Core Decompression in Atraumatic Osteonecrosis of the Hip

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Abstract: Core decompression for osteonecrosis of the femoral head continues to be a controversial procedure. We report the results of core decompression in the treatment of hip osteonecrosis. Forty-two patients (67 hips) were evaluated. Minimum follow-up was 2 years. Preoperative outcome instruments were assessed. Volume of involvement (%) from magnetic resonance imaging was assessed. Failure was described as a total hip arthroplasty (THA). Mean patient age was 40.26 years. The average clinical and radiologic follow-up was 40.7 months and 33.1 months. The average Harris Hip Scores preoperatively and postoperatively were 49 and 58. None of the hips classified as Ficat I progressed to THA, whereas 17% of Ficat II hips and 66% of Ficat III hips progressed to THA. Our results demonstrate no relationship between the volume of involvement of the femoral head or the location of the lesion in progression to collapse. Staging with the Ficat classification demonstrated the most statistically significant correlation with progression to THA. The SF-36 scores at last follow-up on our patients were significantly worse than patients undergoing THA.

Key words: hip, avascular necrosis, core decompression, outcome, arthroplasty.

Osteonecrosis (ON) of the femoral head is a devastating disease that manifests itself primarily in young adults in their 20s to 40s. The natural history of ON includes collapse of the femoral head associated with end-stage arthritis, pain, and loss of function [1–7]. Haenisch [8] described this entity for the first time 70 years ago, and since then there has been an important increase in the incidence of the disease. In 1962, Mankin and Brower [9] described 27 cases [10]. The prevalence of ON is unknown, but there are 10,000 to 20,000 new cases per year in the United States [5]. The average age at onset of ON patients reported in most series has been 38 years [5,6]. The incidence of bilateral disease has been reported to range from 20% to 80% and even higher for patients treated with steroids [11].

Many reports on the cause, pathogenesis, progression, staging, and treatment of ON have been published [5–7,12–28]. Despite a number of studies relating specific risk factors to this disease, the pathogenesis remains a source of much controversy. ON has been associated with many conditions. Long-term corticosteroid use [1–3,5,19], alcohol abuse [2,3,12,13], smoking [13], systemic lupus erythematosus [25], sickle cell disease [18], organ transplantation [23], hypercholesterolemia and hypertriglyceridemia [17,20], Gaucher's disease, and Caisson's disease [29] are believed to be risk factors. Idiopathic cases are those in which no risk factor is apparent.

The treatment of ON is controversial. In 1964, Johnson [28] described the importance of increased intraosseous pressure within the femoral head in its pathogenesis. Arlet and Ficat [30] proposed that ON was produced by intraosseous hypertension followed by intramedullary venous stasis, edema, necrosis, fibrosis, and infarction [21]. Patients in their study who underwent diagnostic biopsy benefited
from pain relief. This finding led these investigators to believe that core decompression would also diminish intraosseous pressure and allow restoration of blood flow in the hypoxic femoral head.

Several investigators have shown that core decompression has promising results if performed in early-stage ON. At this time in the disease process, core decompression may delay the ongoing pathologic events, preventing or postponing collapse of the femoral head [21,30–32]. Other investigators have been critical of core decompression and concluded that it is an ineffective procedure with significant morbidity [6,33]. The differences in outcomes between studies could be due to different surgical techniques, volume of involvement of the femoral head, or different primary causes. We report here the results of core decompression in the treatment of ON with minimum 2-year follow-up.

Materials and Methods

Selection of Subjects

Between October 1992 and April 1996, 42 consecutive patients (67 hips) with ON of the femoral head were treated with core decompression at the University of Miami. Preoperatively, diagnosis was established by history, physical examination, radiographic findings, bone scan, and magnetic resonance imaging (MRI). All surgeries were performed by 1 surgeon (C.J.L.). In bilateral ON, both hips underwent core decompression during the same surgical procedure. All patients were followed for a minimum of 2 years.

