Lesser trochanteric osteotomy in total hip arthroplasty for treating CROWE type IV developmental dysplasia of hip

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Received: 11 November 2012 / Accepted: 13 December 2012 / Published online: 5 January 2013
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Abstract

Purpose The study was designed to evaluate the efficacy and safety of lesser trochanteric osteotomy for femoral shortening in total hip arthroplasty in treatment of 28 cases of CROWE IV developmental dysplasia of the hip (DDH). **Methods** Patients underwent progressive femoral shortening at the level of lesser trochanteric to make reduction possible into the anatomical acetabulum in all hips. The results were collected and evaluated clinically and radiographically.

Results The mean follow-up period was 55.3 months. The average postoperative leg length discrepancy was eight millimetres for unilateral THA patients. A modified Merle d'Aubigné scale was improved from 9.3 preoperatively to 15.9 postoperatively. Sciatic nerve palsy was confirmed in two hips which resolved completely in six months. The Trendelenburg sign was positive in two hips at the final follow-up. No revision surgery was required by the final follow-up.

Conclusion Lesser trochanteric osteotomy proved to be safe and effective in femoral shortening for treatment of CROWE IV DDH without the problem of nonunion at the site of osteotomy.

Introduction

The reduction of the femoral head into the anatomical acetabulum has proved to yield favourable biomechanical results in total hip arthroplasty (THA) for CROWE type

IV developmental dysplasia of the hip (DDH) [1]. High dislocation of the hip up to six centimetres with severe contracture of soft tissue and potential leg lengthening of more than four centimetres [2, 3], however, is always one of the major challenges and an indication for femoral shortening. Femoral shortening for CROWE type IV (DDH) is useful or sometimes necessary to assist the reduction without excessive soft tissue tension. Subtrochanteric osteotomy either transverse, oblique chevron or T-shaped has been well documented with good clinical results [4–9], but nonunion and complexity in performance remain the major concerns in the procedure [4, 10]. Progressive osteotomy at the femoral neck with greater trochanteric osteotomy [11] and distal femur osteotomy were also reported in previous studies [12].

Here we reviewed 28 cases (30 hips) of femoral shortening using lesser trochanteric osteotomy for CROWE IV DDH leaving the greater trochanter intact, and evaluated the effectiveness and safety of this procedure.

Material and methods

Ethics statement

The study protocol has been approved by the institutional review board of Nanjing Jinling Hospital, Nanjing, China. Written informed consents were obtained from all the individuals in this manuscript to publish these case details.

Patients

A retrospective review was made of 28 cases (30 hips) of CROWE IV DDH who underwent THA from May 1999 to April 2010. The mean follow-up period was 55.3 months (Range, 24–132 months) (Table 1). The patients included in this study met CROWE classification criteria [13]. Pain and

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severe functional impairment with limp, pelvic obliquity, flexion deformity of the hip and knee, lumbar scoliosis and lordosis were the main indications for THA. Patients who had high dislocation of the hip from slipped capital femoral epiphysis or tuberculosis were excluded from the study. There were three males and 25 females with mean age of 35.3 years (Range, 17–67 years) at the time of operation. There were 18 noncemented and 12 cemented acetabular cups in this group. All femoral components were fixed cementlessly. Bilateral THA was performed in two patients under the same anaesthesia. Modular S-ROM stem (Depuy, Warsaw, Indiana) with a Duraloc Acetabular Cup (Depuy) was used in eight hips, while the Ribbed Hip System (LINK, Germany) was used in 11 hips and the Summit hip system (Depuy, Warsaw, Indiana) in 11 hips (Table 1).

Radiological evaluation

All patients had standard pelvic AP and lateral view radiographs for preoperative, postoperative and follow-up evaluation. The radiographic evaluation was done by an author who was not involved in the surgery. Parameters of the true acetabulum were identified including location, size, depth and anteversion angle as well as bone defect of anterior and posterior borders. Hip dislocation height was also measured on the radiographs based on methods of the triangle of Ranawat [14]. Pelvic height was used to calculate the height of the true acetabulum and the anatomical centre of rotation of the hip. An equilateral triangle, with the side length comprising one-fifth of the pelvic height, was drawn from 5 mm lateral to the teardrop on Kohler's line. Then, the

Table 1 Demography of patients and main results of lesser trochanteric osteotomy for femoral shortening

