International Orthopaedics (2019) 43:573–577
https://doi.org/10.1007/s00264-018-4035-3

ORIGINAL PAPER

# Sciatic and femoral nerve injury among patients who received Bernese peri-acetabular osteotomy

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Received: 5 February 2018 / Accepted: 12 June 2018 / Published online: 18 June 2018
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## Abstract

**Aim** To investigate the incidence, risk factors, and the last follow-up recovery status of sciatic and femoral nerve injury among patients who received Bernese peri-acetabular osteotomy (PAO).

**Patients and methods** The clinical file of 643 consecutive patients who received PAO from June 2012 to June 2016 was retrospectively reviewed. The number of nerve injury patients was calculated and the causes of injury were recorded.

**Results** The sciatic or femoral nerve injury occurred in eight patients (1.24%), including four sciatic nerve injuries and four femoral nerve injuries. The reasons for sciatic nerve injury included one direct sciatic nerve injury happened at the time when deep osteotomy penetrated the posterior column to cut the nerve trunk at the area where the nerve runs through out of the greater sciatic foramen during quadrilateral bone osteotomy. The other two direct sciatic nerve injuries occurred at the inside pelvis by long drill bit or Kirschner wire drilling before the transverse screw fixation. No direct injury reasons could be found for the remaining five patients with one partial sciatic nerve injury and four femoral nerve palsies. The three patients with direct sciatic nerve injuries were partly recovered at the last follow-up. Full recovery was found in one sciatic nerve injury and four femoral nerve injury patients.

**Conclusion** The sciatic nerve can be injured directly or indirectly during PAO. It is of great importance to understand the risk factors and the precautionary measures of nerve injuries during PAO.

**Keywords** Bernese peri-acetabular osteotomy · Complication · Sciatic nerve injury · Femoral nerve injury

Developmental dysplasia of the hip (DDH) is associated with the occurrence and progression of hip osteoarthritis (OA). The Bernese peri-acetabular osteotomy (PAO) is widely accepted in the treatment of symptomatic patients with DDH by reorienting dysplastic acetabulum and optimizing biomechanical environment of hip joint [1–6]. However, due to the deep location of hip joint and the complicated neurovascular structure around it, the PAO is a technically demanding procedure with possible occurrence of neurovascular complications [1]. Rare as it is, the complications of sciatic or femoral nerve injury have very serious consequences. So how to avoid sciatic or femoral nerve injury is particularly important during PAO surgery.

According to a report by Ganz et al. [7] in 1988, of the 75 DDH patients who received PAO, only one patient showed the transient palsy of femoral nerve and no sciatic nerve injury occurred. From the current literatures, we find that there is very limited information with regard to the mechanisms of sciatic or femoral nerve injury during PAO and the related risk factor analysis. The purpose of this retrospective study is to identify the incidence and risk factors of sciatic and femoral nerve injury during or after PAO by analyzing 643 consecutive DDH patients in our department. We also aim to put forward some precautionary measures to avoid nerve injury during PAO surgery. Though the lateral femoral cutaneous nerve and obturator nerve have more incidences to be injured during PAO, because of lack of clinical significance and incomplete of patient's file information, these two nerve injuries will not be investigated in this study.

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## Materials and methods

The consecutive medical file of 643 patients with DDH who were admitted to our hospital and received PAO from June 2012 to June 2016 was retrospectively reviewed. All surgeries were performed by senior surgeons in our department. The indications of PAO were as follows: (1) Hartofilakidis classification [8] type A DDH with hip symptoms; (2) "good" or "excellent" joint congruency on antero-posterior (AP) pelvic X-ray with hip abduction/internal rotation (functional pelvic view) according to Yasunaga [9] classifications; (3) absent or mild secondary hip osteoarthritis OA (Tönnis grade [10] of 0, 1, or 2) on weight-bearing AP pelvic X-ray and intact or mild damage of articular cartilage on MRI; (4) Patient age: between ten and 50 years old. The contraindications were as follows: (1) complete hip dislocation; (2) poor joint congruency on AP functional pelvic X-ray; (3) severe secondary hip OA (Tönnis grade of 3) on X-ray and severe wear of articular cartilage on the weight-bearing area of hip joint on MRI; (4) patient age was more than 50 years old or less than ten years old.