Clinical Evaluation

Patient information was gathered prospectively using a standard preoperative questionnaire filled out during the first office visit. General health and a detailed history of associated risk factors for ON and medical comorbid conditions were assessed for each patient at this time. Surgery-specific outcome instruments, such as the Harris and Postel D’Aubigne (PD) hip scores, were recorded preoperatively for all patients. An SF-36 assessment was performed preoperatively for all patients. An SF-36 assessment was performed before surgery. A pain analog scale was used to score the frequency and intensity of pain quantitatively. These instruments were also used to assess outcome at 6 weeks, 3 months, 6 months, 1 year, and annually thereafter. Thirty-four hips (50.7%) had more than 1 risk factor involved in pathogenesis. These risk factors included steroid use, n = 46 hips (68.6%); alcohol abuse, n = 6 (9.0%); lupus, n = 13 (19.4%); sickle cell disease, n = 3 (4.5%); current smoking >10 pack-years, n = 3 (4.5%); Caisson’s disease, n = 2 (3.0%); hypercholesterolemia or hypertriglyceridemia, n = 4 (6%); organ transplantation, n = 6 (9%); human immunodeficiency virus, n = 2 (3%); and idiopathic, n = 4 (6%).

Steroid usage was divided into 3 different categories based on dose and duration of treatment. Dosing was classified as <10 mg/d (70 mg/wk), 10 to 30 mg/d, or >30 mg/d (low, medium, and high doses). Duration of steroid treatment was also subclassified into short-term (<1 month), medium-term (1–6 months), and long-term (>6 months). Of the 27 patients (46 hips) in which steroid use was considered to be a risk factor for ON, all but 1 had received steroid treatment for a period >6 months. Seven patients received treatment for lupus; 2 for mixed connective tissue disease; 6 after organ transplantation (3 heart and 3 kidney transplants); 2 for psoriasis; and 1 for each of the following diagnoses: Wegener’s granulomatosis, idiopathic thrombocytopenic purpura, antiphospholipid syndrome, Guillain-Barré syndrome, myasthenia gravis, Raynaud’s disease, chronic asthma, extraction of a pituitary tumor, and retinal arteritis. One patient stated that he had received a short course of high-dose intravenous steroids after extraction of a pituitary tumor. Seventeen (62.9%) of these patients had bilateral hip involvement.

A detailed history of alcohol use and cigarette smoking was collected. Patients were divided into regular drinkers (every day), occasional drinkers (2 or 3 days/wk), social drinkers (2 or 3 times a month), and nondrinkers. Former drinkers were alcoholics with at least 6 months of abstinence. Weekly alcohol consumption rate was defined by calculating the ethanol content for each type of beverage consumed times the number of cans, bottles, or glasses drank by the patients in that week. The alcohol content for the different beverages was beer, 4%; wine, 12%; and hard liquor, 40%. Weekly alcohol and drink-years were classified according to Matsuo et al. [13]: <400, 400 to 1,000, and >1,000 mL/wk and <4,000, 4,000 to 10,000, and >10,000 mL/week-year. For example, if a patient drank 6 beers daily for the last 5 years, the calculation would be done as follows:

\[
333 \text{ (mL in a beer)} \times 0.04 \text{ (alcohol content)} \times 6 \text{ (no. of beers/d)} \times 7 \text{ days}
\]

The first result would be the alcohol consumption for a week and, when multiplied by 5, the total drink-years. Calculations were done only on the regular and occasional drinkers because the weekly consumption in the social group was too low. Thirty patients (71%) were drinkers, and 12 were non-
drinkers. Of those who drank alcohol, 3 were regular drinkers, 2 were former regular drinkers, 12 were occasional drinkers, and 13 were social drinkers. All patients under the category occasional drinkers drank <100 mL/wk except for 1 who drank 239 mL/wk of alcohol. One patient in the regular drinker category (heavy beer drinker) was lost to follow-up so that weekly alcohol consumption could not be established. Of the remaining patients, the average alcohol consumption per week for regular drinkers was 1,422 mL, and for former regular drinkers, it was 2,079 mL/wk.