No.	Sex	Age	Follow-up	Femoral stem	T sign ^a	Sciatic nerve palsy ^b	Femoral fracture	LLD (mm) ^c	
								Pre-	Post-
1	F	23	41	Summit	N	N	N	51	1.2
2	F	63	31	Summit	N	N	N	45	1.1
3	F	17	101	Summit	N	Y	N	39	1.2
4	F	49	48	Summit	N	N	N	52	0.8
5	M	32	71	Summit	N	N	N	57	0.9
6	F	53	44	Summit	N	N	N	58	0.4
7	F	40	60	Summit	N	N	N	34	0.5
8	F	46	55	Summit	Y	N	N	44	0.5
9	M	23	94	Summit	N	N	N	49	0.9
10	F	43	44	Summit	N	N	N	51	1.3
11	F	23	68	Summit	N	N	N	47	0.4
12	M	44	54	Ribbed	N	N	Y	43	0.3
13	F	43	40	Ribbed	N	Y	N	62	0.5
14	F	56	64	Ribbed	N	N	Y	60	0.6
15	F	27	85	Ribbed	N	N	N	44	0.5
16	F	31	80	Ribbed	N	N	N	43	0.4
17	F	40	64	Ribbed	N	N	N	53	1
18	F	34	63	Ribbed	N	N	N	49	1.1
19	F	53	56	Ribbed	N	N	N	58	0.5
20	F	33	132	Ribbed	N	N	N	56	0.6
21	F	24	71	Ribbed	N	N	N	33	0.4
22	F	22	60	Ribbed	N	N	N	35	0.8
23	F	30	30	S-ROM	N	N	N	51	1.2
24	F	28	32	S-ROM	N	N	N	11	0.8
				S-ROM	N	N	N	11	0.8
25	F	26	24	S-ROM	N	N	N	38	4.2
26	F	25	29	S-ROM	Y	N	N	42	4.6
27	F	27	29	S-ROM	N	N	Y	7	0
				S-ROM	N	N	N	7	0
28	F	20	26	S-ROM	N	N	N	40	1.5

^a Trendelenburg sign results by the final follow-up; ^b By the 6th-month follow-up; ^c Leg length discrepancy

midpoint of the hypotenuse was estimated to be the centre of rotation of the hip. The vertical distance from the femoral head centre to the anatomical hip centre was considered to be the dislocation height of the hip (Fig. 1a). Templating on radiographs was used to determine the length, diameter and position of femoral stem.

Periprosthetic radiolucency was recorded in both acetabulum cup and femoral stem according to the method described by Delee and Charnley [15]. Progressive radiolucency of over two millimetres in width or migration of over five millimetres in any direction was considered to be loosening, with the pelvic teardrops used as reference points. Subsidence of femoral stem was measured according to Engh [16]. It was determined by the change in distance from the superomedial tip of stem to the most proximal point on lesser trochanter. A change of over five millimetres was considered significant.

Surgical technique

All the operations were completed by one experienced orthopedic surgeon. The lateral position and a posterior-lateral approach was used. After the external rotators were detached, the elongated capsule was exposed. The capsule was opened and a provisional osteotomy was performed at the base of the femoral neck which was usually further distal than in a regular THA. If necessary, the iliopsoas and part of the gluteus maximus were detached from the femoral insertions.

Exposure of the anatomical acetabulum was performed by capsulectomy and thorough removal of osteophyte and excessive soft tissue. Adipose tissue and transverse ligament were both good indicators for finding the true acetabulum. After preliminary location, a k-wire was inserted into the upper border of the acetabulum for precise positioning by intraoperative radiograph. The acetabulum was then widened and deepened at a designated angle of abduction and anteversion. If the

coverage was found to be less than 80 %, a structural autograft was constructed using the resected femoral head with two cancellous bone screws for fixation to the upper border of the acetabulum. A cemented cup was used for the acetabulum with severe bone deficiency in the anterior and posterior border or for those in whom press fit proved impossible.

When sequential rasping was performed in the femoral canal, attention was paid to the correction of the anteversion angle and possible fracture of the proximal femur. If necessary, a prophylactic cerclage wire could be useful to prevent femoral fracture. A trial reduction of the hip was done to evaluate the stiffness of the circumarticular soft tissue. Flexing and internally rotating the hip with persistent distal traction was carried out by an assistant. Pressure on the trial femoral head plus a sling around the neck to apply distal traction was used to aid the reduction with the pelvis tightly fixed on the operating table. The limb was deflexed and externally rotated to reduce the hip when the femoral head was on the level of acetabulum. During the process of reduction, the knee was always positioned in flexion to protect the sciatic nerve. If the reduction could not be achieved, additional shortening of the femur was performed with progressive resection of lesser trochanter based on the stiffness of the soft tissue (Fig. 1b). The greater trochanter was protected and the abductors kept intact during the osteotomy. The trial femoral stem was then impacted correspondingly deeper. The hip should be reduced under moderate tension on the soft tissue and the sciatic nerve explored after reduction. An excessive anteversion angle needed to be managed and reduced to a level that the combined anteversion of cup and stem was in the range from 30° to 45°.