The patients with femoral or sciatic nerve injury were identified by reviewing medical files, operative records, and the follow-up data of 643 patients. All patients had minimum follow-up for more than one year. The severity of nerve injury was evaluated by identifying the weakness of corresponding muscle strength because the sensory change disturbance resulted from nerve injury is lack of specificity. The severity of muscle strength change was evaluated according to a grading system by Medical Research Council (grades 0–5). The sciatic nerve injury was identified by weakness or loss of muscle strength when patients were asked to do ankle dorsal extension or plantar flexion motion. For patient with femoral nerve injury, we evaluated the quadriceps weakness or loss of muscle strength. The lateral femoral cutaneous nerve is a purely sensory nerve and the obturator nerve only dominates adductor muscles, the injury of which has little effects on hip functions or long-term outcomes of PAO surgery. Therefore, these two nerves are not involved in the analysis of this study.

### Surgical technique

The surgical technique of PAO we used was described in detail by Ganz et al. [7] and Luo DZ et al. [11]

## Results

A total of 643 PAO patients' medical files from June 2012 to June 2016 were reviewed. Eight patients (1.24%, three males and five females) were identified with sciatic or femoral nerve injury (Table 1). The average age was 26 years old, ranging from 14 to 36. Sciatic nerve injury occurred in four cases (0.62%) and femoral nerve injury occurred in the other four cases (0.62%). Among four patients who had sciatic nerve injuries, three patients received PAO only and one patient received PAO and surgical hip dislocation (SHD) for inside hip joint inspection and labrum repair at the same time. Among four patients who had femoral nerve injuries, two patients received PAO only and the other two patients with hypertrophic labrum abnormality and femoral torsion angle more than 40° had received PAO with SHD and proximal femoral derotational osteotomy (PFO) at the same surgery.

Three sciatic nerve injuries were caused by direct damage. Patient 1 had complete loss of ankle dorsal flexion and extension right after anesthesia recovery. With the suspicion of sciatic nerve trunk injury caused by osteotome penetrated too deep at the corner of acetabular posterior wall (Fig. 1), the emergency nerve exploration was carried out. Partial rupture of the nerve trunk was found outside the great sciatic foramen. Then the nerve suture was performed. The muscle power of plantar extension had reached grade 4, but no dorsal flexion motion was spotted 18 months after PAO surgery. Patient 2 had direct sciatic nerve injury caused by long drill bit penetrated into pelvis before the transverse screw fixation (Fig. 2). She had grade 3 dorsal extension with normal planter flexion 24 months after surgery without further improvement. Patient 4 also had direct sciatic nerve injury caused by long Kirschner's wire penetrated too deep inside pelvis before acetabular transverse screw fixation. This patient had grade 4 dorsal extension with normal planter flexion 22 months after surgery. She had normal gait with mild weakness of ankle dorsal flexion since then. The clear cause of injury to the last sciatic nerve injury patient (patient 3) could not be identified. He lost dorsal flexion after surgery but had full recovery 12 months after surgery. The damage mechanism of all four patients who had femoral nerve palsy could not be identified. Three of these four patients had their femoral nerve palsy found the day after surgery. One patient's femoral nerve palsy was found one month after surgery. They all received full recovery 12 months after surgery.

## Discussion

Developmental dysplasia of hip is one of most common hip disorders in China. The Bernese periacetabular osteotomy (PAO) reported by Ganz et al. [7] in 1988 could improve femoral head coverage by correction of acetabular position, thus optimizing hip joint biomechanical environment. Therefore, the PAO is widely used in the treatment of hip dysplasia [11].

PAO is a technical demanding surgery. Because hip joint has complicated neurovascular structure around, the visual field of PAO surgery is limited; therefore, the possibility of nerve injury should be on the alert. There are four main nerves around hip joint which could encounter the danger: sciatic

**Table 1** Details of patients with nerve injuries following PAO

| Number | Age (years) | Follow-up duration (months) | Gender | Surgical methods | Nerve involved | The time when nerve injury was found | Treatment | Final follow-up | Date of operation | Final follow-up date | Mechanism of injury |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 20 | 18 | F | PAO | Sciatic | Immediately post-operation | Exploration and nerve suture | Partly recovered: plantar extension 4/5 dorsal flexion 0/5 | 2016.01 | 2017.07 | Osteotome cut the nerve trunk directly |
| 2 | 22 | 44 | F | PAO | Sciatic | Immediately post-operation | Observation | Partly recovered 3/5 | 2013.09 | 2017.05 | Drill bit drilling |
| 3 | 14 | 56 | M | PAO | Sciatic | First day post-op | Observation | Fully recovered | 2012.09 | 2017.05 | Unknown |
| 4 | 36 | 32 | F | PAO + SHD | Sciatic | Immediately post-operation | Observation | Partly recovered 4/5 | 2014.08 | 2017.04 | Kirschner wire drilling |
| 5 | 32 | 32 | M | PAO | Femoral | First day post-op | Observation | Fully recovered | 2014.09 | 2017.05 | Unknown |
| 6 | 33 | 24 | F | PAO | Femoral | 1 month post-op | Observation | Fully recovered | 2015.05 | 2017.05 | Unknown |
| 7 | 20 | 21 | F | PAO + PFO + SHD | Femoral | First day post-op | Observation | Fully recovered | 2015.08 | 2017.05 | Unknown |
| 8 | 28 | 13 | M | PAO + PFO + SHD | Femoral | First day post-op | Observation | Fully recovered | 2016.03 | 2017.04 | Unknown |

