In selecting the best surgical method for treating early stage osteonecrosis of the femoral head (ONFH), the factors normally considered are the progression of the disease and the patient's age. Although most clinicians agree that the focus, when first treating patients under 50 years of age, should be on preserving the joint, there is significant controversy as to the appropriate procedure in any given case. Core decompression is one of the joint salvage surgical procedures that has generated a great deal of controversy among researchers, who dispute both its effectiveness and the incidence of complications. Despite this controversy, core decompression is the most widely used method, based on its being a relatively simple surgical technique and the widespread acceptance of its efficacy in treating diseases in the earlier stages. A transtrochanteric rotational osteotomy, which is also called the Sugioka Operation owing to its introduction by Sugioka et al. in 1978, is widely recog-
nized as having the advantage of allowing a surgeon to change the body-weight-bearing portion of the hip more effectively than the other salvage surgical procedures such as a femoral proximal osteotomy. However, the procedure is relatively difficult to perform and, to date, no other researchers have reported results as favorable as those reported by Sugioka et al.12,17,23).

This study examined 35 patients (49 cases) and 18 patients (19 cases) who had been treated with a core decompression and Sugioka’s transtrochanteric rotational osteotomy, respectively, for a nonsteroidal ONFH. After a minimum of three-year postoperative follow-up, a comparative analysis of the clinical and radiological results according to the extent of the lesion at the time of surgery was made.

**MATERIALS AND METHODS**

Authors performed 78 core decompression procedures for 48 patients between January 1993 and May 1998 and 22 Sugioka’s transtrochanteric osteotomy procedures for 20 patients between April 1994 and March 1998.

This study involved 35 patients (49 hips) who had been treated with a core decompression; and 18 patients (19 hips) who had been treated with the Sugioka’s transtrochanteric rotational osteotomy. Most patients were treated for a non-steroidal ONFH and were followed-up for at least three years.

The greater trochanter lateral approach was used for the core decompression surgery, reaching the bases of the necrotic femoral portions.

Sugioka’s transtrochanteric rotational osteotomy was mainly performed on patients under 50 years of age in whom the necrotic lesion occupied at least 30% of the whole femoral head and was located at the superior femoral head. In this location, the lesion area directly bears the body weight, but approximately 35-40% (or higher) of the normal bone is preserved at the anterior or posterior portions of the femoral head. This surgery was performed in all cases by the senior author (WY Shon) in strict compliance, with the methods described by Sugioka et al.21). The procedure is as follows:

Ollier’s approach was first used to incise the skin, and a greater trochanter osteotomy was performed to reveal the articular capsule. The acetabular margin was approached to allow access to cut the articular capsule, and then two pins on the trochanter and the neck of femur were then used to check the femoral internal or external rotation. An inter-

trochanteric osteotomy was performed vertically to the long axis of the neck of the femur, and a secondary osteotomy was made perpendicular to the superior lesser trochanter in order to leave the lesser trochanter in the distal bony part. After the osteotomy, the proximal bony piece was held steady, whilst allowing for an intentional varus angulation depending upon the tilt of the trochanteric osteotomy. In the next step, the femoral head was rotated anteroposteriorly, using pins on the proximal bony piece, to an angle of 70-90° depending upon the location and extent of the lesion, so that the body-weight-bearing articular facet might be replaced with a healthy articular facet without necrosis. The portion on which the osteotomy was conducted was fixed with 3 to 4 cannulated hip screws and the greater trochanter, on which osteotomy had already been made, was then fixed.

1. Age and sex distribution of treatment groups

Thirty-five patients (4 women and 31 men) were treated with a core decompression. Among these, there were 14 with a bilateral ONFH, with an average age of 40.5 years (range=21-58) at the time of surgery. Eighteen patients (one woman and 17 men) were treated with Sugioka’s transtrochanteric rotational osteotomy, with an average age of 38.2 years (range=22-47) including one 34-year-old patient with bilateral ONFH.

