Curved intertrochanteric varus osteotomy for osteonecrosis of the femoral head

S. Sakano, Y. Hasegawa, Y. Torii, M. Kawasaki, N. Ishiguro

From Nagoya University School of Medicine, Nagoya, Japan

We reviewed the outcome of curved intertrochanteric varus osteotomy in the treatment of osteonecrosis of the femoral head in 20 hips. A mean varus angulation of 31˚ was obtained by the osteotomy. The ratio of intact area on the weight-bearing portion increased from 19% to 61%. The mean elevation and lateral displacement of the greater trochanter were 1.2 cm and 0.5 cm, respectively. These changes in the position of the greater trochanter were very small when compared with those after conventional varus wedge osteotomy. Nonunion or delayed union was not observed. Quantitative analyses showed aggressive bone remodelling in the medial intertrochanteric region. Eighteen hips survived without collapse after a mean follow-up of 48 months.

We conclude that curved varus osteotomy can be used to preserve the hip joint in patients with osteonecrosis of the femoral head.

Osteonecrosis of the femoral head causes pain and limitation of movement of the hip. Total hip replacement (THR) is an effective treatment, however, the long-term results are unsatisfactory due to a high rate of revision surgery.1,2 As osteonecrosis of the femoral head usually occurs in young adults, it is desirable to avoid or postpone THR. In order to delay the onset of degenerative changes, attempts have been made to prevent the collapse of the femoral head using different osteotomies. Varus osteotomy is designed to move the necrotic lesion medially and bring the intact lateral articular surface into a weight-bearing position. This technique was initially devised as a treatment for osteoarthritis of the hip by Pauwels,3 and later adapted for osteonecrosis by Merle d’Aubigne et al4 and Kerboul et al.5 The success rate of the varus wedge osteotomy in the treatment of osteonecrosis of the femoral head is reported to be 73% to 76%, indicating its effectiveness.6,7

This operation, however, has some disadvantages, such as the elevation or lateral displacement of the greater trochanter, and an incidence of nonunion or delayed union of about 8%.6,7 In order to overcome these problems Nishio and Sugioka8 developed an intertrochanteric varus osteotomy between the greater and the lesser trochanter which is curved so as to place the femoral head in a varus position by rotating it in the coronal plane. Theoretically, varus angulation can be obtained with little change in the position of the trochanters. Previously, a curved varus osteotomy has been reported for the treatment of the dysplastic hip.9 Saito, Ohzono and Ono10 have also described four cases of curved varus osteotomy in the treatment for osteonecrosis of the femoral head, as part of a study on operations to preserve the joint. To our knowledge, there have been no reports of the clinical and radiographic outcome of curved varus osteotomy for the treatment of osteonecrosis of the femoral head. This study presents the short-term results of this operation.

Patients and Methods

Between August 1990 and May 2002, 20 curved intertrochanteric varus osteotomies were performed to treat osteonecrosis of the femoral head in 20 patients. There were ten males and ten females. The diagnosis of osteonecrosis was based on the clinical history, physical examination, radiographic appearance and MRI findings. There was a history of alcohol abuse in one patient, steroid therapy in 13, alcohol abuse during steroid therapy in two, and fracture of the femoral neck in three. One patient had idiopathic necrosis. Six patients continued steroid therapy after the osteotomy. The mean age at the time of operation was 38 years (17 to 61). The mean follow-up was 48 months (8 to 149). According to the
In Ficat staging system, 11 14 hips were in stage II, four in stage III and two in stage IV. According to the Steinberg classification, the size of the necrotic lesion was C with more than 30% involvement of the head in all 20 hips. The localisation of the affected lesion was shown to be type I-B in three hips and type I-C in 17 using the classification of the Japanese Investigation Committee of Health and Welfare.

Operative procedure. Under general anaesthesia, a longitudinal skin incision is made over the greater trochanter with the patient in the lateral position. After dissection of the deep fascia, the greater and lesser trochanters are exposed posteriorly by rotating the hip joint internally (Fig. 2). The external rotators and quadratus muscle are retained with the preservation of the medial femoral circumflex artery. In order to expose the top of the greater trochanter, 1 cm posterior sections of the insertion of gluteus medius and minimus are detached. A curved Kirschner wire is prepared by adjusting it according to the pre-operative radiograph in the line from the greater to lesser trochanter. Under fluoroscopic guidance, this wire is introduced into the intertrochanteric region as planned pre-operatively, and multiple drill holes are made from the posterior to anterior cortex. An intertrochanteric curved osteotomy is then carried out from the greater to lesser trochanter using a 5 mm osteotome. Recently in the three hips, a reciprocating saw has been used with a crescentic guide.