Patients were classified as nonsmokers, former smokers, and current smokers. Pack-years was used to calculate the cumulative effects of smoking on former and current smokers. They were classified in <10, 10 to 20, and >20 pack-years. Twenty-one patients were smokers. Thirteen of these patients had quit smoking at least 6 months before ON diagnosis and core decompression. One patient quit <6 months before surgery. Of the remaining current smokers, the average was 12.1 pack-years. Three patients who were current smokers of >10 pack-years had no other identifiable risk factor. Two of these patients smoked normal filtered cigarettes, at least 1 pack/d, and the other smoked half a pack of normal nonfiltered cigarettes.

Systemic lupus erythematosus and other collagen vascular diseases were also classified as independent risk factors for ON. Hypercholesterolemia (>220 mg/dL) and hypertriglyceridemia (>150 mg/dL), based on values taken before surgery, were also considered risk factors.

Radiographic and MRI Evaluation

All radiographs and MRI scans were evaluated preoperatively and at each follow-up visit by 1 of us (C.J.L.). The extent of disease of the femoral head was classified according to Ficat and Arlet, Florida, Philadelphia, and ARCO staging systems. The volume of involvement of the femoral head was assessed on T1-weighted MRI scans (47 hips). The 3 cuts on MRI with the largest affected area were photographed with a digital camera. These pictures were imported into a software program (Sigma Scan). The percentage of involvement of the femoral head on each cut was calculated (area of necrosis/area of head). The 3 measurements were then averaged.

Surgical Technique

The surgical technique for core decompression has been described elsewhere [34].

Outcome Assessment

Surgical outcome after core decompression was assessed using 3 criteria: i) progression to total hip arthroplasty (THA), ii) progression in the Ficat staging system, and iii) Harris and PD scores and the SF-36 outcome instrument. The effects of age, sex, the presence and number of risk factors, body mass index, radiographic stage, comorbid medical conditions, and biopsy results on outcome were also assessed.

Statistical Method

Before any analysis, the normality of the distribution of the continuous variables was assessed, and, if necessary, the data were transformed or nonparametric methods were used. Independent groups were compared using either the t-test or analysis of variance (ANOVA) or the nonparametric counterparts of these tests, the Mann-Whitney or the Kruskall-Wallis test. To assess associations between discrete variables, chi-squared analyses were used. Multiple linear regression was used to assess, after adjusting for relevant covariates, the effect of comorbid medical conditions and risk factors on outcome. A P < .05 was considered statistically significant. Statistical analysis was performed using SPSS 8.0 software (SPSS Inc, Chicago, IL).

Results

Forty-two consecutive patients underwent core decompression during the study period. The mean age (± standard deviation [SD]) was 40.26 ± 13.21 years (range, 20–66 years; median, 37.5 years), and 16 were women (38.09%) and 26 were men (61.9%). The left hip was involved in 6 (14.3%), the right hip in 10 (23.8%), and both hips in 25 (61.9%). The average clinical follow-up was 40.7 months, and the average radiographic follow-up was 33.1 months. Two patients (2 hips) were lost to follow-up. The average body mass index was 26.89 ± 4.08 SD. Preoperative evaluation revealed that 11 patients (26.2%) believed that their general health was excellent; 2 (4.8%), very good; 17 (40.5%), good; 8 (17%), fair; and 4 (9.5%), poor.