2. Causative factors of avascular necrosis in treatment groups

In the core decompression treatment group, the factors causing the osteonecrosis consisted of alcohol abuse (38 hips) and idiopathic causes (11 hips). In the Sugioka’s transtrochanteric rotational osteotomy group, the factors causing the osteonecrosis were alcohol abuse (8 hips) and idiopathic causes (11 hips).

3. Radiological classification of avascular necrosis in treatment groups

The classification systems used were the Ficat-Arlet (F-A) Stage classification and the Shimizu’s classification based on the extent of the lesion on the coronal MRI images. This was classified as Shimizu’s Grade A if its maximum radial distance from the circumference was less than one-quarter the diameter of the circle, Shimizu’s Grade B, if
the distance was one to less than one-half of the diameter and Shimizu’s Grade C, if the distance was one-half if the diameter or greater.

The hips of the patients in this study were classified into the F-A Stages as follows: for the core decompression treatment group, Stage I=22, Stage IIa=16, Stage IIb=8 and Stage III=3; and for the Sugioka’s transtrochanteric rotational osteotomy treatment group, Stage IIa=13 cases, Stage IIb=4 and Stage III=2 (Table 1-1).

The extent of the disease progression (Grades A, B or C) in each hip was classified using Shimizu’s classification. In the core decompression treatment group, regarding the extent of the disease, there were five Grade A hips, 28 Grade B hips and 16 Grade C hips, and regarding the lesion location, included five Grade A hips, 15 Grade B hips and 29 Grade C hips. In the Sugioka’s transtrochanteric rotational osteotomy treatment group, regarding the extent of the disease, there were seven Grade B hips and 12 Grade C hips and regarding the lesion location, there were two Grade B hips and 17 Grade C hips (Table 1-2).

4. Clinical results

The average follow-up period was 46 months (range=36-82 months) in the core decompression treatment group and 53 months (range=37-108 months) in the Sugioka’s transtrochanteric rotational osteotomy treatment group. In all cases, the outpatient ambulant follow-up results were clinically and radiologically evaluated.

In order to assess the clinical results, no pain or a Harris Hip Score (HHS) of at least 90 points was considered “excellent”, and very little inconvenience, limited motion or a HHS of 80-89 points was considered “good”. Both “excellent” and “good” classifications were considered to be successful outcomes. Mid-level pain or worse, or a HHS of 70-79 points, were considered to be “fair”, and severe pain or a HHS of <70 points were considered to be “poor”. Among the latter two, including the hips that required a later total hip replacement or subsequent salvage operation and the hip, which had radiological failure, were determined to be outcome failures.

The radiological results were also used to classify the treatment outcomes as successes or failures. Those hips were considered to be “improved” if the affected portions were replaced by new bony tissues (under Malizos et al.’s criteria) and the articular facet was normal or better. Those hips with an unimproved articular facet were considered to be “not changed” while those with a progressive collapse of the femoral head more than 2 mm were considered to be “worsened”. Those cases resulting in a destroyed hip joint or subsequently treated with a total hip replacement were considered to be “failed”. The “Improved” and “not changed” hips were considered successful outcomes, while the worsened or failed hips were considered failures.

The Fisher’s Exact Test was used for statistical analyses. The patients in both treatment groups were classified hierarchically based on their radiological stages for parallel analysis. A p value 0.05 was considered significant.

RESULTS

There were significant differences between the two treatment groups (core decompression and Sugioka’s transtrochanteric rotational osteotomy) when compared by the F-A stages and the causative factors. The results were analyzed according to the F-A stage. The causative factors are known not to affect the outcome of the treatment and were not analyzed.

1. Clinical results

The clinical results for the 49 core decompression hips, as
evaluated at the follow-up (mean=46 months, range=36-82 months), were as being follows: six hips (12%) were graded as being excellent, 15 (31%) as good, two (4%) as fair and 26 (53%) as poor, yielding a 43% success rate. In the core decompression treatment group, 11 hips were subsequently treated with a total hip replacement and one hip...