The anterior periosteum is then dissected along the line of the osteotomy and the femoral head rotated into a varus position by displacing the femoral neck in a cranial direction. The correction is verified fluoroscopically. The femoral head was stabilised using two or three screws in the first ten hips and with a compression hip screw in the next ten hips. Flexion or extension was not added; however, it is possible to add either if desired. The internal fixation was routinely removed two years after the operation.

Assessment. Anteroposterior (AP) radiographs of the hips in neutral and maximum abduction were obtained pre-operatively. During the follow-up, AP radiographs in the neutral position were taken at one month and every six months thereafter. The varus angulation achieved was calculated by subtracting the post-operative neck-shaft angle from the pre-operative angle.

The vertical distance (VD) from the top of the greater trochanter to the tear-drop line was measured (Fig. 3). The elevation of the greater trochanter was expressed by subtracting the pre-operative from the post-operative VD. The lateral distance (LD) from the teardrop to the lateral border of the greater trochanter was measured. The lateral displacement of the greater trochanter was measured by subtracting the pre-operative from the post-operative LD.
The intact area of the femoral head on the weight-bearing portion was calculated as a ratio as shown in Figure 3. Briefly, the point M was determined by drawing a perpendicular line to the acetabulum from the midpoint of the acetabular edge W and the tear-drop. The point N was the edge of the necrotic lesion. The point C was where a vertical line from the point W crossed the articular surface of the femoral head. The ratio of intact area was calculated by dividing the distance from C to N by that from W to M.

Correlation between the ratio of intact area in the pre-operative abducted position and the post-operative neutral position was analysed by Pearson’s correlation coefficient.

To assess the remodelling at the intertrochanteric region, the area of newly formed bone was analysed on the AP radiographs in ten patients. The area of newly formed bone was measured using Scion Image Beta 4.02 (Scion Corporation, Frederick, Maryland). Changes in the width of the intertrochanteric region and neck-shaft angle were also evaluated on the series of radiographs. AP radiographs were taken with the hips in neutral. Regeneration of the necrotic lesion and any complications including collapse were recorded. Clinical evaluation was carried out using the Harris Hip Score (HHS) pre-operatively and during follow-up.
Results
A mean varus angulation of 31˚ (15 to 46) was obtained by the osteotomy. The ratio of intact area of the femoral head on the weight-bearing portion increased from 19% to 61% after the osteotomy. The ratio of intact area of the femoral head calculated on the pre-operative radiographs at maximum abduction showed a strong correlation with the ratio of intact area on the post-operative radiographs at the neutral position (r = 0.891, p < 0.0001) (Fig. 4). In one hip it was difficult to determine the edge of the intact area in the femoral head on the AP radiograph. The mean elevation of the greater trochanter was 1.2 cm (0.5 to 2.0), which was markedly smaller than that with a conventional varus wedge osteotomy.\(^\text{18}\) The mean lateral displacement of the greater trochanter was very small, 0.5 cm (0 to 1.7).

Bone formation and remodelling in the medial intertrochanteric region dramatically increased during follow-up (Fig. 5) reaching a plateau at 2.5 years (Fig. 6a). The mean width of the intertrochanteric bone decreased to 62% of the original width immediately after the osteotomy; however, it recovered to 88% in 1.5 years and 91% in three years (Fig. 6b). As remodelling progressed, the mean neck-shaft angle also increased gradually from 101˚ to 109˚ (Fig. 6c). Regeneration of bony trabeculae in the necrotic lesion was seen in one hip, although the other hips showed only slight or no bone formation in the lesion.

Eighteen of the 20 hips survived without collapse after a mean follow-up of 48 months. The mean pre-operative HHS of 74 points improved to a mean of 89 at the time of final follow-up. The mean score for pain increased from 31 points to 40 and that for function from 35 points to 39. Nine patients had no limp, eight a slight limp, two a moderate limp and one a severe limp. No hip joint required a THR. A major complication was a fracture in the intertrochanteric region which occurred in two hips. In both cases, two screws had been used to stabilise the osteotomy and the fracture occurred two weeks post-operatively. The fracture was treated conservatively by skin traction. One healed without deformity, whereas the other had an increased varus angulation from 38˚ to 76˚, causing severe limp. This patient was excluded from assessment of remodelling in the intertrochanteric region. No fracture was observed in the ten hips fixed with a compression hip screw (Fig. 7). There was no delayed or nonunion.

