Prediction of the outcome of transtrochanteric rotational osteotomy for osteonecrosis of the femoral head

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We have studied the correlation between the prevention of progressive collapse and the ratio of the intact articular surface of the femoral head, after transtrochanteric rotational osteotomy for osteonecrosis. We used probit analysis on 125 hips in order to assess the ratio necessary to prevent progressive radiological collapse over a ten-year period. The results show that a minimum postoperative intact ratio of 34% was required. This critical ratio may be useful for surgical planning and in assessing the natural history of the condition.


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Non-traumatic osteonecrosis of the femoral head (ONFH) is a common condition. It is generally seen in the third, fourth or fifth decades of life, and progresses to destructive arthritis after subchondral collapse. Treatment by cemented total hip arthroplasty (THA) is followed by a high rate of loosening in younger patients, while the long-term results of non-cemented THA for ONFH are as yet unknown. It follows that preservation of the joint is considered whenever possible because most of the patients are young.

Sugioka introduced the concept of transtrochanteric rotational osteotomy as an effective method of treatment. The intention is to transpose the surviving healthy portion of the head to the central area beneath the acetabular roof. The ratio of the transposed intact articular surface of the femoral head to the weight-bearing surface of the acetabulum on postoperative anteroposterior (AP) radiographs is said to be associated with progressive collapse, but few authors have discussed the correlation between the prevention of this and the postoperative intact ratio.

In our study, the postoperative intact ratio necessary to prevent radiological progressive collapse during the initial ten-year period after transtrochanteric rotational osteotomy was assessed using probit analysis. We have discussed the possible application of the critical ratio for patients with ONFH.

Patients and Methods

We reviewed 125 hips with the diagnosis of non-traumatic ONFH, treated consecutively between January 1980 and December 1988, in which the occurrence of progressive collapse was determined ten years after rotational osteotomy. The postoperative intact ratio was measured according to the method of Sugioka et al from neutral anteroposterior (AP) radiographs taken within eight weeks of surgery (Fig. 1). They were reviewed by four authors (KM, YN, TI, and ES) and all demarcations and reference points were decided by consensus.

Radiological progressive collapse was defined as having occurred when the maximum collapse of the transposed intact area beneath the acetabular weight-bearing portion on the final follow-up AP radiograph was more than 2 mm compared with the postoperative film. Accurate determination of collapse was sometimes made difficult by the formation of osteophytes. We therefore used superimposing paper, on which the contour of the femoral head on the postoperative AP radiograph had been traced over the contour of the femoral head on the final follow-up film. In patients who had undergone prosthetic replacement, the AP radiograph taken just before arthroplasty was used as the final assessment. In hips with progressive collapse we reviewed serial radiographs taken after the osteotomy together with the film in which progressive collapse first became visible.

Basic statistical values for the postoperative intact ratio, including the mean, median and standard deviation, were calculated. The postoperative intact ratio of hips with progressive collapse (collapse group) was compared with those hips without progressive collapse (non-collapse group).
without (no-collapse group) using Student’s t-test. The level of significance (p = 0.05) of the postoperative intact ratio necessary to prevent progressive collapse during the initial ten-year period after transtrochanteric rotational osteotomy was assessed using probit analysis. A Kaplan-Meier curve was produced with a threshold level which predicted a 5% probability of collapse in the probit analysis, dividing the postoperative intact ratio into two groups. The occurrence of progressive collapse was used as the endpoint. For all the analyses we used the SPSS 6.1J on a Macintosh computer (SPSS Japan Inc, Tokyo, Japan).

Clinical assessments were made before the operation and at the final follow-up according to the Japanese Orthopaedic Association (JOA) score, which allot(s) up to 40 points for pain and 20 points each for mobility, walking and function in daily activities (Table I). The JOA score and the rate of prosthetic replacement were compared between the collapse and the no-collapse groups using Student’s t-test and Fisher’s exact test, respectively.