Fig. 1. (A) A 27-year-old man with bilateral, idiopathic osteonecrosis of femoral head (stage IIB in right hip and stage IIA in left hip). The lesion was classified as Type 1-C according to Ohzono's radiographic classification. (B) The necrotic lesions of both femoral head with invasion into weight-bearing area was revealed by magnetic resonance image. (C) The sagittal image of MRI of right femoral head showed intact area of posterior one third of femoral head. (D) A intact area of posterior part of femoral head was one third of total femoral head surface on Sugioaka's lateral view of right hip. (E) 13 months after trochanteric osteotomy of right hip and core decompression of left hip, no collapse and well union of the osteotomized site in right hip and collapse of the femoral head with progression of necrosis in left hip was seen. (F) Nine years after trochanteric osteotomy, there is no collapse with mild osteophytes of femoral head and the clinical results were excellent.
with a Sugioka’s transtrochanteric osteotomy. At the radiological follow-up, 27 hips of the original 49 (55%) were found to have failed based on them having to undergo a subsequent total hip replacement or suffering progressive femoral head collapse.

The clinical results for the 19 Sugioka’s transtrochanter rotational osteotomy treatment hips, as evaluated on the follow-up (mean=52 months, range=37-85 months) were as being follows: seven hips (37%) were graded as being excellent, seven (37%) as good, one (5%) as fair and four (21%) as poor, yielding a 74% success rate. Upon the radiological follow-up, two hips (10%) showed a severe varus deformity and were treated with a valgus osteotomy and one hip survived. In addition, one hip underwent the Girdle Stone procedure followed by a total hip replacement in treating an associated infection. Three others hips in this treatment group were also subsequently treated with a total hip replacement (one hip with a femoral head collapse and the two hips that had both a femoral head collapse and varus deformity). Therefore, the failure rate at the final radiological follow-up was 4 hips out of 19 (21%).

2. F-A Stage and Shimizu grade comparisons

For the 22 F-A Stage I hips, all of which were in the core decompression treatment group, 15 (68%) obtained a clinically and radiological successful results, and seven hips (32%) were determined to be failures (Fig. 1). Of the latter, three cases were evaluated subsequently to be treated with a total hip replacement and one was treated with a Sugioka’s transtrochanteric osteotomy. The radiological evaluations corresponded with the clinical outcomes for the F-A Stage I hips.

Among the 22 F-A Stage I hips, four of the four (100%) Shimizu Grade A hips, nine of the 15 (60%) Shimizu Grade B hips and two of the 3 (67%) Shimizu Grade C hips showed clinically and radiologically successful results (p<0.01) (Table 2).

Sixteen hips (1 Shimizu’s Grade A, 10 Shimizu’s Grade B and 5 Shimizu’s Grade C) in the core decompression treatment group and 13 (8 Shimizu’s Grade B and 5 Shimizu’s Grade C) in the Sugioka’s transtrochanteric rotational osteotomy treatment group were F-A Stage IIA. Among these, five out of 16 hips (31%) and 11 out of 13 hips (85%), respectively, were evaluated as being clinical successes and six out of 16 hips (38%) and 11 out of 13 hips (85%), were evaluated as respectively, as radiological successes. Among the 10 failed hips in the core decompression group, six hips were Shimizu’s Grade B and four hips were Shimizu Grade C. The radiological success rates between the two treatment groups with F-A Stage IIA showed a significant difference (success rates: core decompression, 38%; osteotomy 85%; p=0.003) and the correlation between radiological success and the Shimizu classification was also significant (p<0.05) (Table 3).

