Percutaneous drilling for the treatment of secondary osteonecrosis of the knee

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Osteonecrosis of the knee comprises two separate disorders, primary spontaneous osteonecrosis which is often a self-limiting condition and secondary osteonecrosis which is associated with risk factors and a poor prognosis. In a series of 61 knees (38 patients) we analysed secondary osteonecrosis of the knee treated by a new technique using multiple small percutaneous 3 mm drillings.

Total knee replacement was avoided in 59 knees (97%) at a mean follow-up of 3 years (2 to 4). Of the 61 knees, 56 (92%) had a successful clinical outcome, defined as a Knee Society score greater than 80 points. The procedure was successful in all 24 knees with small lesions compared with 32 of 37 knees (86%) with large lesions. All the procedures were performed as day cases and there were no complications. This technique appears to have a low morbidity, relieves symptoms and delays more invasive surgery.

The knee is the second most common anatomical location for osteonecrosis after the femoral head, representing approximately 10% of all cases.1 When the disease involves the knee, similar associated agents and hypothesised patho-aetiologies to those for the femoral head are present.2-8 Since Ahlback, Bauer and Bohne,9 first described the entity in 1968, the term osteonecrosis of the knee has come to refer to two different disorders, which can be clearly distinguished, primary or spontaneous osteonecrosis10-17 and secondary osteonecrosis.18-25

The former is a unilateral disorder which generally appears in patients older than 55 years and usually involves a single femoral condyle or the tibial plateau.14 Patients present with acute severe well-localised pain. The condition is not associated with any known risk factors for osteonecrosis and typically there is no involvement of other joints. It is usually self-limiting and responds to non-operative treatment when lesions are small. In patients with larger lesions, it may lead to a collapse and the need for total joint replacement.

In comparison, secondary osteonecrosis of the knee is usually found in patients younger than 45 years and is the subject of our study. It often presents with multiple lesions of different size which may affect the distal femur, the proximal tibia, and/or the patella.26-27 It is bilateral in more than 80% of cases and the femoral head is also involved in approximately 90% of all cases.27 Patients have associated risk factors such as a history of the use of alcohol and corticosteroids, sickle-cell anaemia and systemic lupus erythematosus.27-28 Non-operative treatment is generally not successful, leading to total joint replacement in approximately 80% of cases.28-30 In one study, 26 of 32 knees (81%) treated by protected weight-bearing required total knee replacement (TKR) by the sixth annual follow-up.28

The optimal surgical treatment for secondary osteonecrosis of the knee is a matter of controversy. Core decompression with a large-diameter trephine28,31 with or without bone grafting,32-34 osteotomy35 and arthroscopic debridement36 have all been used. TKR,37-39 is reserved for patients with late stage of the disease.

Kim et al40 reported an improved outcome and lower morbidity with the use of a multiple small-drilling technique, in comparison with core decompression in patients with osteonecrosis of the femoral head. In their study the rate of collapse in the group treated by multiple small-diameter drilling was 14.3% compared with 45% in that treated by traditional core decompression. Since the year 2000, the senior author (MAM) has used multiple small drillings to perform core decompression of the hip and other affected joints as this appeared to be an easier technique with a smaller incision, less morbidity, and better clinical results. In the hip this technique has led to minimal
complications with no fractures. Our aim was to evaluate the early clinical and radiological results of this technique when used for secondary osteonecrosis of the knee. We analysed various clinical and radiological variables in relation to the clinical outcome. In addition, an evaluation of the morbidity of the procedure was made.

Patients and Methods
We reviewed the results of 61 core decompressions of the knee in 38 patients with early stage (pre-collapse) symptomatic secondary osteonecrosis, performed between September 2000 and May 2003. The study was approved by our Institutional Review Board. All the procedures were carried out using the small-diameter drilling technique. Inclusion criteria for the study were patients with true secondary osteonecrosis of the knee who had stage-I or stage-II disease according to Ficat and Arlet as modified for the knee. We excluded patients who presented with radiological collapse (stage III or IV), had a diagnosis of spontaneous osteonecrosis of the knee, or post-traumatic or post-arthroscopic osteonecrosis. All patients were prospectively enrolled in our database and studied for a minimum of two years after the procedure. None was lost to follow-up. A total of 13 patients (22 knees) had been treated elsewhere initially and had been offered more invasive procedures (osteotomy, bone grafting, and TKR) as treatment for persistent disabling pain. Post-operatively, the radiological and clinical outcome was assessed and clinical factors such as a history of previous core decompression, the location and size of the lesion, the aetiology of osteonecrosis, gender, age and the involvement of other joints were determined, to see if they had any prognostic effect on the clinical and radiological outcome.