We assessed three factors to examine whether or not they contributed to the occurrence of progressive collapse: 1) body mass index (BMI; body-weight divided by height squared) as the weight index; 2) the condition of the contralateral hip (osteo­my, prosthetic replacement, or no treat­ment); and 3) a history of corticosteroid treatment. The ‘collapse’ and the ‘no-collapse’ groups were contrasted using Student’s t-test for BMI and the chi-squared test for the differences in proportion of the contralateral hip and the corticosteroid history. The records of all patients were reviewed to determine whether they had had knee pain during the period of follow-up.

To test the reproducibility of the method of measurement, ten independent observers measured each postoperative intact ratio in six randomly selected hips. They were all medical students. Each observer measured each hip six times, with an interval of one week between each measurement. The data were analysed for intrapersonal and interpersonal variances and the coefficient of repeatability was calculated; when this was less than 5%, the reproducibility of a method was considered reasonable.

Results

In the study, 28 hips were judged to have undergone progressive collapse whereas 97 had not done so ten years after transtrochanteric rotational osteotomy. The collapse group consisted of 21 men and seven women with a mean age of 39.7 ± 11.2 years (24 to 62), while the no-collapse group...
group comprised 59 men and 21 women with a mean age of 40.3 ± 12.8 years (18 to 66).

The basic statistical values and the histogram of the postoperative intact ratio are shown in Table II and Figure 2, respectively. The mean postoperative intact ratio was 21.1 ± 17.6% in the collapse group, and 50.8 ± 23.1% in the no-collapse group (significance p < 0.0001). The results of probit analysis are shown in Table III. The minimum postoperative intact ratio necessary to prevent a progressive collapse during the initial ten years after osteotomy was 34%. A Kaplan-Meier curve is shown in Figure 3.

There was no significant difference in the JOA clinical score before the operation (mean 60.6 and 60.4 points, respectively). At the final follow-up (mean period 13.8 years) the mean JOA score in the no-collapse group was 80.2 points, with 33.8 points for pain, and either no pain or mild pain in 86 hips (89%). The mean JOA score in the collapse group was 62.2 points, with 19.3 points for pain, and no pain or mild pain in only seven hips (25%) (mean follow-up period 9.2 years). The no-collapse group showed a significantly better JOA score than the collapse group (p < 0.0001). A total of 13 of the 28 hips (46%) had had prosthetic replacement in the collapse group compared to three out of 97 hips (3%) in the no-collapse group (p < 0.0001).

The mean BMIs of the patients in the collapse and the no-collapse groups were 24.7 ± 3.7 kg/m² and 23.6 ± 4.2 kg/m², respectively, showing no significant difference.

In the collapse group 11 (39%) of the 28 hips had either a rotational osteotomy or varus osteotomy and four (14%) a prosthetic replacement for ONFH in the contralateral hip. The remaining 13 hips (46%) had no surgical treatment. In the no-collapse group, 51 (53%) of the 97 hips had either a rotational or a varus osteotomy, and nine (9%) a prosthetic replacement for ONFH in the contralateral hip; 37 hips (38%) had no surgical treatment. There was no significant difference in the proportion of the three conditions between the two groups.

### Table II. Basic statistical values of the postoperative intact ratio of the 125 hips with ONFH

<table>
<thead>
<tr>
<th>Statistical value</th>
<th>Postoperative intact ratio (%)</th>
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<tbody>
<tr>
<td>Mean</td>
<td>44.14</td>
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<tr>
<td>Standard error</td>
<td>2.25</td>
</tr>
<tr>
<td>Median</td>
<td>42.0</td>
</tr>
<tr>
<td>Mode</td>
<td>30.0</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>25.17</td>
</tr>
<tr>
<td>Variance</td>
<td>633.43</td>
</tr>
<tr>
<td>Range</td>
<td>100.0</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.0</td>
</tr>
<tr>
<td>Maximum</td>
<td>100.0</td>
</tr>
</tbody>
</table>