Among the 8 hips (3 Shimizu’s Grade B and 5 Shimizu’s Grade C) in the core decompression group and the four hips (Shimizu’s Grade C) in the Sugioka’s transtrochanteric rotational osteotomy group which were F-A Stage IIB, one hip from each group (11% and 25%, respectively) showed a clinically successful result, and two hips from each group (22% and 50%, respectively) showed radiologically successful

### Table 2. Radiological results according to the Shimizu classification in the F-A Stage I treatment groups

<table>
<thead>
<tr>
<th>Category</th>
<th>Treatment group</th>
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<tbody>
<tr>
<td></td>
<td>Core decompression</td>
</tr>
<tr>
<td>Radiological success</td>
<td>15/22 hips (68%)</td>
</tr>
<tr>
<td>Shimizu grade (extent)</td>
<td></td>
</tr>
<tr>
<td>Grade a</td>
<td>4/4 hips (100%)</td>
</tr>
<tr>
<td>Grade b</td>
<td>9/15 hips (60%)</td>
</tr>
<tr>
<td>Grade c</td>
<td>2/3 hips (67%)</td>
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</tbody>
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### Table 3. Radiological results according to the Shimizu classification in the F-A Stage IIA treatment groups

<table>
<thead>
<tr>
<th>Category</th>
<th>Treatment group</th>
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</thead>
<tbody>
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<td></td>
<td>Core decompression</td>
</tr>
<tr>
<td>Radiological success</td>
<td>6/16 hips (38%)</td>
</tr>
<tr>
<td>Shimizu grade (extent)</td>
<td></td>
</tr>
<tr>
<td>Grade a</td>
<td>1/1 hips (100%)</td>
</tr>
<tr>
<td>Grade b</td>
<td>4/10 hips (45%)</td>
</tr>
<tr>
<td>Grade c</td>
<td>1/5 hips (20%)</td>
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</table>

### Table 4. Radiological results according to the Shimizu classification in the F-A Stage IIB treatment groups

<table>
<thead>
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<th>Category</th>
<th>Treatment group</th>
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<tbody>
<tr>
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<td>Core decompression</td>
</tr>
<tr>
<td>Radiological success</td>
<td>2/8 hips (25%)</td>
</tr>
<tr>
<td>Shimizu grade (extent)</td>
<td></td>
</tr>
<tr>
<td>Grade a</td>
<td>0/0 hips</td>
</tr>
<tr>
<td>Grade b</td>
<td>1/3 hips (33%)</td>
</tr>
<tr>
<td>Grade c</td>
<td>1/5 hips (20%)</td>
</tr>
</tbody>
</table>
results. Each one of the 3 Shimizu’s Grade B hips and 5 Shimizu’s Grade C hips showed radiological successful results (Table 4). However, in this F-A Stage IIb group there were no significant differences between the two treatment groups nor were there any significant differences according to the extent of the lesion and location under the Shimizu classification.

All three F-A Stage III hips (Shimizu’s Grade C) in the core decompression group were evaluated clinically and radiologically as failures, while all of the Stage III hips in the Sugioka’s transtrochanteric rotational osteotomy group were evaluated clinically and radiologically as successes (Fig. 2).

Eight (53%) of 15 the hip which had survived after Sugio-ka’s transtrochanteric osteotomy showed osteophytic changes in the femoral head but not in the narrowing joint space.

**DISCUSSION**

When a younger patient (under 50 of age) is treated for ONFH, the original joint should be maintained as much as possible due to lifespan of artificial joint. Joint salvage surgery to meet this purpose include core decompression\(^8\),\(^9\), a femoral proximal osteotomy including a transtrochanteric rotational osteotomy\(^20\),\(^21\), and vascularized bone grafting\(^3\),\(^24\). The criteria for selecting the most appropriate of these surgical methods for a particular patient are controversial.