There were 31 women and seven men with a mean age of 42 years (21 to 55). The mean length of symptoms before core decomposition was 31 months (1 to 108). Patients were followed up for a mean of 37 months (24 to 50). Of the 38 patients, 18 (29 knees) had received high dosages, of more than 2 g per month, of corticosteroids for a minimum of 3 months. Alcohol consumption was stratified according to Matsuo et al. The details of the associated risk factors in our series are shown in Table I.

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Number of patients</th>
<th>Number of knees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corticosteroids (total)</td>
<td>18</td>
<td>29</td>
</tr>
<tr>
<td>Systemic lupus erythematosus</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>Asthma</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Inflammatory bowel disease</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Multiple sclerosis</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Unspecified</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Idiopathic</td>
<td>16</td>
<td>24</td>
</tr>
<tr>
<td>Alcohol</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>HIV</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>38</td>
<td>61</td>
</tr>
</tbody>
</table>

Operative technique. The patients were placed in the supine position on a standard operative table. A tourniquet was not typically needed. A 3.2 mm drill bit was inserted percutaneously above the lateral femoral condyle under fluoroscopic guidance (Fig. 1) and was advanced until it reached the lesion in the epiphyseal region, as determined from the pre-operative radiograph or MR scan. Two passes were made into each condyle through smaller-sized lesions and three passes through larger-sized lesions using one common entry point. When advancing the pin, an effort was made to avoid penetration of the cartilage. Once the drilling had been completed, the pin was removed and the wound closed using either a simple bandage or a single nylon suture. For the lesions in the proximal tibia, the pin was inserted using an anterior approach just medial to the midline below the tibial tuberosity. Using the same skin entry point, the drill was then directed to either the medial and/or lateral tibial condylar lesion under fluoroscopic guidance. Any bleeding encountered because of entry to the medullary canal of the femur and/or tibia was controlled by applying pressure for five minutes.

Post-operatively, the patients were allowed 50% weight-bearing for four to six weeks using a cane or crutch in the opposite hand. Chemical prophylaxis for deep-venous thrombosis was not used routinely because these were day case procedures on patients who were mobilised immediately. If the patient had bilateral core decompressions, two crutches were used for a four-point gait. The patients were advanced to full weight-bearing as tolerated. Intensive rehabilitation throughout the recovery period, including strengthening of extensor muscles and range-of-motion exercises, was encouraged. If patients were asymptomatic at one year post-operatively with no radiological evidence of collapse, they were allowed to resume all activities, including high-impact loading sports such as running.

Evaluation of outcome. The clinical outcome was assessed by the authors pre- and post-operatively using the Knee Society rating system. At the time of final follow-up, any patient with a Knee Society score of less than 80 points or who had proceeded to a TKR, was considered to have an unsuccessful clinical outcome.

We retrospectively performed a clinical and radiological review of the medical records. Various parameters were assessed to see if they had any prognostic effect on the outcome. These factors included patient age (above or below 40 years), gender, the use of corticosteroids, the intake of alcohol, the length of symptoms (less than or more than 18 months) and associated co-morbidities such as systemic lupus erythematosus or infection with human immunodeficiency virus (HIV). Radiological factors analysed with respect to outcome included the size and the location of the lesion.