*PAO*, periacetabular osteotomy; *DDH*, developmental dysplasia of the hip; *SHD*, surgical hip dislocation; *PFO*, proximal femoral osteotomy

nerve, femoral nerve, lateral femoral cutaneous nerve, and obturator nerve. The lateral femoral cutaneous nerve is located medial to the ASIS beneath the inguinal ligament and runs distally to anterolateral region of the thigh. This nerve is easy to be damaged by Smith-Petersen approach. Hussell [12] et al. reported that about 30% of patients presented with lateral femoral cutaneous nerve injury during PAO in the treatment of 508 patients, whereas in a report by Francesco Pogliacomi et al. [13], 18 of 36 patients presented with lateral femoral cutaneous nerve injury. As this nerve is a purely sensory nerve, our patient's medical files did not have injury information of it. So we did not investigate lateral femoral cutaneous nerve injury in this study. The obturator nerve only dominates adductor muscles, the injury of which is hardly to be detected and has little effects on hip functions or long-term outcomes of PAO surgery. Therefore, the obturator nerve was also not involved in the analysis in this study.

The sciatic nerve begins from spinal cord on lumbosacral portion and run through the posterior wall of pelvis, and then runs distally to the hip after penetrating the great sacrosciatic foramen. The cadaveric study by M. Kalhor et al. [14] indicated that the sciatic nerve could be touched when the osteotome penetrated the posterior column by 1 cm. They also stated that the sciatic nerve was put under greater tension when the hip was flexed. They concluded that the repositioning of the acetabulum had little impact on sciatic nerve; however, when the medialization of the acetabulum was over 2 cm, the sciatic nerve may contact with the edge of the posterior column. In our study, patient one had direct nerve injury by osteotome deeply penetrating acetabular posterior wall to partially cut the sciatic nerve trunk behind this area when osteotomy was performed at the corner of acetabular posterior wall to connect ischium cut. The position of hip joint of this patient was in flexion, which caused the sciatic nerve at tension. By realizing the possibility of nerve injury, we did immediate nerve exploration and nerve suture. Though the plantar flexion was nearly fully recovered after 18 months of surgery, the dorsal extension did not show significant improvement since then. The lessons learned from this case made us very cautious when we do the acetabular posterior wall osteotomy to make sure that the osteotome is not cut too deep, the hip joint must be kept at extension position.

Ganz et al. [7] suggested that the internal fixation during PAO include two longitudinal screws from iliac wing to acetabular segment plus one transverse screw from anterior inferior iliac spine of the acetabular segment to the inside ilium. Because this transverse screw could increase the fixation strength of acetabulum, we followed the same screw fixation pattern. However, two patients in our study had their sciatic nerve damaged during the transverse screw fixation. Patient two had her sciatic nerve damaged by long drill bit drilling. Then, we used Kirschner's wire which has a smooth surface to

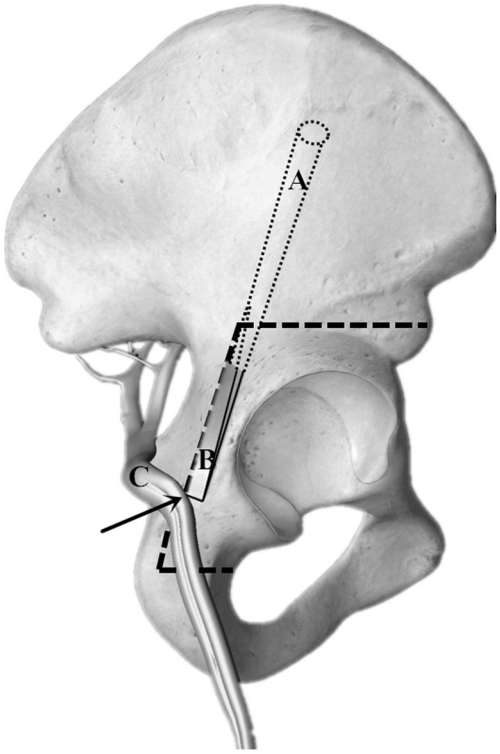


**Fig. 1** This image demonstrates that the osteotome cuts the sciatic nerve trunk behind acetabular posterior wall when osteotomy was performed at the corner of acetabular posterior wall to connect ischium cut. (A) The inside part of osteotome, (B) the outside part of osteotome, and (C) the sciatic nerve trunk. The arrow indicates the location where the osteotome cuts the nerve trunk