### Table III. Results of probit analysis

<table>
<thead>
<tr>
<th>Probability</th>
<th>Postoperative intact ratio</th>
<th>95% Confidence limits</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower</td>
</tr>
<tr>
<td>0.01</td>
<td>132.12</td>
<td>88.50</td>
</tr>
<tr>
<td>0.02</td>
<td>76.89</td>
<td>56.17</td>
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<tr>
<td>0.03</td>
<td>54.54</td>
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<tr>
<td>0.04</td>
<td>42.13</td>
<td>33.66</td>
</tr>
<tr>
<td>0.05</td>
<td>34.14</td>
<td>28.04</td>
</tr>
<tr>
<td>0.06</td>
<td>28.55</td>
<td>23.94</td>
</tr>
<tr>
<td>0.07</td>
<td>24.41</td>
<td>20.77</td>
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<tr>
<td>0.08</td>
<td>21.21</td>
<td>18.23</td>
</tr>
<tr>
<td>0.09</td>
<td>18.67</td>
<td>16.13</td>
</tr>
<tr>
<td>0.10</td>
<td>16.60</td>
<td>14.35</td>
</tr>
</tbody>
</table>

Fig. 2
Histogram of the postoperative intact ratio of 125 hips. The peak postoperative intact ratio occurs at 30% to 40%.
Nine (32%) and 37 (38%) hips were associated with corticosteroid treatment in the collapse and the no-collapse groups, respectively. The difference is not significant.

Two women in the no-collapse group complained of mild pain in the contralateral knee. They were diagnosed as having steroid-induced osteonecrosis. These were the only patients with painful knees in this study.

For all ten observers the intrapersonal and interpersonal variances of repeated measurement were 2.17 and 2.81, and the intraobserver and interobserver coefficients of repeatability were 2.95 and 3.36, respectively. The reproducibility of the method of measurement was considered reasonable.

Discussion

We have previously reported a rate of success of 93% in hips with a postoperative intact ratio of more than 36%. This study confirms our previous data in a statistical manner and probit analysis shows the reliability of 34% as the prognostic level for progressive collapse. This ratio is recommended as a standard for surgeons who carry out this osteotomy. Other factors such as obesity, the quality of the bone associated with corticosteroid treatment, and the condition of the contralateral hip also influence the incidence of progressive collapse after the osteotomy. These factors showed a similar effect in both the collapse and no-collapse groups.

Radiologically, two factors are reported to correlate with the results of transtrochanteric rotational osteotomy for ONFH. The first is the extent of the intact articular surface of the femoral head under the weight-bearing portion of the acetabulum on the postoperative AP film; and the second is the extent of the intact femoral articular surface of either the anterior or posterior area on the preoperative true lateral radiograph (preoperative lateral intact area). Varus realignment of the femoral head is added to the rotational displacement when necessary in transtrochanteric rotational osteotomy and is an important factor in obtaining a larger intact area. The preoperative lateral intact area itself does not correlate with the progressive collapse after the osteotomy, because the rotational angle and the added varus orientation provide possible bias. In this study, we used the postoperative intact ratio as a radiological predictor of progressive collapse because it had reasonable reproducibility.

The no-collapse group showed significantly better clinical results and a lower rate of prosthetic replacement than the collapse group. There was no pain or mild pain in 89% of the hips in the no-collapse group at the final follow-up. Based on these data, it appears that the absence of collapse is associated with a good clinical result and that a collapse of 2 mm leads to clinical failure. The relationship between progressive collapse and the clinical result is supported in previous reports.

Dean and Cabanela specifically reported that 15 of 18 hips (83%) showed a further collapse of the femoral head with an unsatisfactory outcome. MRI has been recognised as being more reliable than radiography for early detection and for estimating the extent of avascular necrosis. Postoperative MRI was not undertaken during the period of our study. It would have been more precise to determine the demarcation of necrosis if it had been performed for all the patients who had transtrochanteric rotational osteotomy. The technique cannot, however, be used during surgery to confirm that a new healthy articular surface is introduced to the weight-bearing part. It is also costly and was judged to be uneconomical.

Ohzono et al reported that the radiological classification of ONFH based on the relationship between a line of demarcation and the weight-bearing surface (types 1-A, 1-B and 1-C) provided an accurate prognosis. The critical ratio of 34% may be useful, not only for surgical planning
before and during surgery, but also in the assessment of the natural history of the disease.

Our study shows that the minimum postoperative intact ratio of 34% can prevent radiological progressive collapse during the initial ten-year period after transtrochanteric rotational osteotomy for osteonecrosis and relates the risk of progressive collapse of a femoral head to the postoperative intact ratio.

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References