Leg-length discrepancy after transtrochanteric curved varus osteotomy for osteonecrosis of the femoral head

S. Ikemura,
T. Yamamoto,
S. Jingushi,
Y. Nakashima,
T. Mawatari,
Y. Iwamoto

*From the Department
of Orthopaedic
Surgery, Kyushu
University, Fukuoka,
Japan*

Transtrochanteric curved varus osteotomy was designed to avoid some of the disadvantages of varus wedge osteotomy, such as post-operative leg-length discrepancy. In this retrospective study we investigated the leg-length discrepancy and clinical outcome after transtrochanteric curved varus osteotomy undertaken in patients with osteonecrosis of the femoral head. Between January 1993 and March 2004, this osteotomy was performed in 42 hips of 36 patients with osteonecrosis of the femoral head. There were 15 males and 21 females with a mean age at surgery of 34 years (15 to 68). The mean follow-up was 5.9 years (2.0 to 12.5). The mean pre-operative Harris hip score was 64.0 (43 to 85) points, which improved to a mean of 88.7 (58 to 100) points at final follow-up. The mean varus angulation post-operatively was 25° (12° to 38°) and the post-operative mean leg-length discrepancy was 13 mm (4 to 25). The post-operative leg-length discrepancy showed a strong correlation with varus angulation (Pearson's correlation coefficient; $r = 0.9530$, $p < 0.0001$), which may be useful for predicting the leg-length discrepancy which can occur even after transtrochanteric curved varus osteotomy.

Varus wedge osteotomy for the treatment of osteoarthritis of the hip was described by Pauwels,¹ and later adapted for the treatment of osteonecrosis by Merle d'Aubigne et al² and Kerboul et al.³ In osteonecrosis, a varus wedge osteotomy aims to move the necrotic lesion medially and bring the intact lateral articular surface into a weight-bearing position. A success rate of 73% to 76% has been reported for this procedure.^{4,5}

Varus wedge osteotomy, however, has some disadvantages, such as elevation or lateral displacement of the greater trochanter, and the potential for delayed or nonunion.^{4,5} In addition, Bombelli⁶ reported a leg-length discrepancy ranging between 29 mm and 38 mm after a 30° varus wedge osteotomy. In order to overcome these problems, Nishio and Sugioka⁷ developed a transtrochanteric curved varus osteotomy, which is performed between the greater and the lesser trochanters. The leg-length discrepancy following this curved transtrochanteric varus osteotomy has been reported to range between approximately 0.5 mm and 20 mm.^{8,9}

In this retrospective study we investigated the correlation between the degree of varus obtained at the osteotomy and the post-operative leg-length discrepancy as well as the clinical results following transtrochanteric curved varus osteotomy for osteonecrosis.

Patients and Methods

Between January 1993 and March 2004, transtrochanteric curved varus osteotomy was performed on 42 hips in 36 patients for osteonecrosis of the femoral head and all were included in the study. Six patients had bilateral operations. All were followed clinically and radiographically at intervals of at least one year. There were 15 males and 21 females with a mean age at the time of surgery of 34 years (15 to 68). The mean follow-up was 5.9 years (2.0 to 12.5). The osteonecrosis was steroid-induced in 32 hips, in four it was secondary to alcohol consumption, in two it was post-traumatic, and in four idiopathic.

The diagnosis of osteonecrosis was based on clinical presentation and imaging studies including radiographs and MRI.¹⁰ According to the classification of the Japanese Investigation Committee of Health and Welfare,¹¹ 37 hips were classified as stage 3A, four as stage 3B, and one as stage 4 (Fig. 1a). The localisation of the necrotic lesion was type B in one hip, type C1 in 36, and type C2 in five (Fig. 1b).

A clinical assessment based on the Harris hip score¹² was made pre-operatively and at final follow-up. In addition, all patients were asked about restriction of activities of daily living (ADL) and the presence or absence of a limp.