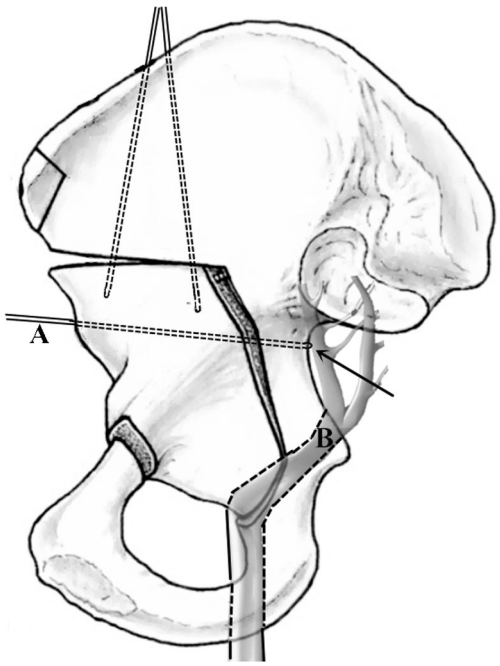


**Fig. 2** The sciatic nerve injury is directly caused by long Kirschner's wire or drill bit (A) penetrated into pelvis before the transverse screw fixation. (B) The sciatic nerve. The arrow indicates the location where the sciatic nerve is damaged by Kirschner's wire or drill bit

replace drill bit but neglected the length of Kirschner wire. Patient four had her nerve damaged by too deep Kirschner's wire penetrating into pelvis. Since then we cut Kirschner's wire into half-length to avoid deep penetration and no further sciatic nerve injury happened with this pattern.

In 508 PAO surgeries reported by Hussell et al. [12], the sciatic nerve injury occurred in five patients. They considered that the sciatic nerve was repressed and injured by repositioning of the acetabulum. One in 36 patients presented with sciatic nerve injury during PAO; according to a report by Francesco Pogliacomi et al. [13], they thought that incorrect placement of a retractor behind the posterior column might be the reason. One patient from our study could not identify the specific reason how his sciatic nerve had transient palsy with complete recovery. The above reasons might give explanation.

The femoral nerve runs between psoas major and iliacus muscle then beneath the inguinal ligament to the thigh. The risk factors of femoral nerve injury during PAO includes entrapment of the femoral nerve into the pubic osteotomy space after repositioning the acetabulum; increased femoral nerve tension after acetabular fragment medialization beyond 2 cm; the stretch injury by retractor, and increased femoral nerve tension caused by anterior displacement of acetabular fragment of > 2 cm and lateral tilt of > 30° [14]. In our study, four patients who had femoral nerve injuries present transient palsy either 1 day or 1 month after the PAO surgery. The explanation of late femoral nerve injury discovery could be negligence of quadriceps power check right after the surgery. The local bleeding after surgery may be another reason. Fortunately, all femoral nerve injury patients had full recovery at the 12-month follow-up. We could not identify the femoral nerve damage pattern, because there was no over medialization or over anterior/lateral tilt cases, there was no open nonunion of pubic osteotomy either.

There are some limitations in this study. First, our study was retrospective in nature. We mainly relied on the patient's medical file review. The severity evaluation of nerve injury was based on the file records and physical examinations. Therefore, we might underestimate the actual severity of the nerve injuries. Second, the incidence of nerve injuries is too low to perform some statistical correlation, so we can only analyze the risk factors according to the patient's file and our surgical records.

In conclusion, PAO is a widely received and effective surgery for treatment of hip dysplasia in adolescents and young adults. Sciatic nerve and femoral nerve injuries are rare but devastating complications [15]. The reasons for nerve injury during PAO could be direct or indirect. Understanding the risk factors, precise surgical techniques and careful post-operative observation are essential to avoid these devastating complications.

## Compliance with ethical standards

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

**Ethical approval** We received the ethics committee review board approval from our institution before the initiation of this study.

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