The average (± SD) onset of symptoms was 11.93 ± 17.15 months (median, 6.50 months). The average (± SD) number of weeks of disease progression before surgery was 16.95 ± 20.88 weeks (median, 8.0 weeks). The preoperative level of function (ambulation distance) was normal in 11 patients; 10 blocks in 4 patients; 2 to 5 blocks in 9 patients; 2 blocks in 3 patients; 1 block in 5 patients; and confined to house ambulation in 10 patients.
The preoperative total Harris and PD hip scores were 49.8 ± 2.4 standard error (SE) and 11.53 ± 0.56 SE. The pain domains within these scores were 20 ± 1.3 SE for the Harris and 2.65 ± 0.23 SE for the PD hip scores. The average SF-36 scores in our patients for the bodily pain domain preoperatively were 39 ± 4.5 SE; for general health, 58.32 ± 3.4 SE; for physical function, 34.8 ± 5.4 SE; and for mental health, 71.88 ± 3.89 SE. There was no statistically significant difference in preoperative Harris and PD scores (48.6 ± 11 SD vs 50.18 ± 20 SD; ANOVA P = .7 and 10.6 ± 4 SD vs 11.7 ± 4.3 SD; ANOVA P = .6) between patients that did not progress to THA and those that did progress to THA. Statistically significant differences in SF-36 bodily pain (23.5 ± 10.46 SD vs 45.54 ± 28.7 SD; P = .025), mental health (55.2 ± 27.1 SD vs 78.8 ± 16.7 SD; P = .004), and vitality domains (P = .04) were found.

Radiographs and MRI scans were evaluated by the surgeon preoperatively and twice at the initiation of this study. The classification stages are shown in Table 1.

No complications occurred during the surgical procedure. A single complication (1 deep venous thrombosis) occurred postoperatively. Pathologic analysis confirmed ON in 38 patients (62 hips). Four patients had a negative biopsy result. Of these, 2 had unilateral and 2 had bilateral disease. One patient had one side positive and the other negative.

The average clinical follow-up, excluding 3 patients that died and 2 that were lost to follow-up, with a successful core decompression was 40.7 ± 17.18 months SD, and the average radiographic follow-up was 33.1 ± 16.8 months SD. The average progression to THA was 20.3 ± 13 months SD. The average clinical follow-up for the surviving hips was 44.4 ± 15 months SD. Sixteen hips (23.8%) progressed to THA. None of the patients graded as Ficat I, 17% of stage II, and 66% of stage III hips progressed to THA. Progression to THA was statistically significantly different when classified according to Ficat stage (chi-squared, P = .02). The rate of progression to THA for the other classification systems is shown in Table 2. Radiographic progression from precollapse to collapsed stages or from collapsed to an arthritic stage occurred in 21 hips (36.8%) when graded with the Ficat staging system. The rate of radiographic progression was 30% for stage I hips, 40% for stage II hips, and 32% for stage III hips. Radiographic progression for the other classification systems is shown in Table 3.

The volumetric measurements made on the preoperative MRI scans demonstrated no correlation between volume of involvement and progression to THA. The average percentage of femoral head involvement in patients that needed THA after core decompression was 38% compared with 48% in patients who had better outcomes (P = .13). The location of the necrotic lesion or the demarcation line with respect to the weight-bearing surface was also assessed as a predictor of outcome. A demarca-

### Table 1. Radiographic Classifications for Osteonecrosis Staging Systems

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### Table 2. Progression to Total Hip Replacement

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<th>Florida</th>
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### Table 3. Radiographic Progression

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<tr>
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<td>33.3%</td>
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<td>II</td>
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<td>38%</td>
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<tr>
<td>III</td>
<td>32%</td>
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tion line located in the medial one third of the weight-bearing surface was classified as A, in the middle one third of the weight-bearing surface as B, and in the lateral one third of the weight-bearing surface as C [14]. Zero hips classified as type A progressed to THA, 1 for type B, and 3 for type C. Although a trend toward worse outcome was observed in patients with type C lesions, the results were not statistically significant ($P = .5$).

