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Leg lengthening of more than 5 cm is a risk factor for sciatic nerve injury after total hip arthroplasty for adult hip dislocation

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ABSTRACT

Total hip arthroplasty (THA) in patients with high hip dislocation is challenging and technically demanding. Nerve injury is a problem associated with leg lengthening after THA. The purpose of this study was to identify the risk factors for sciatic nerve injury after THA in patients with high hip dislocation. Thirty-seven patients (41 THAs) with Crowe type IV hips were consecutively treated. The average leg lengthening (LL) was 3.2 cm. The average Harris hip score was improved from 57.5 points to 83.1 points at the final follow-up. The clinical outcomes after an average 6.4-years follow-up were satisfactory. Sciatic nerve injury was observed in two joints. LL in the two joints (two patients) with sciatic nerve injury was 5.2 cm and 6.7 cm, respectively. Leg lengthening of >5 cm was a risk factor for sciatic nerve injury. Therefore, leg lengthening of >5 cm should be avoided to prevent sciatic nerve injury.

Key Words: sciatic nerve injury, leg lengthening, total hip arthroplasty, crowe type IV

INTRODUCTION

Total hip arthroplasty (THA) in patients with Crowe type IV is challenging and technically demanding.[1-6] First, there is generally hypoplasia of the acetabulum. A smaller acetabular component must be reconstructed to the true anatomical acetabulum for maximum bone coverage.[1, 2, 5] Second, subtrochanteric femoral shortening osteotomy is recommended to prevent nerve injury caused by excessive leg lengthening (LL).[7] Third, there is also generally hypoplasia of the femur and a narrow medullary canal.[8] Thus, smaller or custom-made components are required.[2, 4, 5, 8] There are several complications associated with LL: nerve injury, difficulty in fixing the acetabular component, balance of soft tissue, and dislocation.[1-6]

The prevalence of nerve injury after THA ranges from 0.3–3.7%.[9-16] Many authors have speculated on several causes such as excessive lengthening of the nerve, mechanical compression from a hematoma or extruded cement, compression, or retraction. The surgical approach, hip flexion contracture, and previous hip surgery were also possible causes of nerve injury.[7-9, 12, 16] However, it is often difficult to identify the etiology of the nerve injury.[7] Some authors have

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suggested that LL of 2.7–5.4 cm was the cause of sciatic nerve injury.[1, 3, 12, 16] However, there is no report on the maximum safe amount of LL for preventing significant sciatic nerve injury.

It seems that the possible LL is regulated by the patient's height for preventing sciatic nerve injury.[17]

Therefore, this study aimed to investigate the risk factors of sciatic nerve injury and to clarify the safe range of LL and relative LL to prevent sciatic nerve injury after THA in patients with Crowe type IV hips. Relative LL was calculated as follows (LL ÷ Body Height [BH] × 100 = % of LL/BH).

MATERIALS AND METHODS

Between April 1992 and July 2013, we performed 41 consecutive THAs at our hospital in 37 patients with Crowe type IV hips. The indications for THA were severe hip pain and considerable difficulty in walking. Patients without hip pain did not have an indication for THA. A posterolateral approach with the patients in the lateral position was used. No trochanteric osteotomy was performed. The principle of THA is to achieve seating in the true acetabulum for the socket. Subtrochanteric femoral shortening osteotomy was performed if LL was >4 cm.[1] A previous study demonstrated that the gait pattern of patients with a unilateral high hip dislocation was greatly improved by limb length equalization at the time of THA.[18] If the tension of the sciatic nerve was not tight by palpation during the operation, we changed our principle so that >5 cm LL was permitted after the consecutive treatment of 30 hips with high hip dislocation to correct for the limb length discrepancy. Informed consent was obtained from all patients, and permission to perform this study was granted from the ethical committee of our hospital.

All operations were performed by a single senior surgeon (Y. H.). Subtrochanteric femoral shortening osteotomy was performed in 27 joints. Femoral transverse shortening was performed in 22 hips and step-cut subtrochanteric femoral shortening osteotomy was performed in 5 hips, according to the methods by Paavilainen *et al.*[5]

Radiographs of the standard anteroposterior view of the hips were examined one month and 6 months postoperatively and then annually by the NeoChart computer system (Fujitsu Co., Tokyo, Japan). Radiographic evaluations were performed by two independent surgeons (Y. H. and Y. H.). LL was measured radiographically as the distance between the horizontal teardrop line and the tip of the greater trochanter at six weeks before THA and one month postoperatively.[7, 8] In cases of THA with subtrochanteric femoral shortening osteotomy, LL was calculated by subtracting the amount of femoral shortening from the amount of translation of the tip of the greater trochanter.[17, 19] The resected femur was measured intraoperatively. The height of the tip of the greater trochanter in the neutral position was calculated by adjusting for the degree of abduction or adduction on each radiograph as much as possible.[19] The measurement of LL was performed three times by each surgeon and was then averaged.

