring anterior-posterior and lateral views of the hip. Drilling was transcutaneous, using the MMN-GEXFIX® auger mounted on a motor. It allowed 8-mm cervico-cephalic drilling and the collection of core biopsy specimens 6 mm in diameter. This unique sub-chondral drill respected the integrity of cephalic cartilage. Surgery was performed under general or epidural anaesthesia. Bilateral drilling could be undertaken during the same intervention. Twenty-four-hour drainage, mobilization and early respira-

• level II: weak (IIa) or average (IIb) central opioid antalgics;
• level III: strong central opioids (morphinic).

The two groups were statistically comparable (age, sex, uni- or bilateral lesions, lesion stages, time to diagnosis and duration of follow-up (Table 1).

Sixteen drepanocytic patients (23 hips) were not operated: eight genotype SS (50%), eight genotype SC (50%, NS); five men (31.2%), 11 women (68.8%, NS); seven bilateral lesions (43.8%), nine unilateral (56.2%, NS). Average age was 36.5 ± 6.5 years. They presented 23 affected hips: five in stage I, 12 in stage II, and six in stage III. Time to diagnosis was 2.5 ± 0.5 months, and the duration of follow-up was 13.4 ± 0.5 years.

Twenty-six drepanocytic patients (42 hips) were operated: 14 genotype SS (53.8%), 12 genotype SC (46.2%, NS); 10 men (38.5%) and 16 women (61.5%, NS) were treated for persistent hip pain due to evolutive lesions on imaging, which was repeated at least twice. Fifteen lesions were bilateral (57.7%), 12 unilateral (52.3%, NS). Average patient age was 30.3 ± 2.8 years. We observed 10 hips in stage I, 13 in stage II, and 19 in stage III. Among all hips in different stages, the time period between diagnosis and treatment was 6 ± 2 months. Average length of hospitalization was 5 days (maximum 6, minimum 4), and patient follow-up duration was 11.3 ± 1.8 years. In comparing the
T reatment of Sickle cell disease’s hip necrosis by core decompression: A prospective case-control study

Table 1  Study population, time to diagnosis and follow-up.

<table>
<thead>
<tr>
<th>Non-operated (N=16)</th>
<th>Core decompression (N=26)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 36.5±6.5 years</td>
<td>30.3±2.8 years</td>
<td>NS</td>
</tr>
<tr>
<td>Men 5 (31.2%)</td>
<td>10 (38.5%)</td>
<td>NS</td>
</tr>
<tr>
<td>Women 11 (68.8%)</td>
<td>16 (61.5%)</td>
<td>NS</td>
</tr>
<tr>
<td>Genotype SS 8 (50%)</td>
<td>14 (53.8%)</td>
<td>NS</td>
</tr>
<tr>
<td>Genotype SC 8 (50%)</td>
<td>12 (46.2%)</td>
<td>NS</td>
</tr>
<tr>
<td>Bilateral 7 (43.8)</td>
<td>15 (57.7%)</td>
<td>NS</td>
</tr>
<tr>
<td>Unilateral 9 (56.2)</td>
<td>12 (52.3%)</td>
<td>NS</td>
</tr>
<tr>
<td>Time to diagnosis 2.5±0.5 months</td>
<td>6±2 months</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Follow-up duration 13.4±0.5 years</td>
<td>11.3±1.8 years</td>
<td>NS</td>
</tr>
<tr>
<td>Very satisfied or satisfied 16 (18.7%)</td>
<td>15 (57.7%)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

two groups, the difference in time to diagnosis was shorter in the non-operated group (2.5±0.5 months) than in the operated group (6±2 months, p < 0.001).

Pain evaluation

In the group of 23 non-operated hips before discharge, pain was quantified as grade 2 in 15 hips (65.2%) and grade 3 in eight hips (34.8%). After discharge, it persisted as grade 2 in 14 hips (60.9%) and as grade 3 in nine hips (39.1%). No improvement was observed, necessitating level IIb and III antalgics (p = 0.76).

Among the 42 operated hips, pain was scored as grade 2 in 24 hips (57.1), and grade 3 in 18 hips (42.9%), before drilling. After drilling, it was rated as grade 1 (no pain) in 28 hips (66.7%), grade 2 in 11 hips (26.2%), and grade 3 in three hips (7.1%). In all stages combined, the decrease in postoperative pain was constant, ranging from indolence to moderate pain in 39 out of 42 hips (92.8%), requiring level I or IIa antalgics (93%, p < 0.0001).

Evaluation of MAP score

In the absence of surgical support, in 23 hips, the MAP score was improved in eight hips at 1 year (34.8%), nine hips at three years (39.1%, going from 15 to 18). The score remained “fair to poor” (14 to <9) in 15 hips at 1 year (65.2%) and in 14 hips at 3 years (60.8%). It was statistically unchanged between evaluation before and after conservative treatment, at 1 or 3 years (p = 0.27).

