Relationship Between Preservation of the Lateral Pillar and Collapse of the Femoral Head in Patients With Osteonecrosis

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Abstract

It is difficult to predict if and when the femoral head will collapse and whether the collapse can be minimized. This study examined the final outcome of early-stage osteonecrosis of the femoral head (ONFH) using magnetic resonance imaging to verify the relationship between preservation of the lateral pillar and collapse of the femoral head. A midcoronal section of the femoral head was divided into 3 pillars (medial, central, and lateral) on a T1-weighted image. According to the site of necrosis on the lateral pillar, the necrosis was divided into 3 types: I, the necrosis occupies the central and medial pillars, and the lateral pillar is preserved; II, the necrosis partially occupies the lateral pillar; and III, the necrosis totally occupies the lateral pillar. One group of 87 patients (127 hips) with Association for Research on Osseous Circulation (ARCO) stage I ONFH underwent nonoperative treatment and were followed for 3 to 8 years (average, 6.2 years). Another group of 42 patients (72 hips) with ARCO stage I ONFH underwent debridement and impacted bone graft and were followed for 5 to 9 years (average, 7.1 years). In both groups, the more preserved the lateral pillar, the less collapse occurred. The authors concluded that whether ONFH progressed to collapse is determined by preservation of the lateral pillar. The lateral pillar is the keystone for maintaining the sphere of the femoral head and its preservation.

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It has been well documented that a majority of necrotic femoral heads may progress to collapse.\textsuperscript{1-4} A collapsed femoral head may progress to hip osteoarthritis, resulting in total hip arthroplasty. Femoral head collapse is the most common cause of severe hip pain and loss of function. Therefore, research continues on whether it is possible to predict if and when the femoral head will collapse and whether it can be minimized as much as possible. Currently, several methods are available to predict the collapse of a necrotic femoral head; each has its own advantages and limitations, and each can be improved upon to some extent.\textsuperscript{5-9}

Based on the evaluable long-term follow-up data from patients with severe acute respiratory syndrome (SARS)-associated osteonecrosis of the femoral head (ONFH), where the condition is mainly caused by the dosed corticosteroid, and from patients admitted to the authors’ center for joint-preserving surgery, the authors found that the progression of a necrotic femoral head to collapse is closely associated with the preservation of the lateral pillar of the head.

**Materials and Methods**

**Research Methodology**

The midcoronal section of a femoral head can be divided into the lateral, central, and medial pillars, which account for 30%, 40%, and 30% of the head width, respectively (Figure 1). Based on magnetic resonance imaging (MRI) and computed tomography (CT) data from the initial census of patients with Association for Research on Osseous Circulation (ARCO) stage I SARS-associated ONFH,\textsuperscript{10} ONFH is classified into 3 types according to the invasion of the necrosis into the lateral pillar: I, the necrosis occupies the central and medial pillars, and the lateral pillar is preserved; II, the necrosis partially occupies the lateral pillar; and III, the necrosis totally occupies the lateral pillar (Figure 2).

Patients undergoing joint-preserving surgery at the authors’ center were in ARCO stage II. For these patients, ONFH was classified in accordance with dimensional reconstruction from the preoperative midcoronal CT image or T1-weighted MRI.

During follow-up, the collapse rate and time to collapse from the initial examination were observed for the patients who did not undergo surgery and the collapse rate and time to collapse after surgery were recorded for those patients who did.

**Clinical Data**

The natural progression group comprised 87 patients (127 hips), including 26 men and 61 women, 21 to 59 years old (mean, 33±9 years). Bilateral hips were involved in 45 patients, the left hip in 17 patients, and the right hip in 20 patients.

All patients underwent 3 months of conservative therapy during the initial examination period (December 2003 to February 2004), including medications (anticoagulation, anticongestion, bone absorption relief, bone restoration improvement, chondral protection), protective weight bearing, physical therapy, exercise therapy, and magnetic therapy. All patients were followed for at least 3 years (range, 3-8 years) and 3 visits (range, 3-6 visits). During initial examination, types I, II, and III ONFH were found in 37, 47, and 43 hips, respectively.

The joint-preserving surgery group comprised 42 patients (72 hips), including 19 men and 23 women, 22 to 54 years old (mean, 30.7±9 years) at the time of the surgery. All patients were followed for 1 to 3 visits over more than 5 years. Preoperatively, types I, II, and III ONFH were found in 10, 32, and 30 hips, respectively.

Regarding the surgical procedure, via an anterior modified Watson-Jones approach, the anterior side of the hip was accessed. Debridement, performed at the juncture of the femoral head and neck to remove the necrosis, was followed by impacted bone graft with autogenous iliac and artificial bone. Details of the technique have been previously reported.\textsuperscript{11}

**Statistical Analysis**

The data were analyzed using SPSS version 17.0 statistical software (SPSS Inc., Chicago, Illinois). Chi-square and Fisher’s exact tests were used for statistical analysis of the data. A P value less than .05 was considered statistically significant.

**Results**

**Natural Progression Group**

As shown in Table 1, a low femoral head collapse rate and long time to collapse were found in type I ONFH. The collapse rate in type II ONFH was significantly higher than that of type I ONFH (P=.014), and the time to collapse was markedly shortened. Type III had a significantly higher collapse rate and shorter time to collapse compared with type II ONFH (P=.001) (Figure 3).