Discussion
Varus osteotomy was originally introduced as a treatment for osteoarthritis of the hip, and its application was later extended to osteonecrosis of the femoral head.\(^\text{3-5}\) This conventional varus wedge osteotomy was reported to show good or excellent results in 73% of cases after a mean 12.5-year follow-up.\(^\text{7}\) Mont et al\(^\text{6}\) showed that 76% of the hips had a good or excellent result at a mean of 11.5 years after varus wedge osteotomy with or without correction of extension or flexion. These reports indicated that varus osteotomy can be used to preserve the joint in patients with osteonecrosis. Elevation and lateral displacement of the greater trochanter have been recognised as complications of the procedure. Bombelli\(^\text{18}\) reported that 1.8 cm to 2.4 cm of elevation of the greater trochanter occurs with varus angulation of 20˚ and 2.9 cm to 3.8 cm with angulation of 30˚. In this study, we found that the mean elevation of the greater trochanter was only 1.2 cm when the mean varus...
angulation of 31˚ was obtained. These data indicate that the elevation of the greater trochanter after curved varus osteotomy is very low compared with that after conventional varus wedge osteotomy. This is consistent with the data shown in dysplastic hips treated with a curved varus osteotomy.9,19 Furthermore, we also found that lateral displacement of the greater trochanter was very low after curved varus osteotomy. Nonunion or delayed union is another complication of wedge osteotomy, reported to be about 8%.6,7 In contrast, we observed neither complication.

After curved varus osteotomy, marked new bone formation was observed in the medial intertrochanteric region. Immediately after the operation, the thickness of intertrochanteric bone decreased to 62%; however, three years later, it recovered to 91%. The newly formed bone increased consistently year by year; this new bone formation on the medial intertrochanteric region may be based on Wolff’s Law. This kind of remodelling is also seen during fracture healing.20 It has been suggested that biomechanical stress and loading affect osteogenic and osteoclastic gene expression and their transcriptional regulation.21,22 Remodelling of the femoral neck after internal fixation of slipped capital epiphysis and varus osteotomy for acetabular dysplasia in children has been well documented.23-26 In these reports, the femoral neck-shaft angle was shown to increase after the operation. In this series, an increased femoral neck-shaft angle was noted after curved varus osteotomy. This indicates that the ability to create new bone in the medial intertrochanteric region is still retained in adults. However, when considering the necrotic lesions, only one case showed new trabecular formation in the femoral head. Even though aggressive remodelling and new bone formation were observed in the intertrochanteric region, very little bony regeneration was identified in the femoral head, suggesting the existence of factors that inhibit or abolish osteogenesis in the necrotic lesion.

Several osteotomies have been described for the treatment of osteonecrosis of the femoral head. Intertrochanteric osteotomy, including varus and valgus osteotomies, has been reported to give satisfactory results...
in 73% of cases after a mean follow-up of 5.3 years. Maistrelli et al.\textsuperscript{28} noted that 71% of hips had satisfactory results at two years after intertrochanteric varus or valgus osteotomy and 58% at 8.2 years. Gallinaro and Masse\textsuperscript{29} described satisfactory results in 62.5% of cases after flexion osteotomy at a mean follow-up of 10.2 years. Flexion valgus osteotomy with autogenous bone-grafting has shown a survival rate of 87% without replacement arthroplasty ten years after operation.\textsuperscript{30} Sugioka's rotational osteotomy is another option for the treatment of osteonecrosis and is designed to move the femoral head into any degree of rotation and varus angulation. Sugioka et al.\textsuperscript{31} have reported a 78% success rate after three to 16 years follow-up. Since 1989, we have used rotational osteotomy and reported a success rate of 62% after three- to seven-year follow-up.\textsuperscript{13} We are relatively satisfied with these results, despite the fact that this osteotomy is technically difficult, and the possible angle of rotation which may be achieved is not predictable pre-operatively.\textsuperscript{14} The results of rotational osteotomy studies are, to date, discordant between Asian and Western countries.\textsuperscript{12-38}

Between August 1990 and May 2002 we performed 197 joint-preserving operations to treat osteonecrosis of the femoral head. Of these, 177 were rotational and 20 curved varus osteotomy. The indications for rotational osteotomy were type I-B, I-C and II with an intact area of the femoral head which measured 36% or more in Lauenstein's view.\textsuperscript{14} The indications for curved varus osteotomy were type I-B and I-C with an intact area of the femoral head which measured less than 36% in Lauenstein's view, but more than 30% on the weight-bearing portion in the anteroposterior view in maximum abduction. From 2001, the indications for curved varus osteotomy were extended to those with an intact area more than 20% of the weight-bearing portion in maximum abduction. Recently, we have used a curved varus osteotomy as our choice as it is less invasive and less technically demanding. It is also a reliable procedure because it increases the intact area in the femoral head on the weight-bearing portion as planned pre-operatively (Fig. 4). There were two cases of intertrochanteric fracture which were stabilised with screws in this study. This appears to be the only major complication of the curved varus osteotomy when compared with a varus wedge osteotomy. However, after the introduction of a compression hip screw, no fractures have occurred; thus, rigid fixation appears necessary to reduce this complication as the width of the intertrochanteric region initially decreases after the osteotomy.

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References