After drilling, assessment of the MAP score in 42 hips revealed stabilization, showing improvement of joint function, scoring 15 to 18 (very good to good) at 1 year in 28 hips (66.7%) with degradation (14 to <9) in 14 hips (33.3%). At 3 years, 30 hips (71.4%) had a score of 15 to 18, 12 hips (28.6%) had a score of 14 to less than 9. Improvement was statistically very significant after drilling and throughout follow-up (p < 0.0001).

Evolution of necrotic lesions

In the group treated by discharge (23 hips): 5 (21.7%) were in stage I, 12 (52.2%) in stage II, and 6 (26.1%) in stage III. The time to diagnosis was 2.5±0.5 months. Lesion evolution was: a) among 5 hips in stage I, 2 (40%) were stable and 3 (60%) deteriorated towards stage III; b) among 12 hips in stage II, 3 (25%) were stable, 6 (50%) degenerated to stage III and 3 (25%) to stage IV; c) all 6 hips in stage III deteriorated to stage IV (Fig. 2A and B). In the non-operated group, lesion evolution was favorable in 5 out of 23 hips (21.7%). The Chi-square test showed no improvement after conservative treatment (p = 0.26). Nine hips (39.1%) in stage IV underwent arthroplasty after 2.6±2.4 years.

In the group of 42 hips treated by drilling, presenting painful and evolutive necrosis, 10 (23.8%) were in stage I, 13 (31%) in stage II, and 19 (45.2%) in stage III. In all stages combined, the time to diagnosis was 6±2 months. The evolution of these lesions was: a) all 10 hips in stage I were unchanged and stable; b) all 13 hips in stage II were unchanged and stable; c) among 19 hips in stage III, 2 (10.5%) improved, 4 (21%) stayed in the same stage, and 13 (68.4%) evolved towards arthrosis, i.e. stage IV (Fig. 3A, B, C). Twenty-nine out of 42 hips evolved favorably, the benefit from drilling being significant (p < 0.0001). Ten arthrotic hips (23.8%) were re-

![Figure 2](https://example.com/fig2.png)  Patient with genotype SS aged 21 years, left stage III ONFH treated by discharge (A). Unfavorable evolution towards subluxation osteoarthrosis at 3 years of follow-up (B).
operated, by uni- or bilateral arthroplasty after $7.4 \pm 2.7$ years.

**Evaluation according to the Koo and Kim Index**

In addition to ONFH staging, the Index of Koo and Kim [19] evaluated the severity and evolution of necrotic lesions in both patient groups. In the non-operated group, it was calculated by grouping stages I—II and III—IV during diagnosis. It was below 30° in 12 hips in stages I—II (52.3%) and in 1 hip in stages III—IV (4.3%); it was above 30° in five hips in stages I—II (21.7%) and in 5 other hips in stages III or IV (21.7%).

In the operated group, in stages I—II, the index was below 30° in 12 (28.5%) hips and above 30° in 11 hips (26.1%). In stages III—IV, it was below 30° in 6 (14.2%) hips and above 30° in 13 hips (30.9%).

In the last assessment (13.4 ± 0.5 years), an index above 30° was a severity factor. Comparing the Index of Koo and Kim in the non-operated group to the operated group, in terms of ONFH staging, significant degradation was evident in the non-operated versus the operated group ($p = 0.002$).

**Patient satisfaction**

Morbidity was absent in our series (no hematoma, infection, femoral neck fracture initiated by the drilling hole). In the non-operated group, three out of 16 (18.7%) patients were "very satisfied to satisfied", while 13 out of 16 (81.3%) were "hardly satisfied or unsatisfied". In the operated patient group, 15 out of 26 (57.7%) patients were "very satisfied or satisfied", and 11 (42.3%) were "hardly satisfied or unsatisfied". The difference was significant in patients treated by drilling ($p = 0.02$).

**Discussion**

The difference in follow-up duration for the two groups (13.4 ± 0.5 years for the non-operated group and 11.3 ± 1.8 years for the operated group) was not statistically significant. Given the bias in recruitment of our patients, we verified that the groups were similar and had the same length of follow-up (Table 1). In the non-operated group, temporary discharge of 2 to 3 months was difficult (premature discontinuation of 1 or both canes), if not impossible for patients to follow in case of bilateral lesions.

**Evaluation of pain and MAP scores**

By comparing the two groups, the decompression achieved with drilling would explain the antalgic effect and improvement of joint function in the operated group ($p < 0.0001$), ONFH accompanying stasis and intracapital hyperpressure phenomena responsible for pain. Decompression in the femoral head by drilling would account for the rapid antalgic outcome and the stoppage of hip function degradation [12,20,22–24].