Core decompression theoretically results in less pain due to the reduced pressure within the femoral head, the reduction of pressure from the matrix edema with a resulting increase in blood flow, and the suppressed progression of necrosis within the femoral head\(^17\). Even though the relatively simplicity of a core decompression makes it the most widely used surgical procedure for treating an ONFH, its effectiveness and the occurrence of complications make it highly controversial\(^8\),\(^13\),\(^14\),\(^17\). Using a core decompression, Stulberg et al.\(^18\) reported that a core decompression resulted in significant radiological improvements. However, Mont et al. indicated that the depression of the femoral head, the size of the lesion and invasion on the lateral body-weight-bearing facet are important factors affecting the prognosis after a core decompression. In a 12-year follow-up of 68 cases, Mont et al. reported that Steinberg Stages III and IV showed radiological success rates of 41% and 8%, respectively, and that the hips in which the lateral body-weight-bearing facet is invaded showed a success rate of 23%. In addition, the hips with an MRI Kerboul index of 250 or higher and those with an index <250 showed a success rate of 16% and 57%, respectively\(^15\). Similarly, this study found that the F-A Stages I and IIa, which are in the early stages without a femoral head collapse showed significantly different outcomes depending on the extent of the lesion (p<0.05). Hips with a large amount of bone necrosis or with a lateral body-weight-bearing facet invasion upon did not have a very good prognosis. In young patients, for hips with a large amount of necrosis or when there is necrosis of the body-weight-bearing portions, more active treatment methods e.g. transtrochanteric rotational osteotomy or other active surgical procedure, should be used even if the disease is in the early stage. Since Sugioka first introduced the transtrochanteric rotational osteotomy in 1978\(^21\), it has been performed by a few experienced clinicians on patients with localized necrotic areas. Its accepted advantages include that it allows the replacement of the necrotic body-weight-bearing portions with healthy tissue using rotating the femoral head around the long axis of the neck of the femur. This is more effective than other salvage surgical procedures such as a femoral proximal osteotomy and that it causes no severe deformity in the proxi-
mal femur, thereby making any future surgical procedure for total hip replacement easier. The disadvantages of transtrochanteric rotational osteotomy include the need for experienced surgical skills and a longer postoperative recuperation period. Sugioka et al. reported that a transtrochanteric rotational osteotomy worked very well for treating early stage necrosis and even with F-A stage IV hips associated with degenerative changes due to progressive depression. However, results as good as these have not been reported by other researchers.

In general, a transtrochanteric rotational osteotomy was also reported to work better with earlier stage lesions and smaller necrotic areas. Saito et al. stressed that experienced technical skills and a careful selection of patients with proper indications will be needed to obtain satisfactory results from this procedure. In this study, transtrochanteric rotational osteotomy was performed, in strict compliance with the methods reported by Sugioka et al. As a result of this surgery on patients with the proper indications, as selected by the preoperative plain radiographs and MRI, relatively satisfactory results were obtained, although not as favorable as those of Sugioka. Ohzono et al. reported that the location and extent of the lesion greatly affects the results. Similarly, Sugioka et al. reported success rates of 88-91%. It was also reported that the extent of the lesion on the body-weight-bearing areas significantly affected the success of the procedure. The analysis of success rates in this study based on the lesion location according to the Shimizu classifications showed similar implications.

This study identified femoral head osteophytes in 8 (53%) out of 15 hips at the mean 53-months follow-up. There were no cases where the joint space narrowed, but a proper evaluation will require a longer follow-up period. Saito et al. emphasized the importance of the fixation materials in minimizing the occurrence of complications from a transtrochanteric rotational osteotomy, such as the fractured neck of the femur caused by postoperative stress, delayed the union of the portions treated with an osteotomy and varus deformity. According to Kotz, Mizuho Ika’s large screws or the USA’s screws are more useful for fixation than A-O compression hip screws. Sugioka also preferred large screws. It is believed that, because gradually introducing weight bearing is essential for remodeling and can prevent the newly created cartilage from degenerating, this gradual burdening is very important even though a strong internal fixation instrument might be required.