The Harris hip score (HHS) was evaluated at six weeks before THA, one year after THA, and at the final follow-up postoperatively. These were retrospectively reviewed and collected from the patients' medical record.

The diagnosis of the sciatic nerve injury, severity of the injury, and clinical presentation of the injury were collected from the patients' medical records. Sciatic nerve injuries were identified from clinical documents without any electrophysiologic examination. Weakness in dorsal and plantar flexion and numbness of the tibial and peroneal territories of the sciatic nerve were included in the sciatic nerve injury. Transient sensory deficit and no motor palsy were excluded.

We investigated the relationships among nerve injury; body mass index (BMI) classified according to Farrell *et al.* (<25 kg/m^2, 25 to <30 kg/m^2, and ≥30 kg/m^2); preoperative hip flexion angle classified according to Oe *et al.* (0–30°, 31–60°, 61–90°, and 91–120°); false acetabulum; and previous hip operations.[8, 16]

STATISTICAL ANALYSIS

The statistical analyses included the Fisher's exact test, Kaplan-Meier survivorship analysis, and intraclass correlation coefficients (ICCs). All analyses were performed using SPSS, version 21 (IBM Corp., Armonk, NY, USA). The ICCs were used to address the inter-observer reliability. A p value <0.05 was considered statistically significant.

RESULTS

The demographics of this study group are shown in Table 1. There were 36 women and one man with a mean age of 61.3 years (range, 40–80 years) at the time of the operation. The patients' average height was 150.1 cm (range, 140–162 cm), average body weight was 50.5 kg (range, 38–74 kg), and BMI was 22.3 kg/m^2 (range, 15.7–29.6 kg/m^2). The average follow-up was 6.4 years (range, 1–21 years).

Table 1 Patient demographics

Parameters	Values
Gender (female/male)	36/1
Age (years old)	61.3 (range, 40–80)
Height (cm)	150.1 (range, 140–162)
Weight (kg)	50.5 (range, 38–74)
BMI (kg/m^2)	22.3 (range, 15.7–29.6)
Previous operation (yes/no)	15/26
Follow-up (years)	6.4 (range, 1–21)

BMI: body mass index

Thirty-seven (90.2%) of 41 joints had a BMI of <25 kg/m^2. The preoperative hip flexion angles were as follows: 13 (31.7%) of 41 joints were 31–60° and 20 joints (48.8%) were 61–90°. Eighteen hips (43.9%) of 41 joints had false acetabulums, and 15 (36.6%) of 41 joints had previous operations of the hip.

The previous Schanz osteotomy had been performed in 13 joints, open reduction had been performed in one joint for congenital dislocation, and a previous operation had been performed in one hip joint for septic arthritis.

The mean limb length discrepancy observed radiographically in the 33 patients with unilateral high hip dislocation was reduced from 6.1 cm (range, 3.0–8.0 cm) to 1.7 cm (range, 0–3.3 cm). The mean length of excised femoral segment was 2.7 cm (range, 1.5–3.5 cm).

The mean LL was 3.2 cm (range, 1.5–6.7 cm) (ICC: 0.887, 95% confidence interval [CI]: 0.611–0.971). Sciatic nerve injury was observed in two joints (4.9%). Femoral nerve injury and

Table 2 Summary of patient's date with LL>5.0 cm

Case	Age	Sex	Body height (cm)	LL (cm)	% of LL/BH	Sciatic nerve injury
1	69	F	143	5.2	3.64	+
2	57	F	155	6.7	4.32	+
3	68	F	157	6	3.82	–
4	80	F	155	5.7	3.68	–
5	73	M	162	5.4	3.33	–
6	44	F	158	5.3	3.35	–
7	73	F	155	5.1	3.29	–

LL: leg lengthening
BH: Body height
% of LL/BH: Leg Lengthening /Body height ×100

peroneal nerve injury were not observed. The mean operative time and blood loss were 174 min (range, 57–240 min) and 714 g (range, 200–1,200 g), respectively. At the final follow-up, the preoperative mean HHSs were improved from 57.5 points (range, 21–74 points) to 83.1 points (range, 74–94 points).

LL in the two joints (two patients) with sciatic nerve injury was 5.2 cm and 6.7 cm, respectively. The % of LL/BH in patients with sciatic nerve injury was 3.64% and 4.32% (Table 2). Postoperative computed tomography (CT) scans did not reveal any hematomas or extruded cement in the two joints with a cemented acetabular component. Three months postoperatively, a patient achieved complete neurological recovery (Table 2, case 1), but another patient had moderate numbness in the foot and severe motor palsy with a persistent foot drop, which required a molded ankle foot orthosis (Table 2, case 2) (Fig. 1).