Pre- and post-operative radiological analysis included anteroposterior and lateral radiography as well as MRI.
These were assessed by two of the authors (GAM and TMS) to determine the stage and size of the lesion according to the system of Ficat and Arlet, as modified for the knee.\textsuperscript{27} This system defines stage-I disease as knees with normal appearance, and stage-II disease as those with cystic and/or osteosclerotic lesions. In patients with stage-I disease in whom plain radiography did not illustrate the lesion adequately, or in equivocal cases in which the lesion was not well delineated on the radiographs, an MR scan was used to stratify the size of the lesion using the method initially described by Lotke and Ecker.\textsuperscript{46} The volume of the lesion was approximated by multiplying the height by
width and depth of the lesion. Femoral and tibial lesions were stratified as small (zero to < 10 cc), medium (10 to 20 cc), or large (> 20 cc). The size of the lesion was then stratified and analysed according to clinical outcome. To assess inter- and intra-observer error in radiological measurements an evaluation of both authors was made. The inter-observer agreement was an exact match in 93% of the cases, and the reliability was excellent, with agreement of measurements in all cases (100%). Both authors independently assessed all the radiographs and MR scans and if there was a disagreement, the senior author interpreted the films until a decision could be made regarding staging, size or degree of collapse of the lesion.

Statistical analysis. The data were compiled and tabulated using Microsoft Excel spreadsheets (Microsoft, Redmond, Washington). Descriptive statistics were calculated using SigmaStat for Microsoft Windows Version 3.0 (SPSS Inc., Chicago, Illinois). For statistical analysis, a Student’s t-test with 95% confidence intervals (CI) was used for different subgroups to evaluate their effect on a successful or unsuccessful outcome. This included various clinical (age, gender, length of symptoms, and risk factors) and radiological (size and location of lesion) parameters.

Results

Small-diameter core decompression (Table II). Of the 61 knees (38 patients) treated by multiple drilling, 56 (92%) had a good or excellent clinical outcome at the most recent follow-up (mean 3 years; range 2 to 4). The mean objective knee score improved from 48 points (40 to 63) pre-operatively to 92 points (74 to 100) at the final follow-up (p < 0.0001). The final mean range of flexion was 112˚ (80˚ to 130˚). Five knees (8%) had a poor outcome, two of which required TKR. Both had a Knee Society score of 90 and 91 points at their final follow-up at two and three years, respectively. The remaining three knees (2 patients) with a poor outcome had persistent symptoms which required alternative surgical procedures. One patient underwent a bone-grafting procedure and one was treated by arthroscopic debridement for both knees. After these procedures, both had Knee Society scores of less than 80 points at the final evaluation.

Location of lesions. Evaluation of radiographs and MR scans showed that core decompression appeared to be more effective when osteonecrosis affected only the femoral condyles. Of 20 lesions, 19 (95%) exclusively involving the femur, had a successful clinical outcome (Table II). A slightly lower success rate was achieved in knees with lesions affecting both the tibia and the femur with 37 of 41 knees (90%) having a successful clinical outcome.

Size of lesion. Small and medium-sized osteonecrotic lesions responded better to small-diameter drilling than large ones (p = 0.02). All of the small lesions had a successful outcome (24 knees) compared with only 32 of 37 with large lesions (86%; Table II).

Clinical details and outcome. None of the following parameters had a significant effect on the outcome: gender, age, multiple joint involvement, length of symptoms, and associated co-morbidities (all p > 0.05). There was a trend for patients with systemic lupus erythematosus to have a higher rate of failure (12.5%) compared with other risk factors such as the history of corticosteroid use (without systemic lupus/erythematosus) which had a success rate of 91% (Table II).

Complications. There was a low morbidity rate and no intra-operative complications. Blood loss was greater when the lesion was located in the proximal tibia compared with the distal femur, but in most cases this was controlled by direct pressure at the entry point of the drill. One patient developed a post-operative haematoma which resolved within five days and had no further complications.

Discussion

Previous reports have used large-diameter trephines or drills to perform a core decompression.27,28 Our aim was to evaluate the early clinical and radiological outcome of a new technique of core decompression for secondary
osteonecrosis of the knee. This technique uses small-diameter percutaneous drilling. In a study using this technique on the hip, 80% of stage-I hips (24 of 30) had relief from pain and more extensive surgical procedures were deferred at a mean follow-up of 24 months (20 to 39). In that study, there was minimal morbidity with no fractures or other complications. In our study 97% of the knees (59) had symptomatic relief and delay of more invasive procedures. The success rate in smaller lesions was 100% and in the larger lesions 86%.

Secondary osteonecrosis tends to have a poor outcome with non-operative management. In general, the lesions are larger in size and occur in young and more active patients. In addition, patients are often immunocompromised secondary to other disease processes. Mont et al treated 32 knees with true secondary osteonecrosis of the knee non-operatively. At the final follow-up, only six (19%) survived the non-operative treatment.