Mean postoperative Harris and PD hip scores at last follow-up for the whole cohort were $58.5 \pm 2.8$ SE and $11.4 \pm 0.7$ SE. Postoperative Harris pain domain was $25.8 \pm 1.98$ SE, and PD pain was $3.19 \pm 0.31$ SE. The average postoperative SF-36 bodily pain domain was $29.6 \pm 3.8$ SE; physical function, $28.7 \pm 4.3$ SE; mental health, $62.3 \pm 4.6$ SE; and general health, $56.76 \pm 4.2$ SE. At last follow-up, patients that progressed to THA (follow-up before THA) had statistically significantly worse Harris total ($42.6 \pm 12.6$ SD vs $63.7 \pm 19.2$ SD; $P = .001$), Harris pain ($16.7 \pm 8.8$ SD vs $29.0 \pm 13.6$ SD; $P = .006$), PD total ($8.2 \pm 4.8$ SD vs $12.4 \pm 5.0$ SD; $P = .01$), PD pain ($1.8 \pm 1.6$ SD vs $3.6 \pm 2.1$ SD; $P = .01$), and SF-36 bodily pain scores ($24 \pm 24$ SD vs $31.5 \pm 23.6$ SD; $P = .02$) when compared with those that did not progress to THA. There was no statistically significant difference in postoperative scores and SF-36 domains when the analysis was performed using Ficat stage as the dependent variable (ANOVA, $P > .05$).

Stepwise multiple regression analysis was performed using THA and radiographic progression as the dependent variables and sex, age, body mass index, and risk factors as the independent variables. The only variable that entered the model was alcohol consumption ($\beta$ coefficient = $3.33 \pm 0.125$ SE, $P = .011$) but only as a predictor of progression to THA, not of advance in radiographic staging. The effect of multiple risk factors was also analyzed. Of the 24 hips that progressed radiographically, $54.3\%$ had only 1 risk factor, and $41.7\%$ had $\geq 2$ risk factors. Of the 42 hips that did not progress radiographically, $50\%$ had 1 risk factor involved, and $42.9\%$ had $> 1$ risk factor. In this group, 3 hips ($7.1\%$) were idiopathic. These results were not statistically significant. This analysis was also performed using THA as an endpoint obtaining similar results.

**Discussion**

The surgical treatment of ON of the femoral head is controversial. Although improved outcomes have been reported when comparing surgical treatment with conservative nonsurgical treatment, no surgical procedure is universally accepted. The ideal treatment modality must be simple, reproducible, and with low morbidity and mortality rates. It should not increase the difficulty of a subsequent THA.

Ficat [31] reviewed the results of core decompression in 133 patients with ON of the hip (average follow-up, 9 years, 6 months) and reported a successful clinical result in 90% with no radiographic progression in 79% of the patients. The failure rate was 6% for stage I hips and 18% for stage II hips.

An English literature review by Mont et al. [35] between 1960 and 1993 reported 24 studies with 1,206 hips that were treated with core decompression. It included studies with favorable as well as unfavorable outcomes. Satisfactory clinical results were reported in 63.5% of the hips treated with core decompression compared with a 22.7% success rate using nonoperative treatment. The survival rate for Ficat stage I was 84%; for stage II, 65%; and for stage III, 47%. Higher success rates were seen in centers with higher volume of core decompressions. Hungerford [1] studied 204 hips (follow-up, 32–37 months) and reported a 96% (47 of 49) success rate for Ficat stage I, 77% (82%) for stage II, and 60% (39 of 65) for stage III. Stulberg et al. [36] reported their findings of a prospective, randomized study that compared core decompression with conservative nonsurgical management. Success of treatment was based on Harris Hip Score. Stage I hips treated with core decompression and conservative treatment resulted in 70% and 10% success rates. Stage II hips resulted in a success rate of 71% for those treated with core decompression and 0% for those with conservative treatment. Stage III hips resulted in success rates of 73% and 10%.