There was no joint of the 34 joints with a sciatic nerve injury that had an LL of <5.0 cm. However, sciatic nerve injury was observed in two joints of the 7 joints that had an LL of >5.0 cm. Sciatic nerve injury occurred more in the joints that had an LL of >5.0 cm than in joints that had an LL of <5.0 cm ($p = 0.00256$) (Table 3).

The heights of the patients who had an LL of >5.0 cm and a sciatic nerve injury were 155 cm and 143 cm, respectively. The heights of patients who had an LL of >5.0 cm without a sciatic nerve injury were 162 cm, 158 cm, 157 cm, and 155 cm, 155 cm. the heights of the patients with a sciatic nerve injury were smaller than those without a sciatic nerve injury (Table 2). It has been assumed that a sciatic nerve injury occurs in an extremity that is lengthened by a percentage of LL/BH of 3.5. Sciatic nerve injury occurred more in the joints that had a percentage of LL/BH of ≥3.5 than in joints that had a percentage of LL/BH of <3.5 ($p = 0.0073$) (Table 2). An LL of >5.0 cm and a percentage of LL/BH of ≥3.5 were significant risk factors of sciatic nerve injury (Table 3).

The operative time and blood loss were not associated with sciatic nerve injury ($p = 0.536$ and $p = 0.751$, respectively). False acetabulums, previous operation, BMI, and the preoperative hip flexion angle were not associated with sciatic nerve injury (Tables 3).

Revision was performed in six joints due to osteolysis and in one joint due to loosening of the femoral component. The Kaplan-Meier survivorship at 5 and 10 years revealed a cumulative survival rate of 89.8% and 73.3%, respectively, with any implant revision as the end point.

Dislocation was observed in six joints (14.6%). Four joints were successfully treated conservatively by using single closed reduction, and two joints were treated using surgical reduction.

Fig. 1 a)

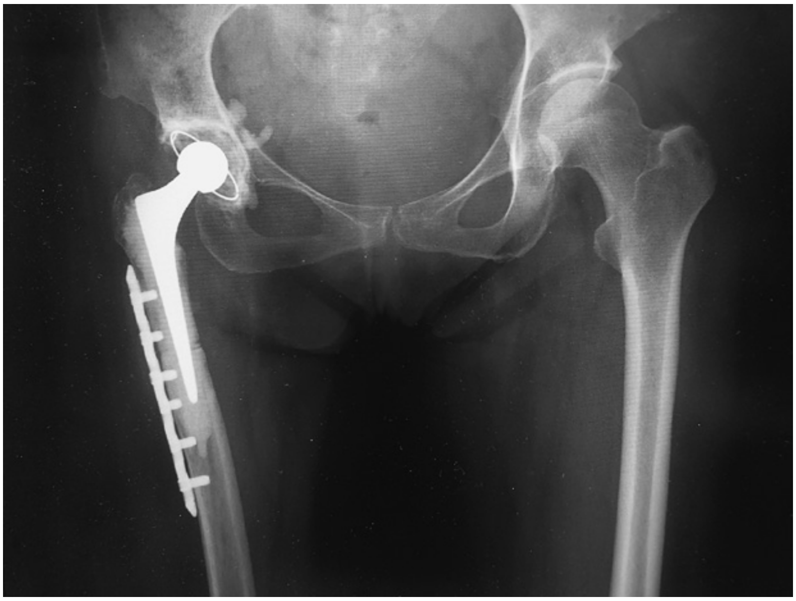

Fig. 1 b)

Fig. 1 A 57-year-old woman with a height of 155 cm, weight of 45 kg, and a preoperative hip flexion angle of 120º. a) Preoperative radiograph showing a high dislocation of the right hip due to congenital hip dislocation with a leg length (LL) discrepancy of 8.7 cm. The LL is 8 cm in the preoperative planning. b) Total hip arthroplasty is performed with 3.0 cm femoral osteotomy using an Exeter stem. Postoperative radiograph after 6.7 cm LL with a percentage of LL/body height of 4.32, which is beyond the expectation. She noticed a weakness in dorsal and plantar flexion and numbness of the tibial and peroneal territories of the sciatic nerve postoperatively. One year postoperatively, she had moderate numbness in the foot and severe motor palsy with a persistent foot drop, which required a molded ankle orthosis.