In secondary osteonecrosis, for large lesions and collapsed femoral condyles and/or tibial plateaux, joint-preserving procedures often fail, necessitating TKR. For small lesions with intact articular surfaces, less invasive procedures such as the technique used in our study are justified. One validation for a surgical procedure such as core decompression is to delay TKR, which will probably not outlast the younger patient’s lifetime. This less invasive procedure may delay arthroplasty long enough for technology to catch up with patient demand. Two other factors come into play, namely, the morbidity of the procedure and its impact on the success of future TKR. It is common for patients with osteonecrosis to require more than one procedure in their lifetime. We believe that this procedure performed at an early stage in the disease does not adversely influence other more extensive procedures at a later time. In our series the two patients who had TKR performed because of failed small-diameter drillings had a positive outcome with a Knee Society score > 90 points at their most recent follow-up.

Other studies have described the use of core decompression for secondary osteonecrosis of the knee. Mont et al studied 47 early-stage knees (25 patients) managed by core decompression. Of these, 34 (72%) had a good or excellent Knee Society score at a mean follow-up of 11 years (4 to 16). All the patients in that study were less than 45 years of age to avoid considering patients who may have spontaneous osteonecrosis of the knee. In our study, the success rate was even higher with a favourable clinical and radiological outcome in 92% of knees (56 of 61) although the mean follow-up time was less (3 years; range, 2 to 4). Lorke, Battish and Nelson discussed the treatment of both primary spontaneous osteonecrosis and secondary osteonecrosis of the knee and concluded that core decompression was one of the three most widely reported treatment options, the other two being unicompartmental treatment and TKR. Furthermore, they noted that core decompression was the surgical procedure with the least associated morbidity. The percutaneous drilling technique used in our study is a modification of core decompression in which patients were immediately mobilised, with minimal morbidity being associated with the procedure.

Enright, Haake and Weisdorf reported a series of 28 patients with secondary osteonecrosis after bone-marrow transplantation and the use of corticosteroids. A total of six were treated by core decompression which failed to halt progression of the disease. All progressed to arthroplasty. In our study, TKR was avoided in 97% of patients with only two knees of 61 progressing to joint replacement. The other three knees with an unsuccessful outcome were treated by repeated core decompression or other more invasive procedures such as bone grafting. The possible requirement of future procedures, including repeated core decompression, should be taken into consideration when treating patients with early-stage osteonecrosis.

Although the reported outcome using our technique is good, there were several limitations of the study. It was a small series (61 knees) with a relatively short-term mean follow-up of three years. Only patients with symptomatic secondary osteonecrosis of the knee were included. We lacked a control group of patients because our technique was suggested as an immediate option for relief from pain to many patients who had been offered more invasive procedures such as TKR elsewhere. We do not believe that it is appropriate to withhold this method of treatment when the results of non-operative treatment have led to collapse in over 80% of patients. Our patients are complex and often have a history of previous invasive treatments which may have had an adverse effect on the outcome. However, the present percutaneous technique was straightforward, with low morbidity, and was easily mastered. In addition, it compared favourably with the standard large trephine core-decompression technique in terms of clinical results.

The desire to avoid a joint replacement in young patients in the early stages of osteonecrosis has prompted an increasing interest in alternative options. These new techniques have been implemented for the treatment of osteonecrosis of the femoral head and may become applicable to the knee. Non-operative options include pharmacological measures, the use of hyperbaric oxygen, pulsed electromagnetic fields and extracorporeal shock-wave therapy. Operative modalities may include cementation of the sequestered dead bone, stem-cell therapy and the addition of demineralised bone matrix, bone morphogenetic proteins and various other growth factors. Many of these methods may be used in conjunction with the presently described technique of percutaneous drilling.

Percutaneous drilling for the early stages of secondary osteonecrosis of the knee appears to be a reasonable initial surgical intervention which may preclude the later need for more invasive and complex procedures. It was successful in 92% of knees and performed well even in knees with large...
lesions. It has a low morbidity, is a quick procedure to perform and can be done as a day case. There have been no major complications and it appears to be a safe and effective alternative to alleviate symptoms and to avoid TKR in a high percentage of patients.

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References