■ S. Ikemura, MD, Orthopaedic Surgeon
■ T. Yamamoto, MD, PhD, Assistant Professor of Orthopaedic Surgery
■ S. Jingushi, MD, PhD, Associate Professor of Orthopaedic Surgery
■ Y. Nakashima, MD, PhD, Assistant Professor of Orthopaedic Surgery
■ T. Mawatari, MD, PhD, Assistant Professor of Orthopaedic Surgery
■ Y. Iwamoto, MD, PhD, Professor and Chairman of Orthopaedic Surgery
Department of Orthopaedic Surgery
Graduate School of Medical Sciences, Kyushu University, 3-1-1 Maidashi, Higashi-ku, Fukuoka 812-8582, Japan.

Correspondence should be sent to Dr T. Yamamoto; e-mail: yamataku@ortho.med.kyushu-u.ac.jp

©2007 British Editorial Society of Bone and Joint Surgery
doi:10.1302/0301-620X.89B6.18499 \$2.00

J Bone Joint Surg [Br]
2007;89-B:725-9.

Received 7 August 2006;
Accepted after revision 16 January 2007

Diagrams showing the classification of osteonecrosis of the femoral head according to the Japanese Investigation Committee of Health and Welfare.¹¹ Figure 1a – Anteroposterior view. Stage 1: no specific findings of osteonecrosis on plain radiographs, however observed on MRI, bone scintigram, or histology. Stage 2: sclerosis without collapse of the femoral head. Stage 3A: collapse of the femoral head less than 3 mm. Stage 3B: collapse of the femoral head of 3 mm or more. Stage 4: osteoarthritic change. Figure 1b – Type A: necrotic area occupies the medial one-third or less of the weight-bearing portion. Type B: the medial two-thirds or less. Type C1: more than two-thirds but not extending to the acetabular rim. Type C2: more than two-thirds and extending to the acetabular rim.

Anteroposterior (AP) radiographs were taken in the supine position to measure the neck-shaft angle pre- and post-operatively (Fig. 2). We standardised the rotation of the lower limbs on AP radiographs by positioning both patellae in the exact frontal position throughout the radiological examination. In order to eliminate magnification errors, we measured the distance between two points: the top of the obturator foramen and the teardrop (Fig. 3a). Leg-length discrepancy was measured as the difference in the distance between the top of the obturator foramen and the inferior aspect of the lesser trochanter before and after operation, since the osteotomy line does not pass through the inferior aspect of the lesser trochanter (Fig. 3b).

The post-operative intact ratio was measured according to the method of Sugioka, Hotokebuchi and Tsutsui¹³ from the neutral AP radiograph taken within eight weeks of surgery (Fig. 4).¹⁴ During follow-up, we looked for progression of collapse and osteoarthritic changes on both AP and lateral radiographs.

Indication for this operation. The success rate of osteotomy including transtrochanteric curved varus osteotomy in the treatment of osteonecrosis has been reported by Miyanishi et al,¹⁴ who showed that patients who had more than 34% of the articular surface of the femoral head intact post-operatively had a good clinical outcome. Therefore osteotomy was indicated in a patient where the pre-operative AP hip radiograph in maximum abduction showed the possibility of determining an intact articular surface of more than 34%. To prevent adduction contracture, we excluded patients in whom the hip joints could not be abducted more than 20°.

However, one patient with only 30% of intact articular surface of the femoral head was considered suitable for this procedure because of her age (27 years) and her strong desire to preserve her hip joint.