Postoperative rehabilitation

Flexion of the hip and knee at 30° was maintained when the patient was on the bed during the first two weeks

Fig. 1 **a** Determination of anatomical hip centre and distance of hip dislocation with use of the method of the Ranawat triangle; **b** The dashed line represents the planned cutting line which was determined by the difference between the hip dislocation height and step spacer height

postoperatively, in order to further protect the neurovascular tissue. Patients without intraoperative femoral fracture were encouraged to undertake partial weight bearing and motion under the protection of crutches on the third day postoperatively. Simple flexion and extension exercises were scheduled from then on. The ipsilateral crutch was discarded and full weight bearing was initiated two weeks postoperatively, but the contralateral crutch was maintained for three months when the abductor muscles had recovered significantly.

Follow-up

Detailed physical examination and standard radiographs were carried out for each patient six weeks, six months, one year and then every two years after the operation. The patients were rated by the Modified Merle d'Aubigné scale which included pain, function and mobility evaluation. Complications and their clinical outcomes were recorded at each follow-up. Detailed clinical neurological examination of the sciatic nerve function was performed at each follow-up visit. Leg length was measured from the anterior superior iliac spine to the medial malleolus on physical examination.

Statistical analysis was performed using the Wilcoxon rank test for Merle d'Aubigné scales. The P value <0.05 was considered significant statistically.

Results

The mean follow-up period was 55.3 months (range, 24–132 months). The modified Merle d'Aubigné hip scale was improved from 9.3 (range, 6.1–11.5) preoperatively to 15.9 (range, 12.1–17.2) by the final follow-up (Table 2). The femoral head was reduced into the anatomical acetabulum for each hip. Preoperative dislocation height of femoral head on radiographs and intraoperative osteotomy height (12 mm above the upper border of the lesser trochanter was set as the zero point) average to 51 mm (range, 45–66 mm) and 22 mm (range, 18–28 mm), respectively. The femoral head centre was reduced by 45 mm (range, 38–61 mm). Pre- and postoperative leg length discrepancies were 47 mm and

8 mm (range, 3–15 mm) for unilateral THA (Table 1). Seven patients noticed postoperative leg length discrepancy. Six out of them complained of longer ipsilateral limb length than the contralateral side, while another complained of shorter. But no limbs were longer than the non-operated side based on the result of physical measurement. Those who complained of longer length reported no perceptible leg length discrepancy at the follow-up of six months. No infection, dislocation or loosening of prosthesis was reported by the final follow-up (Fig. 2).

Intraoperative fracture of the proximal femur occurred in three hips. Cerclage wires (LINK,GERMANY) were applied for fixation. The patients were encouraged to undertake partial weight bearing 14 days postoperatively. The mean period for fracture union was 3.2 months (range, 2.5–4 months). No nonunion or loosening of the femoral stem was demonstrated by the final follow-up. One hip had a perforation at the distal femur which was bypassed with a longer stem under the same anaesthesia.

Sciatic nerve palsy was demonstrated in two hips with numbness of the dorsum of foot and weakness of ankle extension postoperatively. The patients had 30° flexion of the hip and knee to relieve tension of the nerve and were administered cobamamide for three months. The two nerve palsies recovered within six months without functional defects.

All patients had positive Trendelenburg signs preoperatively. The sign became negative in nine hips (30 %) after the operation. It was still positive but markedly reduced in 19 hips (63.3 %). Two hips (6.7 %) maintained a positive Trendelenburg sign resulting in a mild limp until the final follow-up. Otherwise, there was a complaint of thigh pain by the patient who had the distal femur perforation. Due to the narrow and irregular femoral canal, the femoral stem was

Fig. 2 A 22-year-old female with a unilateral Type IV DDH underwent a lesser trochanteric osteotomy. **a** Preoperative; **b** 3 years postoperative

Table 2 Pre- and post-operative subscores of Modified Merle d'Aubigné and Poste Scale

Modified Merle d'Aubigné Scale	Preoperative	Postoperative
Pain	3.1±1.1	5.6±0.6*
Walking	2.9±1.4	5.4±0.3*
ROM	3.4±2.1	4.9±1.6*
Total	9.4±1.7	15.9±1.1*

* $p<0.05$

impacted tightly. High pressure or tight contact with the femoral diaphysis may explain the thigh pain. At the six month follow-up the pain was fully relieved.