This study also found a stress fracture of the neck of the femur due to excessive varus in one hip, and varus deformities in three hips. These latter three hips were treated with a total hip replacement for the depression of the femoral head (two hips) and an associated infection after a valgus osteotomy (one hip). In the remaining hip, a postoperative bone scan could not identify any hemokinetic shadow in the a femoral head and neck, and it was therefore evaluated as a failure due to a femoral head collapse. In conducting a transtrochanteric rotational osteotomy, the level of surgical skill is as important as the selection of the suitable patients. In order to make a proper varus, the surgeon must be capable of performing an osteotomy, rotating and fixing well without damaging the postero medial circumflex artery and achieving a firm fixation. It will be necessary to develop new devices that are capable of fixing the osteotomy portions in a stable manner.

CONCLUSION

These results showed that a core decompression is effective only in the early stages of osteonecrosis (F-A stage I) and in small lesions or a location that is a non-weight bearing area. However, Sugioka’s transtrochanteric rotational osteotomy produced more successful results than core decompression even though for a large extent of a necrotic lesion of a nonsteroidal ONFH. This study suggests that a transtrochanteric rotational osteotomy is a more dependable procedure for the treatment of a large lesion of nonsteroidal ONFH than a core decompression, particularly when the lesion of necrosis extends into the body-weight-bearing area of the femoral head, or when the overall extent of the necrosis is large for patients under the age of 50.

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비외상성 대퇴골두 괴사증에 시행한 핵심 감압술 및 경전자 회전 절골술의 결과의 비교

문준규・왕준호・허창용・손원용
고려대학교 의과대학 구로병원 정형외과

목적: 대퇴골두 괴사증 환자 중 핵심 감압술 49예와 수지오까 전자부 회전 절골 19예의 결과를 비교하여 보고하고자 한다.

d대상 및 방법: 각각의 수술결과를 Ficat-Alert (F-A) 분류에 따른 골두 괴사 시기별과 Shimizu 등급에 따른 괴사의 정도에 따라 분석하였다. 핵심 감압술군의 평균 추시기간은 46개월(37-108개월), 수지오까 전자부 회전 절골술군의 경우는 52개월(36-82개월)이었다. 환자의 증상이 소실되었거나, 방사선 사진상에 진행되는 소견이 없었던 경우를 성공적인 결과로, 방사선 검사에서 괴사가 진행되거나 대퇴골두의 함몰의 소견이 관찰되거나 고관절 치환술 또는 다른 대퇴골두 구제술을 시행한 경우를 실패로 판정하였다.

결과: 49예의 핵심 감압술군 중 21예(43%)에서, 19예의 수지오까 전자부 회전 절골술군 중 14예(74%)에서 성공적인 결과를 보였다. 핵심 감압술 중 22예의 F-A I기 중 15예(68%)에서 방사선학적 성공적 결과를 보였으며 4예의 Shimizu A 등급은 전례에서, 18예의 Shimizu B와 C 등급에서는 11예(61%)에서 성공적인 결과를 보였다(p<0.01), 16에의 F-A IIA기 중 6예(38%)에서, 8예의 F-A IIB기 중 2예(25%)에서 성공적인 결과를 보였다. 반면에 수지오까 전자부 회전 절골술군 중 F- A IIA기 15예 중 11예(85%)에서, F-A IIB기 4예 중 2예(50%)에서 성공적인 결과를 보였다. F-A III기에서 핵심감압술을 시행한 전례에서 Shimizu C 등급이었으며, 3예 모두 실패의 결과를 보였으나, 2예의 수지오까 전자부 회전 절골술군은 2예 모두 성공적인 결과를 나타냈다.

결론: 핵심 감압술은 대퇴 골두 괴사 F-A I기에서만 효과적이었고, 괴사의 부위와 크기의 정도가 결과에 중요한 영향을 미쳤으며, 비스테로이드성 대퇴 골두 무혈성 괴사의 정도가 심한, 특히 50세 이하의 젊은 환자에게는 수지오까 전자부 회전 절골술이 좀 더 믿을 만한 수술방법으로 사료되었을 것으로 보인다.

색인 단어: 대퇴골두, 골괴사, 핵심감압술, 경전자 회전 절골술