**Evaluation of necrotic lesions**

The time to diagnosis of ONFH in the two groups could be explained by the under-evaluation of signs indicating hip pain or by accessibility to complementary examinations (TDM, MRI) of patients, with repetition of these tests investigating lesion evolution. Furthermore, drepanocytosis, a disease of pain, makes it difficult to differentially diagnose the pain of "drepanocytic crises" or "the beginning of hip necrosis" [3,15]. Repeated complementary examinations defined the evolutive character of the necrotic lesions.
The concept of evolution remains vital in the definition of drepanocytic ONFH and indication of drilling [3]. The time to diagnosis between groups was 3.5 months (p < 0.001). The shorter time period in the non-operated group could have been due to easier access to complementary examinations (TDM or MRI), for these patients with heavy medical histories and frequent or post-partum hospitalizations.

Simple drilling would produce greater improvement of necrotic lesions than surgical abstention. This benefit of drilling was noted by Bellot et al. [23]. ONFH operated in stages I and II remained stable after drilling without requiring arthroplasty (failure of drilling, p = 0.0001). A positive evolution was also reported by Styles and Vichinsky [7], in their series of 13 hips with a follow-up duration of 3 to 5 years. In addition to the indolence caused by decompression, the benefit of drilling was manifested by lengthening the time to arthroplasty (difference of 4.8 years, p < 0.01) in favor of the operated group, a significant difference which confirmed interest in the drilling technique. Given the frequency and severity of total hip prosthesis complications in drepanocytic patients, it would be desirable to undertake screening for an early diagnosis of necrosis, beginning with a simple surgical intervention (drilling) before considering arthroplasty [7].

Two cases of stage III ONFH (osteochondritis of the femoral head and necrosis with sub-chondral dissection) were improved without loss of sphericity (Fig. 4A, B). This reversibility of the lesions, after treatment, has been reported by Chung et al. [5] and Hernigou et al. [25]. The tunnel drilled, open after ablation of the core biopsy specimen, would serve as an outlet for decompression of the femoral head [12,22]. It would promote the colonization of conjunctive tissue, favorable to neovascularization of the femoral head by vessels of the peritrochanteric region. This neovascular theory [12] would explain the repair of bone lesions observed in our study. Osteocondensation images were considered as stages of wound-healing of medullary necrosis, translating to non-evolving ONFH. They were the result of repetitive ischemic characteristics.

### Evaluation according to the Koo and Kim Index

As in the study by Hernigou and Lambotte [26], the Koo and Kim Index was a significant factor of lesion degradation. It was more significant in the non-operated than in the operated group in our series. Failure of drilling was assessed by prosthetic revision (with its time of occurrence [23]).

### Patient satisfaction

Simple and effective drilling and the long time period before eventual arthroplasty may explain the satisfaction of operated group patients and permit better acceptance of reintervention in drepanocytic patients often anguished when confronted by the risks of a major surgery [27].

### Hip arthroplasty

Since the last 10 years, progress in anaesthesia and better medical care of the disease have made it possible to operate on drepanocytic patients under better conditions and to improve the results of hip arthroplasties (immediate indolence with enhanced prosthesis survival from 5 to 15 years). Nevertheless, the systematic use of total hip arthroplasty must be tempered by peri- and postoperative difficulties and complications [11,28]. In fact, Hernigou et al. [28] have reported that, out of 312 arthroplasties performed in 244 drepanocytic patients (average age: 32 years, average follow-up 13 years), 3% were revised because of infection, 27% because of medical complications and 13% because of postoperative orthopaedic complications. Considering the frequency of these complications, it is desirable to establish early screening of ONFH to achieve a simple surgical act (drilling) – to limit the use of arthroplasty [7,9,22]

### Conclusions

Discharge in the treatment of ONFH in drepanocytic adults may not be recommended because, to be effective, the procedure must be followed for 2 to 3 months, which is difficult, if not impossible, for patients with bilateral lesions.

Radiological and clinical developments have shown that drilling undertaken in the early stages of ONFH can stop the evolution towards debilitating arthrosis with some efficacy in stage I and II ONFH. It retains limited efficacy, both immediate and long-term, in stage III ONFH. Advanced staging and necrosis spreading must be well-described as they are criteria of the prognostic evolution after drilling.

If well done, this intervention requires brief hospitalization, causes no particular morbidity, and respects hip integrity in case of a new intervention. It is considered as a success if it allows arthroplasty to be deferred for a few years.

Given the fragility of sickle cell disease patients and the immediate (infection, luxation) or late (infectious or...
mechanical loosening) complications of hip prostheses, we recommend early screening of ONFH lesions for treatment by a simple act, that is, drilling, before considering arthroplasty.

This simple drilling technique retains its place in the treatment of sickle cell ONFH. It would be feasible in under-equipped regions where drepanocytosis and its osteoarticular complications are frequent. In the absence of MRI (diagnosis of pre-radiological or stage I ONFH), physicians and surgeons could resort to simple tomography or TDM. To record bone pressure in the femoral trochanteric mass, independently of a surgical intervention, under local anaesthesia, manometry could confirm the diagnosis of early-stage osteonecrosis. These three complementary explorations (bone pressure measurement, tomography or TDM) would permit screening and effective treatment, by drilling, of sickle cell necrotic lesions before the loss of sphericity or the occurrence of sub-chondral dissection.

Conflicts of interest

None

References