Other studies have reported poor outcomes. In 1986, Camp and Colwell [33] reported the results of core decompression in 25 hips. At an average follow-up of 18 months, the success rate for stage I was 37.5% (3 of 8); for stage II, 45.5% (5 of 11); and for stage III, 0% (0 of 6). Their conclusion was that core decompression was an ineffective procedure with significant morbidity. Smith et al. [6] reported their results in 114 patients (follow-up, 40 months) using the modified Ficat staging system. They reported a success rate of 84% (27 of 32) for stage I, 47% (18 of 38) for stage IIA (same as Ficat II), 20% (5 of 20) for stage IIB (crescent sign), and 0% (0 of 19) for stage III (collapse of the femoral head). Their study concluded that core decompression was effective in stage I, but an alternative procedure should be considered for precollapse stages IIA and IIB. Multiple surgeons (13 or 14) and different surgical techniques could account for the high failure rates.
and extremely high complication rates in these 2 studies. The reported complication rate ranges from 0% to 18%. The most common complication is a fracture (subtrochanteric or intertrochanteric). Camp and Colwell [33] reported one of the highest complication rates (15%), surpassed only by Saito et al. [29] (18%). In contrast, the complication rate in the present study was low (0.67%). Our study is in concordance with the studies that report better outcome with low complication rates. Experience and volume may play a major factor in the success rate of this surgical procedure because, as discussed earlier, studies that report worse outcome have multiple surgeons performing the procedure.

Our data demonstrate a unique and important relationship between high alcohol intake (former or actual) and progression to THA. This relationship may be due to permanent changes in the cellular population of the femoral head in this patient population. Although patients responded on the questionnaires that they had stopped drinking before surgery, hidden alcohol abuse and postoperative noncompliance may influence surgical results. Our results suggest that risk factors for ON of the femoral head are not cumulative in predicting outcome after core decompression. Patients with 1 risk factor have similar results after core decompression to patients with >1 risk factor. It is reasonable to believe that core decompression is indicated in early-stage ON of the femoral head of varying cause, even if patients have >1 risk factor involved.

Preoperative and postoperative SF-36 scores for patients with ON of the femoral head are significantly worse than for healthy individuals matched for age (Fig. 1). SF-36 scores at 1 year in our patients were significantly lower than what has been reported in patients undergoing THA [37] (Fig. 2). Core decompression carries significantly less morbidity and mortality, however, when compared with THA in patients with ON of the femoral head.

The patients who had a successful core decompression experienced a significant improvement in all pain subscores and overall scores for the Harris and PD instruments but experienced a decreasing level of function (SF-36 physical function domain preoperatively, 39.79–32.24 at last follow-up). Comorbid medical conditions and multiple joint involvement in some patients may limit their functional improvement independent of their improvement in the pain level in the joint treated with core decompression.

Kerboul et al. [26] introduced a method to measure volume of involvement of the femoral head. They reported that radiographic involvement was an important predictor of surgical outcome. Our results demonstrate no relationship between the estimated volume of involvement of the femoral head or the location of the necrotic lesion assessed by MRI and progression to collapse or THA. Disease stage alone seems to be the best predictor of disease progression after core decompression. With these results in mind, we recommend the simplicity of the Ficat staging system to classify patients with ON.

![Fig. 1. SF-36 domains in patients with osteonecrosis of the femoral head compared with healthy individuals with mean age of 40 years. (□, osteonecrosis; ■, healthy individuals.)](image1)

![Fig. 2. Mean improvement in selected SF-36 scales at 1 year. Core decompression (□) versus total hip replacement (■).](image2)
Our study demonstrates that core decompression is an important alternative in the surgical treatment of early-stage ON of the femoral head. A careful patient selection process must be carried out to discover patients who may not benefit from this surgical procedure.

**Conclusions**

We offer the following conclusions:

1. Core decompression is a safe and effective procedure for Ficat stage I and II hips.
2. Patients with alcohol abuse as a risk factor for ON have significantly worse outcomes after core decompression.
3. Volume as estimated by T1-weighted MRI does not correlate with surgical outcome.
4. ON has a major impact on SF-36 scores.
5. Patients with multiple risk factors do not have worse surgical outcomes after core decompression.

**References**