No dislocation was encountered in this group. Deep venous thrombosis developed in one patient.

Discussion

CROWE type IV DDH was a challenge for total hip arthroplasty. Femoral shortening was usually necessary to reduce the femoral head into the true acetabulum. Subtrochanteric osteotomy is commonly used for femoral shortening which is valuable for protection of neurovascular tissue. Nonunion rate, however, has been reported to range from 0 % to 14 % [17, 18] for either transverse osteotomy or step cut, which might increase the risk of early loosening of prosthesis [4]. Subtrochanteric osteotomy, especially the step cut, requires good conformity of both ends of the femur when performing the osteotomy and a comparatively long learning curve for precise performance and coordination [10]. Lesser trochanteric osteotomy for femoral shortening has no fracture line that requires support and protection for union, and is also easy to perform. Therefore, we do not favour shortening of the femoral diaphysis as the first choice, as has been suggested by others [11].

We managed to avoid excessive osteotomy of the lesser trochanter using resilience of soft tissue around the hip, to maintain the proximal structure intact as much as possible. As a result, the extent of femoral shortening was usually less than in subtrochanteric osteotomy using an overlapping technique. Undercorrection of limb length caused by excessive osteotomy would aggravate limp, lumbar scoliosis and inclination of the pelvis [19]. Theoretically, lesser trochanteric osteotomy increases the sciatic nerve tension more than the subtrochanteric variety. However, we did not find increased incidence of nerve palsy in this group of patients. The two cases of sciatic nerve injury which arose mainly peroneal nerve palsy recovered without any weakness or numbness in the limb at the of six months follow-up. The result was parallel with the previous report that only four cases (5 %) suffered nerve palsies after THA for high dislocated hips without femoral shortening in 74 DDH patients [10]. In addition, other authors [2, 11] did not find that sciatic nerve palsy was associated with the extent of limb lengthening. Risk of rotational instability may increase for cementless prosthesis when excessive proximal structures are sacrificed in performing lesser trochanteric osteotomy. However, this complication was not seen in this study. Besides, a modular prosthesis S-ROM system provides further fixation for femoral stem thanks to a distally fluted design [20].

There are three reasons for weakness of the abductors. First, disuse atrophy of the abductor is always seen in a high

dislocated hip; second, the abductor insertion may be compromised when performing osteotomy and joint reduction with powerful distal traction; finally, the femoral stem is further impacted distally into the canal by the use of short-neck after lesser trochanteric osteotomy, which always reduces the hip offset [21]. Therefore, risk of abductor weakness is generally higher for lesser trochanteric osteotomy than for the subtrochanteric type which had complete retention of abductor and use of standard neck prosthesis [22]. In this group nine hips turned negative and 19 hips achieved prominent improvement in the Trendelenburg sign. Only two hips remained positive which resulted in a mild limp at the final follow-up. This result might be attributed to an increase in the tension of the abductor after the femoral head was reduced into the true acetabulum.

In addition, more attention needs to be paid to chronic complications of the lumbar spine as a result of shortness of effective length of the limb undergoing femoral shortening [23]. Lumbar scoliosis and pelvic inclination compensate for the leg length difference, which exists either in the procedure of subtrochanteric osteotomy or in the lesser trochanteric variety. Although six patients with unilateral THA complained about the operated limb having a longer length than the contralateral side, objective results of measurement showed no substantial overlength of the ipsilateral leg. On the contrary, the functional overlength was considered to further correct the lumbar scoliosis and pelvic inclination.

A limitation of the study was small sample size due to low incidence of high dislocated DDH. In addition, the long term follow-up results would be more convincing for the study. The procedure sacrificed a small part of the proximal femoral structure which was important for the rotational stability of the hip and diminished the risk of non-union at the osteotomy site. Moreover, this procedure was not applicable for the patient with previous surgery of Schanz osteotomy due to severe deformity of proximal femur [24].

This group of patients underwent lesser trochanteric osteotomy for femoral shortening with an evident improvement of the Merle d'Aubigné and Postel hip scale. Risk of neurovascular injury and abductor weakness was comparable to previous reports of femoral shortening for DDH [10, 11, 25, 26]. In general, it was considered a favourable surgical procedure for treatment of CROWE IV DDH.

Conflict of interest The authors declare that they have no conflict of interest.

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