Operative technique. After dissection of the fascia lata and iliotibial tract, the lesser trochanter and intertrochanteric crest are exposed along the planned osteotomy line in inter-

Fig. 2a

Fig. 2b

The method of measuring the neck-shaft angle. Figure 2a – Anteroposterior radiograph where X is the centre of the femoral head, and V is the neck-shaft angle pre-operatively. Figure 2b – Anteroposterior radiograph where 'V' is the neck-shaft angle post-operatively. V - V' is the varus angulation.

nal rotation. A special crescentic guide is attached at least 5 mm lateral to the intertrochanteric crest. The planned degree of varus displacement of the femoral neck is marked on the proximal and distal femur. Under fluoroscopic control, using a reciprocating saw, an intertrochanteric curved osteotomy is made perpendicular to the sagittal plane of the femur. The osteotomy is fixed by a large screw, and then plated with a lag screw (Fig. 2b).

Following the operation, patients start partial weight-bearing at five weeks, but full weight-bearing is delayed for six months. The aim of this prolonged restriction of full weight-bearing is to encourage remodelling of the subchondral bone under the newly-created weight-bearing area.

After final review a questionnaire was also sent to all 36 patients which included an enquiry about the presence of a limp and their satisfaction with the operation. The responses were graded into four categories: excellent (a high degree of satisfaction and no limp), good (a high degree of satisfaction but with a limp), fair (satisfied with a limp) and poor (dissatisfied).

Statistical analysis. Statistical analyses were carried out using the Wilcoxon signed-ranks test and Student's *t*-test. The correlation between the degree of varus angulation and leg-length discrepancy was analysed using Pearson's correlation coefficient. A *p*-value of less than 0.05 was considered statistically significant.

Results

The mean varus angulation obtained by osteotomy was 25° (12° to 38°) (Table I). There was no increase in the varus angu-

lation in any hip during the follow-up period on AP radiographs.

The distance between the top of the obturator foramen, and the teardrop was the same before and after the operation. The mean leg-length discrepancy was 5.0 mm for a 10° to 15° varus angulation, 9.6 mm for 16° to 20°, 12.4 mm (21° to 25°), 13.7 mm (26° to 30°), 18.5 mm (31° to 35°) and 23.0 mm (36° to 40°). A 20° to 30° varus angulation was most commonly performed (27 of 42 hips: 64.3%), in which the leg-length discrepancy was about 15 mm (Table I). The post-operative leg-length discrepancy showed a very strong correlation with the degree of varus angulation (Pearson's correlation coefficient; *n* = 42, *r* = 0.9530, *p* < 0.0001) (Fig. 5).

The mean pre-operative Harris hip score was 64.0 (43 to 85) points, which improved to a mean of 88.7 (58 to 100) points at final follow-up (Fig. 6). After transtrochanteric curved varus osteotomy, an intact articular surface of more than 34% was obtained in 41 of the 42 hips.¹³ The mean post-operative intact articular surface was 53.0% (30% to 81%). Two of the 42 hips developed osteoarthritic changes during the follow-up period. One was a 27-year-old-female with systemic lupus erythematosus, which was stage 3A and type C2 in whom only 30% intact articular surface was obtained post-operatively. Symptoms recurred two years after operation, followed by progressive osteoarthritic changes. She underwent total hip replacement (THR). The other was a 37-year-old-male, with a stage 3A, type C2 hip. Post-operatively 45% intact articular surface was obtained. There were mild osteoarthritic changes two years after the operation. He remains, however, asymptomatic and there has been no progression of the degenerative changes. He continues to be reviewed regularly. Apart from these two patients no hip showed either osteoarthritic changes or further collapse at follow-up.

A total of 13 patients (36.1%) in whom the mean varus angulation was 28.5° (20° to 35°) and the mean leg-length discrepancy was 15.5 mm (12 to 20) reported a limp. A total of 23 patients (63.9%) in whom the mean leg-length discrepancy was 11.9 mm (4 to 21) did not have a limp. The leg-length discrepancy of the patients with a limp was significantly greater than those without a limp (Student's *t*-test; *p* = 0.0036). Insoles to correct leg-length discrepancy, were used by ten of 36 patients (28%).

The outcome in 23 patients was classified as excellent (64%), in 12 as good (33.3%), one as fair (2.8%) and none as poor.