**Joint-preserving Surgery Group**

As shown in Table 2, no femoral head collapse was found in patients with type I ONFH. Collapse occurred in 21.8% of the patients with type II ONFH within 2 to 5 years postoperatively (type I vs type II, P=.003). Collapse occurred in 60% of patients with type III ONFH within 2 to 3 years.
years postoperatively, which was statistically significant (type I vs type III, \( P = .008 \); type II vs type III, \( P = .002 \)). Although the progression profile of the joint-preserving surgery group was roughly similar to that of the natural progression group, a marked reduction in and different reduction proportion for the collapse rate were found among the 3 types of ONFH, with a larger reduction in types I and II and a smaller reduction in type III. This indicates the different efficacy of joint-preserving surgery for each type of ONFH.

**DISCUSSION**

As evidenced by the findings in patients with nontraumatic ONFH, collapse occurred in part of the femoral head regardless of group, while the remaining femoral head kept its roundness. Two different manifestations in early ONFH were evaluated on MRI: (1) the confinement of the necrosis in the bone marrow, with more or less intact cortical bone; and (2) the invasion of the necrosis to the bone marrow and cortex. The follow-up data may demonstrate markedly different outcomes for the femoral head with the 2 different MRI manifestations. For the former change, the femoral head may keep its roundness for a long time before collapse, and necrosis located inside the bone marrow cavity and an intact cortical bone may be observed on CT or radiological examination. However, for the latter condition, the femoral head may collapse, and a subchondral fracture may be observed radiologically.

Herring et al\(^{12}\) performed long-term follow-up in children with Legg-Calvé-Perthes disease and found that the residual height of the femoral head epiphysis was proportional to the roundness of the femoral head repaired after its maturation. Based on this, the Herring classification, a milestone in the research of Legg-Calvé-Perthes disease, was proposed.\(^{12}\) As highlighted by this classification and combined with the current authors’ clinical findings, the current authors performed a comprehensive evaluation of the relationship between femoral head collapse and the intactness and intact width of the femoral head. Based on the natural progression outcome and the joint-preserving surgery outcome of SARS-associated ONFH, this study showed a close association between femoral head collapse and the intactness and intact width of the femoral head. Surgical intervention can minimize but not eradicate femoral head collapse.

Pathology provides a basis for the early changes of osteonecrosis on MRI.\(^{13}\) A majority of researchers agree that nontraumatic osteonecrosis (mainly caused by corticosteroids and/or alcohol) can pri-

### Table 1

<table>
<thead>
<tr>
<th>ONFH Type</th>
<th>No. of Necrotic Hips</th>
<th>Collapse Rate</th>
<th>Time to Collapse, y</th>
<th>Chi-square</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>37</td>
<td>4 (10.8%)</td>
<td>5-7</td>
<td>10.22</td>
<td>.014</td>
</tr>
<tr>
<td>II</td>
<td>47</td>
<td>20 (42.6%)</td>
<td>2-7</td>
<td>57.75</td>
<td>.001</td>
</tr>
<tr>
<td>III</td>
<td>43</td>
<td>41 (95.3%)</td>
<td>0.5-3</td>
<td>28.6</td>
<td>.001</td>
</tr>
</tbody>
</table>

Abbreviation: ONFH, osteonecrosis of the femoral head.
The embolism can be developed at different branch levels in the vascular network of the femoral head. An embolism of a major trunk may lead to a large necrosis, and an embolism of a minor trunk may lead to a small necrosis. The femoral head is mainly nourished by the superior metaphyseal artery, which distributes to the cortex, subchondral bone, and bone marrow, providing an anatomic basis for this. The authors proposed the China-Japan Friendship Hospital classification of ONFH based on the 3 pillars of the femoral head (Figure 4). According to the involvement of necrosis in the 3 pillars on a midcoronal section on MRI (ARCO stage I-II) or CT (ARCO stage II-III), the location of ONFH was divided into 3 types (M, C, and L), and the intact degree of the lateral pillar was divided into subtypes L1, L2, and L3. Using this classification for evaluation of the natural progression of ONFH and the efficacy of joint-preservation surgery for ONFH, the authors concluded that the suitability and accuracy of this classification is preferable over the Japanese Investigation Committee classification. Multicenter data should be obtained for further verification.

A limitation of this study is that a quantitative study was not conducted for the relationship between the intact width of the lateral pillar and femoral head collapse and time to collapse. The effect of age and sex on the classification results was not studied. No biomechanic study results were provided as theoretical support.

**CONCLUSION**

This classification may reflect the progression profile of osteonecrosis more precisely if it is based on the results from larger and more long-term clinical observations. Judging the prognosis of ONFH with this classification and applying an individualized therapeutic regimen may improve the pertinence of therapy.

**REFERENCES**

Figure 4: Schematic diagrams (top) and magnetic resonance images (bottom) of the China-Japan Friendship Hospital classification of osteonecrosis of the femoral head based on the 3 pillars. Type M: Necrosis involves the medial pillar (A). Type C: Necrosis involves the medial and central pillars (B). Type L1: Necrosis involves all 3 pillars, but the lateral pillar is partially preserved (C). Type L2: Necrosis involves the entire lateral pillar and part of the central pillar (D). Type L3: Necrosis involves all 3 pillars, including the cortical bone and marrow (E).