Table 3 Sciatic nerve injury and risk factors

Variable	Sciatic nerve injury + (joints)	Sciatic nerve injury − (joints)	p value
LL			
>5 cm	2	5	0.0256
<5 cm	0	34	
% of LL/BH			
>3.5%	2	2	0.0073
<3.5%	0	37	
False acetabulum			
+	0	18	0.4951
−	2	21	
Previous operation			
+	0	15	0.3963
−	2	24	
BMI			
<25kg/m^2	2	35	0.6335
25 to <30kg/m^2	0	4	
preoperative hip flexion angle			
0–30°	0	1	0.4516
31–60°	1	12	
61–90°	0	20	
91–120°	1	6	

Fisher's exact test

LL: leg lengthening
BH: Body height
% of LL/BH: Leg Lengthening /Body height ×100
BMI: body mass index

There were no postoperative infections.

DISCUSSION

Farrell *et al.* reported that a large number of THAs showed a statistically significant correlation between LL and nerve injury; however, they did not report on the cut-off values of LL for preventing nerve injury, because there was a small difference in LL between patients with nerve injury (1.7 cm) and those without (1.1 cm).[16] In this study, there was a large difference between patients with nerve injury (5.95 cm) and those without (3.05 cm), enabling us to report on cut-off values. According to Nercessian at al., the maximum safe LL was 4.05 cm.[20] However, this was not statistically significant. In the present study, there was no patient with a sciatic nerve injury who had LL of < 5.0 cm. Therefore, we considered that the maximum safe LL was 5 cm for preventing sciatic nerve injury. If the postoperative leg length discrepancy remains within LL < 5.0 cm, an extension shoe is the way to correct the leg length discrepancy.

Myelinated fibers of the palmar nerve showed moderate degenerative changes in the myelin sheath by lengthening of 8% of the metacarpal length, and it became severe at 20% of lengthening.[21] According to Feldesman *et al.*, the femur/stature ratio of Asians was 26.5 and the estimated femur length in our study was 39.75 cm.[22] We did not measure the femur length in this study. By calculating the estimated femur length (39.75 cm) and cut-off values of LL (5.0 cm), the maximum safe LL was up to 12.6% of the femur length in order to prevent nerve injury, which was between 8% and 20%. This finding is reasonable to support that LL of >5.0 cm was a risk factor for sciatic nerve injury.

There are few reports on the correlation between sciatic nerve injury and the patients' height. An LL of >3.0 cm could increase the risk of nerve palsy in patients with a short stature.[19] Sciatic nerve injury was observed in two joints of the 7 joints that had an LL of >5.0 cm. The height of patients with a sciatic nerve injury was shorter than those without a sciatic nerve injury. We believe that an LL of >5.0 cm is one of the risk factors for sciatic nerve injury, and patients with a shorter height are more at risk.

Revision was performed in six joints (14.6%) due to osteolysis. These socket liners were comprised of non-cross-linked polyethylene. Recently, the incidence of osteolysis has dramatically decreased because of the development of highly cross-linked polyethylene.

This study has several limitations. First, this study was retrospective in nature and had a relatively small number of patients. Second, there were cases that underwent THA with subtrochanteric femoral shortening osteotomy or without osteotomy. We cannot elucidate the absolute indication of subtrochanteric femoral shortening osteotomy for preventing sciatic nerve injury. An intraoperative assessment of nerve tension by palpation was the only indication for subtrochanteric femoral shortening osteotomy. However, after 30 hip joints, we tried to lengthen the unilateral high hip dislocation to equalize the leg length as much as possible, since patients complained of leg discrepancy after unilateral dislocated hip after THA. Even in acceptable tension by finger palpation, two hips developed sciatic nerve injury. We stopped the sciatic nerve palpation to prevent sciatic nerve injury. Third, we could only determine sciatic nerve injury in cases with obvious motor palsy in clinical practice when it was documented in the patients' record. Because of the retrospective study design, we could not detect mild sciatic nerve injury. In the future, sciatic nerve injury should be prevented by using motor evoked potentials (MEPs), somatosensory evoked potentials (SEPs) during operation.[7, 23, 24] Fourth, we assessed LL by using standard anteroposterior radiographs with errors of measurement caused by the adduction of flexion contracture. Fifth, we did not measure the femur length in this study. Tanoue *et al.* noted that LL should be within 10% of femoral length to prevent sciatic nerve injury.[25] We should evaluate not only the LL/BH ratio but also the relationship between LL and femoral length to prevent sciatic nerve injury.

CONCLUSIONS

Although, multiple factors may affect safe LL for preventing a sciatic nerve injury, our study indicated that an LL of >5.0 cm was one of the risk factors for sciatic nerve injury after THA for adult hip dislocation. Further study with a large cohort is needed to elucidate the maximum safe LL for preventing a sciatic nerve injury.

CONFLICT OF INTEREST

Yoshitoshi Higuchi and Naoki Ishiguro disclose no financial support of relationship that may pose conflict of interest.

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