There was no incidence of fracture of the greater trochanter, delayed union or nonunion in any of the 42 hips. No deep infections or deep-vein thrombosis was observed. None of the patients showed weakness of the manual muscle testing of the gluteus medius muscle at the final follow-up examination.

Discussion

The transtrochanteric curved varus osteotomy was designed to avoid elevation of the greater trochanter and lateral displacement of the femoral shaft which can lead to disturbance of abductor muscle function and a limp. It

Fig. 3a

Fig. 3b

Diagrams showing the methods of measuring in radiological assessment. Figure 3a – On anteroposterior radiographs, to eliminate magnification errors, we measured the distance between 2 points; the top of A) the obturator foramen and B) the teardrop before and after the operation. Figure 3b – To measure the leg-length discrepancy, the distance between the top of the obturator foramen and the inferior aspect of the lesser trochanter was examined (C) pre-operatively and (D) post-operatively. (C) to (D) is the leg-length discrepancy; (G), gluteus medius muscle. Note the gluteus medius muscle attachment is to the lateral portion of the greater trochanter, which is not affected by the osteotomy.

Fig. 4

Diagram showing method of measurement of the intact ratio of the articular surface of the femoral head to the load-bearing area of the acetabulum on the post-operative anteroposterior radiograph (post-operative intact ratio). Point F is determined by drawing a perpendicular line from the midpoint of E (the edge of the acetabulum) and J (the lowest point of the teardrop) to the acetabular roof. Point H represents the lateral edge of the load-bearing portion. Point I represents the medial edge of the intact articular surface of the femoral head. The post-operative intact ratio is expressed as H-I/E-F.

Table I. The varus angulations and the mean post-operative leg-length discrepancy

Varus angulations(°)	Number of hips	The mean (range) post-operative leg-length discrepancy in mm
10 to 15	2	5.0 (4 to 6)
16 to 20	11	9.6 (8 to 11)
21 to 25	10	12.4 (11 to 14)
26 to 30	11	13.7 (12 to 16)
31 to 35	6	18.5 (17 to 20)
36 to 40	2	23.0 (21 to 25)
Mean 25.0	42	Mean 13.0

was also designed to minimise delayed union or nonunion and leg-length discrepancy which have all been reported after wedge varus osteotomy.^{7,8} The results of transtro-

chanteric curved varus osteotomy have been reported by several authors. Saito, Ohzono and Ono¹⁵ reported four cases and Sakano et al⁹ 20 cases, undertaken for

Fig. 5

Graph showing the relationship between the amount of varus angulation and leg-length discrepancy.

Fig. 6

Graph showing Harris hip score; before operation and at final follow-up. The mean pre-operative Harris hip score was 64.0 (43 to 85) points, which improved to 88.7 (58 to 100) points at the final follow-up examination (Wilcoxon signed-ranks test; $n = 42$, $p < 0.0001$).

osteonecrosis. There have been no descriptions of the correlation between the degree of varus obtained and leg-length discrepancy.

Our results and those of other authors^{8,9} show that leg-length discrepancy can occur after this operation. One reason might be that there is a difference between the centre of rotation of the osteotomy and the centre of the femoral head.

Of 36 patients 13 (36.1%) reported a limp. The mean leg-length discrepancy in these 13 patients was 15.5 mm (12 to 20). However, in none of these patients was there associated pain when reviewed at final follow-up. In addition, the leg-length discrepancy in patients with a limp was significantly greater than in those without a limp (Student's t -test, $p = 0.0036$). Abductor weakness can cause a painless

limp. The minimum follow-up period in this study was more than two years and manual muscle testing of the gluteus medius muscle showed no evidence of residual weakness at the final follow-up examination. We therefore considered that muscle weakness had recovered and was not the cause of a limp, suggesting that leg-length discrepancy alone was the major cause of a limp. Nevertheless, 35 patients (97.2%) considered their outcome to be either 'excellent' or 'good', even with a limp.

Patients scheduled to undergo transtrochanteric curved varus osteotomy often express concern about post-operative leg-length discrepancy. The results shown in Figure 5 and Table I show a strong correlation between the degree of varus and leg length discrepancy and could be used when advising patients.

This work was supported in part by a Grant-in-Aid in Scientific Research (No. 18591665) from JSPS and a grant from Konica Minolta Imaging Science Foundation.

Although none of the authors has received or will receive benefits for personal or professional use from a commercial party related directly or indirectly to the subject of this article, benefits have been or will be received but will be directed solely to a research fund, foundation, educational institution, or other nonprofit organisation with which one or more of the authors are associated.

References

1. Pauwels F. The place of osteotomy in the operative management of osteoarthritis of the hip. *Triangle* 1968;8:196-210.
2. Merle d'Aubigne R, Postel M, Mazabraud A, et al. Idiopathic necrosis of the femoral head in adults. *J Bone Joint Surg [Br]* 1965;47-B:612-33.
3. Kerboul M, Thomine J, Postel M, Merle d'Aubigne R. The conservative surgical treatment of idiopathic aseptic necrosis of the femoral head. *J Bone Joint Surg [Br]* 1974;56-B:291-6.
4. Mont MA, Fairbank AC, Krackow KA, Hungerford DS. Corrective osteotomy for osteonecrosis of the femoral head: the results of a long-term follow-up study. *J Bone Joint Surg [Am]* 1996;78-A:1032-8.
5. Ito H, Kaneda K, Matsuno T. Osteonecrosis of the femoral head: simple varus intertrochanteric osteotomy. *J Bone Joint Surg [Br]* 1999;81-B:969-74.
6. Bombelli R. *Osteoarthritis of the hip: pathogenesis and consequent therapy*. Berlin: Springer-Verlag, 1976.
7. Nishio A, Sugioka Y. A new technique of the varus osteotomy at the upper end of the femur. *Orthop Trauma* 1971;20:381-6.
8. Sugioka Y, Ogata K, Kitajima T, Nishio A. Transtrochanteric curved varus osteotomy in the treatment of dysplastic hip: The Hip. *Proc 8th open scientific meeting of the Hip Society* 1980:227-44.
9. Sakano S, Hasegawa Y, Torii Y, Kawasaki M, Ishiguro N. Curved intertrochanteric varus osteotomy for osteonecrosis of the femoral head. *J Bone Joint Surg [Br]* 2004;86-B:359-65.
10. Sugano N, Kubo T, Takaoka K, et al. Diagnostic criteria for non-traumatic osteonecrosis of the femoral head: a multicentre study. *J Bone Joint Surg [Br]* 1999;81-B:590-5.
11. Sugano N, Atsumi T, Ohzono K, et al. The 2001 revised criteria for diagnosis, classification, and staging of idiopathic osteonecrosis of the femoral head. *J Orthop Sci* 2002;7:601-5.
12. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty: an end-result study using a new method of result evaluation. *J Bone Joint Surg [Am]* 1969;51-A:737-55.
13. Sugioka Y, Hotokebuchi T, Tsutsui H. Transtrochanteric anterior osteotomy for idiopathic and steroid-induced necrosis of the femoral head: indications and long-term results. *Clin Orthop* 1992;277:111-20.
14. Miyazaki K, Noguchi Y, Yamamoto T, et al. Prediction of the outcome of transtrochanteric rotational osteotomy for osteonecrosis of the femoral head. *J Bone Joint Surg [Br]* 2000;82-B:512-16.
15. Saito S, Ohzono K, Ono K. Joint-preserving operations for idiopathic avascular necrosis of the femoral head: results of core decompression, grafting and osteotomy. *J Bone Joint Surg [Br]* 1988;70-B:78-84.